Amazon Relational Database Service

User Guide

Amazon Relational Database Service: User Guide

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What Is Amazon Relational Database Service (Amazon RDS)?

Amazon Relational Database Service (Amazon RDS) is a web service that makes it easier to set up, operate, and scale a relational database in the AWS Cloud. It provides cost-efficient, resizable capacity for an industry-standard relational database and manages common database administration tasks.

> **Note**
> This guide covers Amazon RDS database engines other than Amazon Aurora. For information about using Amazon Aurora, see the *Amazon Aurora User Guide*.
> This guide covers using Amazon RDS in the AWS Cloud. For information about using Amazon RDS in on-premises VMware environments, see the *Amazon RDS on VMware User Guide*.

Overview of Amazon RDS

Why do you want a managed relational database service? Because Amazon RDS takes over many of the difficult or tedious management tasks of a relational database:

- When you buy a server, you get CPU, memory, storage, and IOPS, all bundled together. With Amazon RDS, these are split apart so that you can scale them independently. If you need more CPU, less IOPS, or more storage, you can easily allocate them.
- Amazon RDS manages backups, software patching, automatic failure detection, and recovery.
- To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances. It also restricts access to certain system procedures and tables that require advanced privileges.
- You can have automated backups performed when you need them, or manually create your own backup snapshot. You can use these backups to restore a database. The Amazon RDS restore process works reliably and efficiently.
- You can get high availability with a primary instance and a synchronous secondary instance that you can fail over to when problems occur. You can also use MySQL, MariaDB, or PostgreSQL read replicas to increase read scaling.
- You can use the database products you are already familiar with: MySQL, MariaDB, PostgreSQL, Oracle, Microsoft SQL Server.
- In addition to the security in your database package, you can help control who can access your RDS databases by using AWS Identity and Access Management (IAM) to define users and permissions. You can also help protect your databases by putting them in a virtual private cloud.

If you are new to AWS products and services, begin learning more with the following resources:

- For an overview of all AWS products, see What is Cloud Computing?
- Amazon Web Services provides a number of database services. For guidance on which service is best for your environment, see Running Databases on AWS.

DB Instances

The basic building block of Amazon RDS is the DB instance. A *DB instance* is an isolated database environment in the AWS Cloud. Your DB instance can contain multiple user-created databases. You can access your DB instance by using the same tools and applications that you use with a standalone database instance. You can create and modify a DB instance by using the AWS Command Line Interface, the Amazon RDS API, or the AWS Management Console.

Each DB instance runs a *DB engine*. Amazon RDS currently supports the MySQL, MariaDB, PostgreSQL, Oracle, and Microsoft SQL Server DB engines. Each DB engine has its own supported features, and each version of a DB engine may include specific features. Additionally, each DB engine has a set of parameters in a DB parameter group that control the behavior of the databases that it manages.

The computation and memory capacity of a DB instance is determined by its *DB instance class*. You can select the DB instance that best meets your needs. If your needs change over time, you can change DB instances. For information, see DB Instance Classes (p. 7).

> **Note**
> For pricing information on DB instance classes, see the Pricing section of the Amazon RDS product page.

DB instance storage comes in three types: Magnetic, General Purpose (SSD), and Provisioned IOPS (PIOPS). They differ in performance characteristics and price, allowing you to tailor your storage performance and cost to the needs of your database. Each DB instance has minimum and maximum storage requirements depending on the storage type and the database engine it supports. It's important to have sufficient storage so that your databases have room to grow. Also, sufficient storage makes sure that features for the DB engine have room to write content or log entries. For more information, see Amazon RDS DB Instance Storage (p. 29).

You can run a DB instance on a virtual private cloud (VPC) using the Amazon Virtual Private Cloud (Amazon VPC) service. When you use a VPC, you have control over your virtual networking environment. You can choose your own IP address range, create subnets, and configure routing and access control lists. The basic functionality of Amazon RDS is the same whether it's running in a VPC or not. Amazon RDS manages backups, software patching, automatic failure detection, and recovery. There's no additional cost to run your DB instance in a VPC. For more information on using Amazon VPC with RDS, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

Amazon RDS uses Network Time Protocol (NTP) to synchronize the time on DB Instances.

AWS Regions and Availability Zones

Amazon cloud computing resources are housed in highly available data center facilities in different areas of the world (for example, North America, Europe, or Asia). Each data center location is called an AWS Region.

Each AWS Region contains multiple distinct locations called Availability Zones, or AZs. Each Availability Zone is engineered to be isolated from failures in other Availability Zones. Each is engineered to provide inexpensive, low-latency network connectivity to other Availability Zones in the same AWS Region. By launching instances in separate Availability Zones, you can protect your applications from the failure of a single location. For more information, see Regions, Availability Zones, and Local Zones (p. 37).

You can run your DB instance in several Availability Zones, an option called a Multi-AZ deployment. When you choose this option, Amazon automatically provisions and maintains a secondary standby DB instance in a different Availability Zone. Your primary DB instance is synchronously replicated across Availability Zones to the secondary instance. This approach helps provide data redundancy and failover support, eliminate I/O freezes, and minimize latency spikes during system backups. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

Security

A *security group* controls the access to a DB instance. It does so by allowing access to IP address ranges or Amazon EC2 instances that you specify.

For more information about security groups, see Security in Amazon RDS (p. 1356).

Monitoring an Amazon RDS DB Instance

There are several ways that you can track the performance and health of a DB instance. You can use the Amazon CloudWatch service to monitor the performance and health of a DB instance. CloudWatch performance charts are shown in the Amazon RDS console. You can also subscribe to Amazon RDS events to be notified about changes to a DB instance, DB snapshot, DB parameter group, or DB security group. For more information, see Monitoring an Amazon RDS DB Instance (p. 345).

How to Work with Amazon RDS

There are several ways that you can interact with Amazon RDS.

AWS Management Console

The AWS Management Console is a simple web-based user interface. You can manage your DB instances from the console with no programming required. To access the Amazon RDS console, sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

Command Line Interface

You can use the AWS Command Line Interface (AWS CLI) to access the Amazon RDS API interactively. To install the AWS CLI, see Installing the AWS Command Line Interface. To begin using the AWS CLI for RDS, see AWS Command Line Interface Reference for Amazon RDS.

Programming with Amazon RDS

If you are a developer, you can access the Amazon RDS programmatically. For more information, see Amazon RDS Application Programming Interface (API) Reference (p. 1470).

For application development, we recommend that you use one of the AWS Software Development Kits (SDKs). The AWS SDKs handle low-level details such as authentication, retry logic, and error handling, so that you can focus on your application logic. AWS SDKs are available for a wide variety of languages. For more information, see Tools for Amazon Web Services .

AWS also provides libraries, sample code, tutorials, and other resources to help you get started more easily. For more information, see Sample Code & Libraries.

How You Are Charged for Amazon RDS

When you use Amazon RDS, you can choose to use on-demand DB instances or reserved DB instances. For more information, see DB Instance Billing for Amazon RDS (p. 44).

For Amazon RDS pricing information, see the Amazon RDS product page.

What's Next?

The preceding section introduced you to the basic infrastructure components that RDS offers. What should you do next?

Getting Started

Create a DB instance using instructions in Getting Started with Amazon RDS (p. 64).

Database Engine–Specific Topics

You can review information specific to a particular DB engine in the following sections:

- MariaDB on Amazon RDS (p. 497)
- Microsoft SQL Server on Amazon RDS (p. 542)
- MySQL on Amazon RDS (p. 710)
- Oracle on Amazon RDS (p. 845)
- PostgreSQL on Amazon RDS (p. 1222)

Amazon RDS DB Instances

A *DB instance* is an isolated database environment running in the cloud. It is the basic building block of Amazon RDS. A DB instance can contain multiple user-created databases, and can be accessed using the same client tools and applications you might use to access a standalone database instance. DB instances are simple to create and modify with the Amazon AWS command line tools, Amazon RDS API operations, or the AWS Management Console.

> **Note**
> Amazon RDS supports access to databases using any standard SQL client application. Amazon RDS does not allow direct host access.

You can have up to 40 Amazon RDS DB instances, with the following limitations:

- 10 for each SQL Server edition (Enterprise, Standard, Web, and Express) under the "license-included" model
- 10 for Oracle under the "license-included" model
- 40 for MySQL, MariaDB, or PostgreSQL
- 40 for Oracle under the "bring-your-own-license" (BYOL) licensing model

> **Note**
> If your application requires more DB instances, you can request additional DB instances by using this form.

Each DB instance has a DB instance identifier. This customer-supplied name uniquely identifies the DB instance when interacting with the Amazon RDS API and AWS CLI commands. The DB instance identifier must be unique for that customer in an AWS Region.

The identifier is used as part of the DNS hostname allocated to your instance by RDS. For example, if you specify `db1` as the DB instance identifier, then RDS will automatically allocate a DNS endpoint for your instance, such as `db1.123456789012.us-east-1.rds.amazonaws.com`, where `123456789012` is the fixed identifier for a specific region for your account.

Each DB instance supports a database engine. Amazon RDS currently supports MySQL, MariaDB, PostgreSQL, Oracle, Microsoft SQL Server, and Amazon Aurora database engines.

When creating a DB instance, some database engines require that a database name be specified. A DB instance can host multiple databases, or a single Oracle database with multiple schemas. The database name value depends on the database engine:

- For the MySQL and MariaDB database engines, the database name is the name of a database hosted in your DB instance. Databases hosted by the same DB instance must have a unique name within that instance.
- For the Oracle database engine, database name is used to set the value of ORACLE_SID, which must be supplied when connecting to the Oracle RDS instance.
- For the Microsoft SQL Server database engine, database name is not a supported parameter.
- For the PostgreSQL database engine, the database name is the name of a database hosted in your DB instance. A database name is not required when creating a DB instance. Databases hosted by the same DB instance must have a unique name within that instance.

Amazon RDS creates a master user account for your DB instance as part of the creation process. This master user has permissions to create databases and to perform create, delete, select, update, and insert operations on tables the master user creates. You must set the master user password when you create a DB instance, but you can change it at any time using the Amazon AWS command line tools, Amazon RDS

API operations, or the AWS Management Console. You can also change the master user password and manage users using standard SQL commands.

Note

This guide covers non-Aurora Amazon RDS database engines. For information about using Amazon Aurora, see the *Amazon Aurora User Guide*.

DB Instance Classes

The DB instance class determines the computation and memory capacity of an Amazon RDS DB instance. The DB instance class you need depends on your processing power and memory requirements.

For more information about instance class pricing, see Amazon RDS Pricing.

Topics

DB Instance Class Types

Amazon RDS supports three types of instance classes: Standard, Memory Optimized, and Burstable Performance. For more information about Amazon EC2 instance types, see Instance Type in the Amazon EC2 documentation.

The following are the Standard DB instance classes available:

- **db.m5** – Latest-generation general-purpose instance classes that provide a balance of compute, memory, and network resources, and are a good choice for many applications. The db.m5 instance classes provide more computing capacity than the previous db.m4 instance classes. They are powered by the AWS Nitro System, a combination of dedicated hardware and lightweight hypervisor.
- **db.m4** – Current-generation general-purpose instance classes that provide more computing capacity than the previous db.m3 instance classes.
- **db.m3** – Previous-generation general-purpose instance classes that provide more computing capacity than the previous db.m1 instance classes.
- **db.m1** – Previous-generation general-purpose instance classes.

The following are the Memory Optimized DB instance classes available:

- **db.z1d** – Latest-generation instance classes optimized for memory-intensive applications. These offer both high compute capacity and a high memory footprint. High frequency z1d instances deliver a sustained all core frequency of up to 4.0 GHz.
- **db.x1e** – Latest-generation instance classes optimized for memory-intensive applications. These offer one of the lowest price per GiB of RAM among the DB instance classes and up to 3,904 GiB of DRAM-based instance memory. The db.x1e instance classes are available only in the following regions: US East (N. Virginia), US West (Oregon), Europe (Ireland), Asia Pacific (Tokyo), and Asia Pacific (Sydney).
- **db.x1** – Current-generation instance classes optimized for memory-intensive applications. These offer one of the lowest price per GiB of RAM among the DB instance classes and up to 1,952 GiB of DRAM-based instance memory.
- **db.r5** – Latest-generation instance classes optimized for memory-intensive applications. These offer improved networking and Amazon Elastic Block Store (Amazon EBS) performance. They are powered by the AWS Nitro System, a combination of dedicated hardware and lightweight hypervisor.
- **db.r4** – Current-generation instance classes optimized for memory-intensive applications. These offer improved networking and Amazon EBS performance.

- **db.r3** – Previous-generation instance classes that provide memory optimization. The db.r3 instances classes are not available in the Europe (Paris) region and the South America (São Paulo) region.
- **db.m2** – Previous-generation memory-optimized instance classes.

The following are the Burstable Performance DB instance classes available:

- **db.t3** – Latest-generation instance classes that provide a baseline performance level, with the ability to burst to full CPU usage. These instance classes provide more computing capacity than the previous db.t2 instance classes. They are powered by the AWS Nitro System, a combination of dedicated hardware and lightweight hypervisor.
- **db.t2** – Current-generation instance classes that provide a baseline performance level, with the ability to burst to full CPU usage.

Note
The DB instance classes that use the AWS Nitro System (db.m5, db.r5, db.t3) are throttled on combined read plus write workload.

Terminology for DB Instance Class Hardware Specifications

The following terminology is used to describe hardware specifications for DB instance classes:

- **vCPU** – The number of virtual central processing units (CPUs). A *virtual CPU* is a unit of capacity that you can use to compare DB instance classes. Instead of purchasing or leasing a particular processor to use for several months or years, you are renting capacity by the hour. Our goal is to make a consistent and specific amount of CPU capacity available, within the limits of the actual underlying hardware.
- **ECU** – The relative measure of the integer processing power of an Amazon EC2 instance. To make it easy for developers to compare CPU capacity between different instance classes, we have defined an Amazon EC2 Compute Unit. The amount of CPU that is allocated to a particular instance is expressed in terms of these EC2 Compute Units. One ECU currently provides CPU capacity equivalent to a 1.0–1.2 GHz 2007 Opteron or 2007 Xeon processor.
- **Memory (GiB)** – The RAM, in gibibytes, allocated to the DB instance. There is often a consistent ratio between memory and vCPU. As an example, take the db.r4 instance class, which has a memory to vCPU ratio similar to the db.r5 instance class. However, for most use cases the db.r5 instance class provides better, more consistent performance than the db.r4 instance class.
- **VPC Only** – The instance class is supported only for DB instances that are in a VPC based on the Amazon VPC service. In some cases, you might want to use an instance class that requires a VPC but your current DB instance isn't in a VPC. In these cases, start by moving your DB instance into a VPC. For more information, see Moving a DB Instance Not in a VPC into a VPC (p. 1447).
- **EBS-Optimized** – The DB instance uses an optimized configuration stack and provides additional, dedicated capacity for I/O. This optimization provides the best performance by minimizing contention between I/O and other traffic from your instance. For more information about Amazon EBS–optimized instances, see Amazon EBS–Optimized Instances in the *Amazon EC2 User Guide for Linux Instances.*
- **Max. Bandwidth (Mbps)** – The maximum bandwidth in megabits per second. Divide by 8 to get the expected throughput in megabytes per second.

  Important
  General Purpose SSD (gp2) volumes for Amazon RDS DB instances have a throughput limit of 250 MiB/s in most cases. However, the throughput limit can vary depending on volume size. For more information, see Amazon EBS Volume Types in the *Amazon EC2 User Guide for Linux Instances.* For information on estimating bandwidth for gp2 storage, see General Purpose SSD Storage (p. 29).
- **Network Performance** – The network speed relative to other DB instance classes.

Hardware Specifications for All Available DB Instance Classes

In the following table, you can find details about the Amazon RDS DB instance classes. For a more detailed explanation of the table column terminology, see Terminology for DB Instance Class Hardware Specifications (p. 8). For information about Amazon RDS DB engine support for each DB instance class, see Supported DB Engines for All Available DB Instance Classes (p. 12).

Instance Class	vCPU	ECU	Memory (GiB)	VPC Only	EBS Optimiz	Max. Bandwidth (Mbps)	Network Performance
db.m5 – Latest Generation Standard Instance Classes							
db.m5.24xlarge	96	345	384	Yes	Yes	19,000	25 Gbps
db.m5.16xlarge	64	262	256	Yes	Yes	13,600	20 Gbps
db.m5.12xlarge	48	173	192	Yes	Yes	9,500	10 Gbps
db.m5.8xlarge	32	131	128	Yes	Yes	6,800	10 Gbps
db.m5.4xlarge	16	61	64	Yes	Yes	4,750	Up to 10 Gbps
db.m5.2xlarge*	8	31	32	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.m5.xlarge*	4	15	16	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.m5.large*	2	10	8	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.m4 – Current Generation Standard Instance Classes							
db.m4.16xlarge	64	188	256	Yes	Yes	10,000	25 Gbps
db.m4.10xlarge	40	124.5	160	Yes	Yes	4,000	10 Gbps
db.m4.4xlarge	16	53.5	64	Yes	Yes	2,000	High
db.m4.2xlarge	8	25.5	32	Yes	Yes	1,000	High
db.m4.xlarge	4	13	16	Yes	Yes	750	High
db.m4.large	2	6.5	8	Yes	Yes	450	Moderate
db.m3 – Previous Generation Standard Instance Classes							
db.m3.2xlarge	8	26	30	No	Yes	1,000	High
db.m3.xlarge	4	13	15	No	Yes	500	High
db.m3.large	2	6.5	7.5	No	No	—	Moderate
db.m3.medium	1	3	3.75	No	No	—	Moderate
db.m1 – Previous Generation Standard Instance Classes							

Instance Class	vCPU	ECU	Memory (GiB)	VPC Only	EBS Optimiz	Max. Bandwidth (Mbps)	Network Performance
db.m1.xlarge	4	4	15	No	Yes	450	High
db.m1.large	2	2	7.5	No	Yes	450	Moderate
db.m1.medium	1	1	3.75	No	No	—	Moderate
db.m1.small	1	1	1.7	No	No	—	Very Low
db.z1d – Latest Generation Memory Optimized Instance Classes							
db.z1d.12xlarge	48	271	384	Yes	Yes	14,000	25 Gbps
db.z1d.6xlarge	24	134	192	Yes	Yes	7,000	10 Gbps
db.z1d.3xlarge	12	75	96	Yes	Yes	3,500	Up to 10 Gbps
db.z1d.2xlarge	8	53	64	Yes	Yes	2,333	Up to 10 Gbps
db.z1d.xlarge*	4	28	32	Yes	Yes	Up to 2,333	Up to 10 Gbps
db.z1d.large*	2	15	16	Yes	Yes	Up to 2,333	Up to 10 Gbps
db.x1e – Latest Generation Memory Optimized Instance Classes							
db.x1e.32xlarge	128	340	3,904	Yes	Yes	14,000	25 Gbps
db.x1e.16xlarge	64	179	1,952	Yes	Yes	7,000	10 Gbps
db.x1e.8xlarge	32	91	976	Yes	Yes	3,500	Up to 10 Gbps
db.x1e.4xlarge	16	47	488	Yes	Yes	1,750	Up to 10 Gbps
db.x1e.2xlarge	8	23	244	Yes	Yes	1,000	Up to 10 Gbps
db.x1e.xlarge	4	12	122	Yes	Yes	500	Up to 10 Gbps
db.x1 – Current Generation Memory Optimized Instance Classes							
db.x1.32xlarge	128	349	1,952	Yes	Yes	14,000	25 Gbps
db.x1.16xlarge	64	174.5	976	Yes	Yes	7,000	10 Gbps
db.r5 – Latest Generation Memory Optimized Instance Classes							
db.r5.24xlarge	96	347	768	Yes	Yes	19,000	25 Gbps
db.r5.16xlarge	64	264	512	Yes	Yes	13,600	20 Gbps
db.r5.12xlarge	48	173	384	Yes	Yes	9,500	10 Gbps

Instance Class	vCPU	ECU	Memory (GiB)	VPC Only	EBS Optimiz	Max. Bandwidth (Mbps)	Network Performance
db.r5.8xlarge	32	132	256	Yes	Yes	6,800	10 Gbps
db.r5.4xlarge	16	71	128	Yes	Yes	4,750	Up to 10 Gbps
db.r5.2xlarge*	8	38	64	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.r5.xlarge*	4	19	32	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.r5.large*	2	10	16	Yes	Yes	Up to 4,750	Up to 10 Gbps
db.r4 – Current Generation Memory Optimized Instance Classes							
db.r4.16xlarge	64	195	488	Yes	Yes	14,000	25 Gbps
db.r4.8xlarge	32	99	244	Yes	Yes	7,000	10 Gbps
db.r4.4xlarge	16	53	122	Yes	Yes	3,500	Up to 10 Gbps
db.r4.2xlarge	8	27	61	Yes	Yes	1,700	Up to 10 Gbps
db.r4.xlarge	4	13.5	30.5	Yes	Yes	850	Up to 10 Gbps
db.r4.large	2	7	15.25	Yes	Yes	425	Up to 10 Gbps
db.r3 – Previous Generation Memory Optimized Instance Classes							
db.r3.8xlarge	32	104	244	No	No	—	10 Gbps
db.r3.4xlarge	16	52	122	No	Yes	2,000	High
db.r3.2xlarge	8	26	61	No	Yes	1,000	High
db.r3.xlarge	4	13	30.5	No	Yes	500	Moderate
db.r3.large	2	6.5	15.25	No	No	—	Moderate
db.m2 – Previous Generation Memory Optimized Instance Classes							
db.m2.4xlarge	8	26	68.4	No	Yes	1,000	High
db.m2.2xlarge	4	13	34.2	No	Yes	500	Moderate
db.m2.xlarge	2	6.5	17.1	No	No	—	Moderate
db.t3 – Latest Generation Burstable Performance Instance Classes							
db.t3.2xlarge*	8	Variable	32	Yes	Yes	Up to 2,048	Up to 5 Gbps

Instance Class	vCPU	ECU	Memory (GiB)	VPC Only	EBS Optimiz	Max. Bandwidth (Mbps)	Network Performance
db.t3.xlarge*	4	Variable	16	Yes	Yes	Up to 2,048	Up to 5 Gbps
db.t3.large*	2	Variable	8	Yes	Yes	Up to 2,048	Up to 5 Gbps
db.t3.medium*	2	Variable	4	Yes	Yes	Up to 1,536	Up to 5 Gbps
db.t3.small*	2	Variable	2	Yes	Yes	Up to 1,536	Up to 5 Gbps
db.t3.micro*	2	Variable	1	Yes	Yes	Up to 1,536	Up to 5 Gbps
db.t2 – Current Generation Burstable Performance Instance Classes							
db.t2.2xlarge	8	Variable	32	Yes	No	—	Moderate
db.t2.xlarge	4	Variable	16	Yes	No	—	Moderate
db.t2.large	2	Variable	8	Yes	No	—	Moderate
db.t2.medium	2	Variable	4	Yes	No	—	Moderate
db.t2.small	1	Variable	2	Yes	No	—	Low
db.t2.micro	1	Variable	1	Yes	No	—	Low

* These DB instance classes can support maximum performance for 30 minutes at least once every 24 hours. For more information on baseline performance of these instance types, see Amazon EBS–Optimized Instances in the *Amazon EC2 User Guide for Linux Instances*.

Supported DB Engines for All Available DB Instance Classes

In the following table, you can find details about supported Amazon RDS DB instance classes for each Amazon RDS DB engine. For DB instance class specifications, see Hardware Specifications for All Available DB Instance Classes (p. 9).

The following are DB engine considerations for DB instance classes:

- **Microsoft SQL Server** – Instance class support varies according to the version and edition of SQL Server. For instance class support by version and edition, see DB Instance Class Support for Microsoft SQL Server (p. 546).
- **Oracle** – Instance class support varies according to the version and edition of Oracle. For instance class support by version and edition, see DB Instance Class Support for Oracle (p. 850).
- **PostgreSQL** – The db.m5, db.r5, and db.t3 DB instance classes are supported for the following Amazon RDS PostgreSQL versions:
  - PostgreSQL 9.6.9 and higher 9.6 versions
  - PostgreSQL 10.4 and higher 10 versions
  - PostgreSQL 11.1 and higher 11 versions

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.m5 – Latest Generation Standard Instance Classes					
db.m5.24xlarge	Yes	Yes	Yes	Yes	Yes
db.m5.16xlarge	No	Yes	No	Yes	PostgreSQL 11.6 & higher, 10.11 & higher, 9.6.16 & higher, 9.5.20 & higher
db.m5.12xlarge	Yes	Yes	Yes	Yes	Yes
db.m5.8xlarge	No	Yes	No	Yes	PostgreSQL 11.6 & higher, 10.11 & higher, 9.6.16 & higher, 9.5.20 & higher
db.m5.4xlarge	Yes	Yes	Yes	Yes	Yes
db.m5.2xlarge	Yes	Yes	Yes	Yes	Yes
db.m5.xlarge	Yes	Yes	Yes	Yes	Yes
db.m5.large	Yes	Yes	Yes	Yes	Yes
db.m4 – Current Generation Standard Instance Classes					
db.m4.16xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.m4.10xlarge	Yes	Yes	Yes	Yes	Yes
db.m4.4xlarge	Yes	Yes	Yes	Yes	Yes
db.m4.2xlarge	Yes	Yes	Yes	Yes	Yes
db.m4.xlarge	Yes	Yes	Yes	Yes	Yes
db.m4.large	Yes	Yes	Yes	Yes	Yes
db.m3 – Previous Generation Standard Instance Classes					
db.m3.2xlarge	No	Yes	Yes	Deprecated	Yes
db.m3.xlarge	No	Yes	Yes	Deprecated	Yes

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.m3.large	No	Yes	Yes	Deprecated	Yes
db.m3.medium	No	Yes	Yes	Deprecated	Yes
db.m1 – Previous Generation Standard Instance Classes					
db.m1.xlarge	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.m1.large	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.m1.medium	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.m1.small	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.z1d – Latest Generation Memory Optimized Instance Classes					
db.z1d.12xlarge	No	No	No	Yes	No
db.z1d.6xlarge	No	No	No	Yes	No
db.z1d.3xlarge	No	Yes	No	Yes	No
db.z1d.2xlarge	No	Yes	No	Yes	No
db.z1d.xlarge	No	Yes	No	Yes	No
db.z1d.large	No	Yes	No	Yes	No
db.x1e – Latest Generation Memory Optimized Instance Classes					
db.x1e.32xlarge	No	Yes	No	Yes	No
db.x1e.16xlarge	No	Yes	No	Yes	No
db.x1e.8xlarge	No	Yes	No	Yes	No
db.x1e.4xlarge	No	Yes	No	Yes	No
db.x1e.2xlarge	No	Yes	No	Yes	No
db.x1e.xlarge	No	Yes	No	Yes	No
db.x1 – Current Generation Memory Optimized Instance Classes					
db.x1.32xlarge	No	Yes	No	Yes	No
db.x1.16xlarge	No	Yes	No	Yes	No
db.r5 – Latest Generation Memory Optimized Instance Classes					
db.r5.24xlarge	Yes	Yes	Yes	Yes	Yes

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.r5.16xlarge	No	Yes	No	Yes	PostgreSQL 11.6 & higher, 10.11 & higher, 9.6.16 & higher, 9.5.20 & higher
db.r5.12xlarge	Yes	Yes	Yes	Yes	Yes
db.r5.8xlarge	No	Yes	No	Yes	PostgreSQL 11.6 & higher, 10.11 & higher, 9.6.16 & higher, 9.5.20 & higher
db.r5.4xlarge	Yes	Yes	Yes	Yes	Yes
db.r5.2xlarge	Yes	Yes	Yes	Yes	Yes
db.r5.xlarge	Yes	Yes	Yes	Yes	Yes
db.r5.large	Yes	Yes	Yes	Yes	Yes
db.r4 – Current Generation Memory Optimized Instance Classes					
db.r4.16xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.r4.8xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.r4.4xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.r4.2xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.r4.xlarge	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes
db.r4.large	Yes	Yes	MySQL 8.0, 5.7, 5.6	Yes	Yes

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.r3 – Previous Generation Memory Optimized Instance Classes					
db.r3.8xlarge	Yes	Yes	Yes	Deprecated	Yes
db.r3.4xlarge	Yes	Yes	Yes	Deprecated	Yes
db.r3.2xlarge	Yes	Yes	Yes	Deprecated	Yes
db.r3.xlarge	Yes	Yes	Yes	Deprecated	Yes
db.r3.large	Yes	Yes	Yes	Deprecated	Yes
db.m2 – Previous Generation Memory Optimized Instance Classes					
db.m2.4xlarge	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.m2.2xlarge	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.m2.xlarge	No	Yes	Deprecated	Deprecated	PostgreSQL 9.4
db.t3 – Latest Generation Burstable Performance Instance Classes					
db.t3.2xlarge	Yes	Yes	Yes	Yes	Yes
db.t3.xlarge	Yes	Yes	Yes	Yes	Yes
db.t3.large	Yes	Yes	Yes	Yes	Yes
db.t3.medium	Yes	Yes	Yes	Yes	Yes
db.t3.small	Yes	Yes	Yes	Yes	Yes
db.t3.micro	Yes	No	Yes	Yes	Yes
db.t2 – Current Generation Burstable Performance Instance Classes					
db.t2.2xlarge	Yes	No	MySQL 8.0, 5.7, 5.6	Deprecated	PostgreSQL 9.6, 9.5, 9.4
db.t2.xlarge	Yes	No	MySQL 8.0, 5.7, 5.6	Deprecated	PostgreSQL 9.6, 9.5, 9.4
db.t2.large	Yes	Yes	Yes	Deprecated	Yes
db.t2.medium	Yes	Yes	Yes	Deprecated	Yes
db.t2.small	Yes	Yes	Yes	Deprecated	Yes
db.t2.micro	Yes	Yes	Yes	Deprecated	Yes

Changing Your DB Instance Class

You can change the CPU and memory available to a DB instance by changing its DB instance class. To change the DB instance class, modify your DB instance by following the instructions in Modifying an Amazon RDS DB Instance (p. 220).

Some instance classes require that your DB instance is in a VPC. If your current DB instance isn't in a VPC, and you want to use an instance class that requires one, first move your DB instance into a VPC. For more information, see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

Configuring the Processor for a DB Instance Class

Amazon RDS DB instance classes support Intel Hyper-Threading Technology, which enables multiple threads to run concurrently on a single Intel Xeon CPU core. Each thread is represented as a virtual CPU (vCPU) on the DB instance. A DB instance has a default number of CPU cores, which varies according to DB instance type. For example, a db.m4.xlarge DB instance type has two CPU cores and two threads per core by default—four vCPUs in total.

> **Note**
> Each vCPU is a hyperthread of an Intel Xeon CPU core.

Topics

Overview of Configuring the Processor

In most cases, you can find a DB instance class that has a combination of memory and number of vCPUs to suit your workloads. However, you can also specify the following processor features to optimize your DB instance for specific workloads or business needs:

- **Number of CPU cores** – You can customize the number of CPU cores for the DB instance. You might do this to potentially optimize the licensing costs of your software with a DB instance that has sufficient amounts of RAM for memory-intensive workloads but fewer CPU cores.
- **Threads per core** – You can disable Intel Hyper-Threading Technology by specifying a single thread per CPU core. You might do this for certain workloads, such as high-performance computing (HPC) workloads.

You can control the number of CPU cores and threads for each core separately. You can set one or both in a request. After a setting is associated with a DB instance, the setting persists until you change it.

The processor settings for a DB instance are associated with snapshots of the DB instance. When a snapshot is restored, its restored DB instance uses the processor feature settings used when the snapshot was taken.

If you modify the DB instance class for a DB instance with nondefault processor settings, either specify default processor settings or explicitly specify processor settings at modification. This requirement ensures that you are aware of the third-party licensing costs that might be incurred when you modify the DB instance.

There is no additional or reduced charge for specifying processor features on an Amazon RDS DB instance. You're charged the same as for DB instances that are launched with default CPU configurations.

CPU Cores and Threads Per CPU Core Per DB Instance Class

In the following table, you can find the DB instance classes that support setting a number of CPU cores and CPU threads per core. You can also find the default value and the valid values for the number of CPU cores and CPU threads per core for each DB instance class.

DB Instance Class	Default vCPUs	Default CPU Cores	Default Threads per Core	Valid Number of CPU Cores	Valid Number of Threads per Core
db.m5.large	2	1	2	1	1, 2
db.m5.xlarge	4	2	2	2	1, 2
db.m5.2xlarge	8	4	2	2, 4	1, 2
db.m5.4xlarge	16	8	2	2, 4, 6, 8	1, 2
db.m5.8xlarge	32	16	2	2, 4, 6, 8, 10, 12, 14, 16	1, 2
db.m5.12xlarge	48	24	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24	1, 2
db.m5.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.m5.24xlarge	96	48	2	4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48	1, 2
db.m4.10xlarge	40	20	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20	1, 2
db.m4.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.r3.large	2	1	2	1	1, 2
db.r3.xlarge	4	2	2	1, 2	1, 2
db.r3.2xlarge	8	4	2	1, 2, 3, 4	1, 2
db.r3.4xlarge	16	8	2	1, 2, 3, 4, 5, 6, 7, 8	1, 2
db.r3.8xlarge	32	16	2	2, 4, 6, 8, 10, 12, 14, 16	1, 2
db.r5.large	2	1	2	1	1, 2

DB Instance Class	Default vCPUs	Default CPU Cores	Default Threads per Core	Valid Number of CPU Cores	Valid Number of Threads per Core
db.r5.xlarge	4	2	2	2	1, 2
db.r5.2xlarge	8	4	2	2, 4	1, 2
db.r5.4xlarge	16	8	2	2, 4, 6, 8	1, 2
db.r5.8xlarge	32	16	2	2, 4, 6, 8, 10, 12, 14, 16	1, 2
db.r5.12xlarge	48	24	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24	1, 2
db.r5.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.r5.24xlarge	96	48	2	4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48	1, 2
db.r4.large	2	1	2	1	1, 2
db.r4.xlarge	4	2	2	1, 2	1, 2
db.r4.2xlarge	8	4	2	1, 2, 3, 4	1, 2
db.r4.4xlarge	16	8	2	1, 2, 3, 4, 5, 6, 7, 8	1, 2
db.r4.8xlarge	32	16	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2
db.r4.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.x1.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.x1.32xlarge	128	64	2	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64	1, 2
db.x1e.xlarge	4	2	2	1, 2	1, 2

DB Instance Class	Default vCPUs	Default CPU Cores	Default Threads per Core	Valid Number of CPU Cores	Valid Number of Threads per Core
db.x1e.2xlarge	8	4	2	1, 2, 3, 4	1, 2
db.x1e.4xlarge	16	8	2	1, 2, 3, 4, 5, 6, 7, 8	1, 2
db.x1e.8xlarge	32	16	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	1, 2
db.x1e.16xlarge	64	32	2	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32	1, 2
db.x1e.32xlarge	128	64	2	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64	1, 2
db.z1d.large	2	1	2	1	1, 2
db.z1d.xlarge	4	2	2	2	1, 2
db.z1d.2xlarge	8	4	2	2, 4	1, 2
db.z1d.3xlarge	12	6	2	2, 4, 6	1, 2
db.z1d.6xlarge	24	12	2	2, 4, 6, 8, 10, 12	1, 2
db.z1d.12xlarge	48	24	2	4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24	1, 2

Note
Currently, you can configure the number of CPU cores and threads per core only for Oracle DB instances. For information about the DB instance classes supported by different Oracle database editions, see DB Instance Class Support for Oracle (p. 850).
For Oracle DB instances, configuring the number of CPU cores and threads per core is only supported with the Bring Your Own License (BYOL) licensing option. For more information about Oracle licensing options, see Oracle Licensing (p. 847).
You can use AWS CloudTrail to monitor and audit changes to the process configuration of Amazon RDS for Oracle DB instances. For more information about using CloudTrail, see Logging Amazon RDS API Calls with AWS CloudTrail (p. 487).

Setting the CPU Cores and Threads per CPU Core for a DB Instance Class

You can configure the number of CPU cores and threads per core for the DB instance class when you perform the following operations:

- Creating an Amazon RDS DB Instance (p. 136)

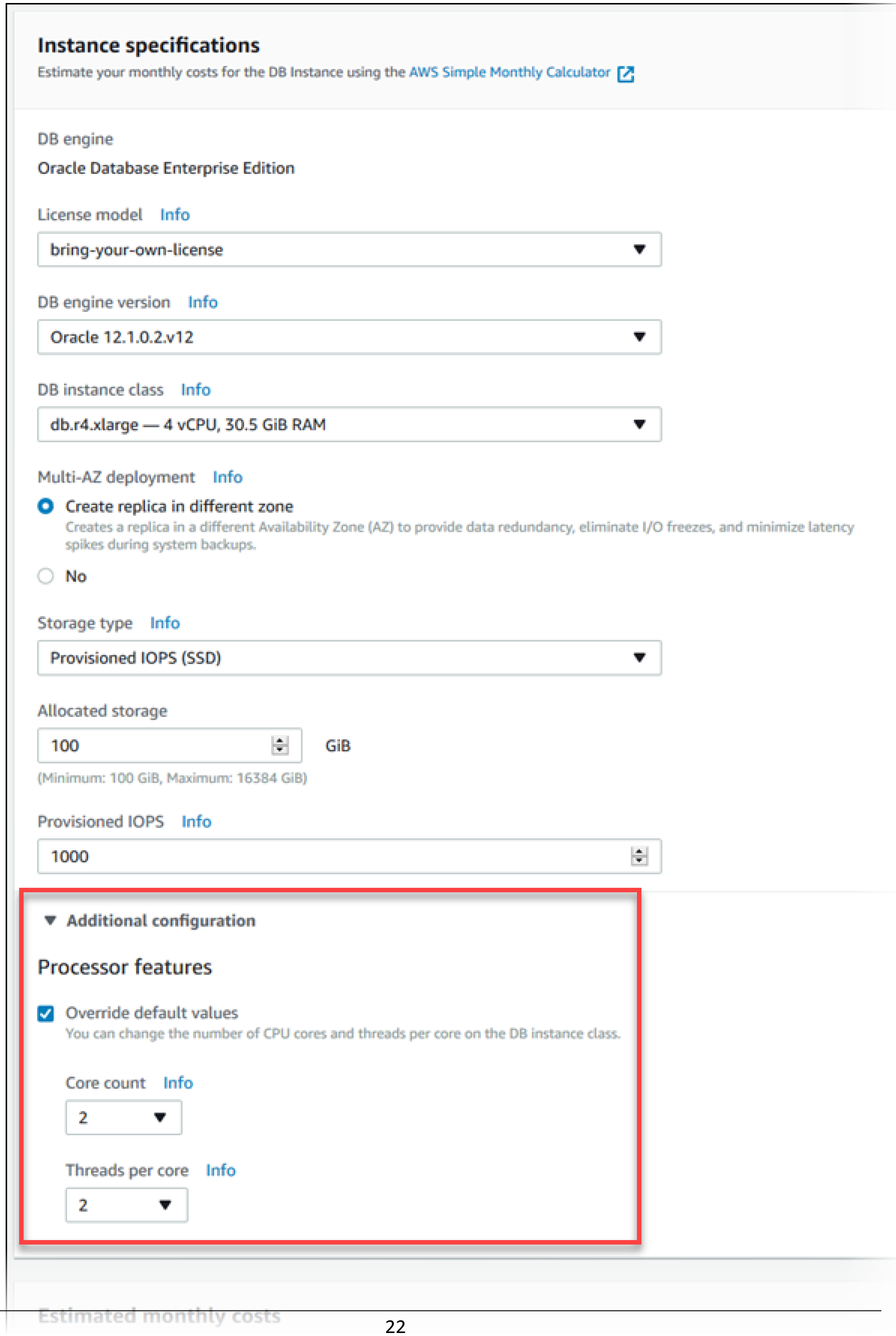
- Modifying an Amazon RDS DB Instance (p. 220)
- Restoring from a DB Snapshot (p. 303)
- Restoring a DB Instance to a Specified Time (p. 336)

Note
When you modify a DB instance to configure the number of CPU cores or threads per core, there is a brief DB instance outage.

You can set the CPU cores and the threads per CPU core for a DB instance class using the AWS Management Console, the AWS CLI, or the RDS API.

Console

When you are creating, modifying, or restoring a DB instance, you set the DB instance class in the AWS Management Console. The **Instance specifications** section shows options for the processor. The following image shows the processor features options.

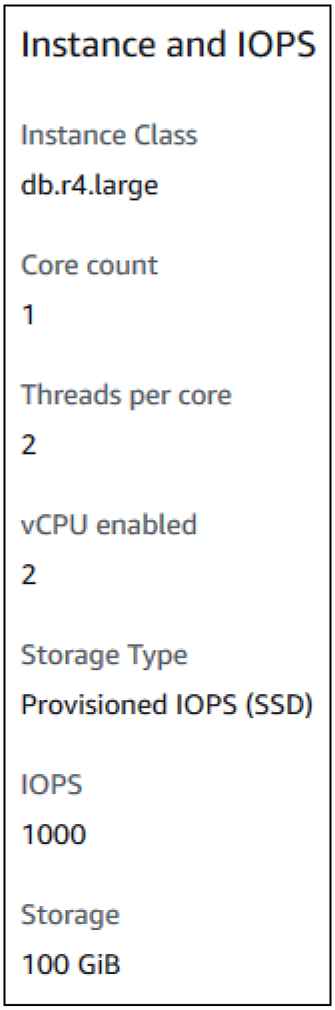

Instance specifications
Estimate your monthly costs for the DB Instance using the AWS Simple Monthly Calculator
DB engine
Oracle Database Enterprise Edition
License model Info
bring-your-own-license
DB engine version Info
Oracle 12.1.0.2.v12
DB instance class Info
db.r4.xlarge — 4 vCPU, 30.5 GiB RAM
Multi-AZ deployment Info
Create replica in different zone
Creates a replica in a different Availability Zone (AZ) to provide data redundancy, eliminate I/O freezes, and minimize latency spikes during system backups.
No
Storage type Info
Provisioned IOPS (SSD)
Allocated storage
100
GiB
(Minimum: 100 GiB, Maximum: 16384 GiB)
Provisioned IOPS Info
1000
Additional configuration
Processor features
Override default values
You can change the number of CPU cores and threads per core on the DB instance class.
Core count Info
2
Threads per core Info
2
Estimated monthly costs

Set the following options to the appropriate values for your DB instance class under **Processor features**:

- **Core count –** Set the number of CPU cores using this option. The value must be equal to or less than the maximum number of CPU cores for the DB instance class.
- **Threads per core** – Specify **2** to enable multiple threads per core, or specify **1** to disable multiple threads per core.

When you modify or restore a DB instance, you can also set the CPU cores and the threads per CPU core to the defaults for the instance class.

When you view the details for a DB instance in the console, you can view the processor information for its DB instance class on the **Configuration** tab. The following image shows a DB instance class with one CPU core and multiple threads per core enabled.



For Oracle DB instances, the processor information only appears for Bring Your Own License (BYOL) DB instances.

AWS CLI

You can set the processor features for a DB instance when you run one of the following AWS CLI commands:

- create-db-instance

- modify-db-instance
- restore-db-instance-from-db-snapshot
- restore-db-instance-from-s3
- restore-db-instance-to-point-in-time

To configure the processor of a DB instance class for a DB instance by using the AWS CLI, include the `--processor-features` option in the command. Specify the number of CPU cores with the `coreCount` feature name, and specify whether multiple threads per core are enabled with the `threadsPerCore` feature name.

The option has the following syntax.

```
--processor-features "Name=coreCount,Value=<value>" "Name=threadsPerCore,Value=<value>"
```

The following are examples that configure the processor:

Examples

Setting the Number of CPU Cores for a DB Instance

Example

The following example modifies `mydbinstance` by setting the number of CPU cores to 4. The changes are applied immediately by using `--apply-immediately`. If you want to apply the changes during the next scheduled maintenance window, omit the `--apply-immediately` option.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --processor-features "Name=coreCount,Value=4" \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --processor-features "Name=coreCount,Value=4" ^
    --apply-immediately
```

Setting the Number of CPU Cores and Disabling Multiple Threads for a DB Instance

Example

The following example modifies `mydbinstance` by setting the number of CPU cores to `4` and disabling multiple threads per core. The changes are applied immediately by using `--apply-immediately`. If you want to apply the changes during the next scheduled maintenance window, omit the `--apply-immediately` option.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --processor-features "Name=coreCount,Value=4" "Name=threadsPerCore,Value=1" \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --processor-features "Name=coreCount,Value=4" "Name=threadsPerCore,Value=1" ^
    --apply-immediately
```

Viewing the Valid Processor Values for a DB Instance Class

Example

You can view the valid processor values for a particular DB instance class by running the describe-orderable-db-instance-options command and specifying the instance class for the `--db-instance-class` option. For example, the output for the following command shows the processor options for the db.r3.large instance class.

```
aws rds describe-orderable-db-instance-options --engine oracle-ee --db-instance-class
 db.r3.large
```

Following is sample output for the command in JSON format.

```
    {
                "SupportsIops": true,
                "MaxIopsPerGib": 50.0,
                "LicenseModel": "bring-your-own-license",
                "DBInstanceClass": "db.r3.large",
                "SupportsIAMDatabaseAuthentication": false,
                "MinStorageSize": 100,
                "AvailabilityZones": [
                    {
                        "Name": "us-west-2a"
                    },
                    {
                        "Name": "us-west-2b"
                    },
                    {
                        "Name": "us-west-2c"
                    }
                ],
                "EngineVersion": "12.1.0.2.v2",
                "MaxStorageSize": 32768,
                "MinIopsPerGib": 1.0,
                "MaxIopsPerDbInstance": 40000,
                "ReadReplicaCapable": false,
                "AvailableProcessorFeatures": [
                    {
                        "Name": "coreCount",
                        "DefaultValue": "1",
                        "AllowedValues": "1"
                    },
```

```
                    {
                        "Name": "threadsPerCore",
                        "DefaultValue": "2",
                        "AllowedValues": "1,2"
                    }
                ],
                "SupportsEnhancedMonitoring": true,
                "SupportsPerformanceInsights": false,
                "MinIopsPerDbInstance": 1000,
                "StorageType": "io1",
                "Vpc": false,
                "SupportsStorageEncryption": true,
                "Engine": "oracle-ee",
                "MultiAZCapable": true
    }
```

In addition, you can run the following commands for DB instance class processor information:

- describe-db-instances – Shows the processor information for the specified DB instance.
- describe-db-snapshots – Shows the processor information for the specified DB snapshot.
- describe-valid-db-instance-modifications – Shows the valid modifications to the processor for the specified DB instance.

Returning to Default Processor Settings for a DB Instance

Example

The following example modifies `mydbinstance` by returning its DB instance class to the default processor values for it. The changes are applied immediately by using `--apply-immediately`. If you want to apply the changes during the next scheduled maintenance window, omit the `--apply-immediately` option.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --use-default-processor-features \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --use-default-processor-features ^
    --apply-immediately
```

Returning to the Default Number of CPU Cores for a DB Instance

Example

The following example modifies `mydbinstance` by returning its DB instance class to the default number of CPU cores for it. The threads per core setting isn't changed. The changes are applied immediately by using `--apply-immediately`. If you want to apply the changes during the next scheduled maintenance window, omit the `--apply-immediately` option.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --processor-features "Name=coreCount,Value=DEFAULT" \
```

```
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --processor-features "Name=coreCount,Value=DEFAULT" ^
    --apply-immediately
```

Returning to the Default Number of Threads Per Core for a DB Instance

Example

The following example modifies `mydbinstance` by returning its DB instance class to the default number of threads per core for it. The number of CPU cores setting isn't changed. The changes are applied immediately by using `--apply-immediately`. If you want to apply the changes during the next scheduled maintenance window, omit the `--apply-immediately` option.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --processor-features "Name=threadsPerCore,Value=DEFAULT" \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --processor-features "Name=threadsPerCore,Value=DEFAULT" ^
    --apply-immediately
```

RDS API

You can set the processor features for a DB instance when you call one of the following Amazon RDS API operations:

- CreateDBInstance
- ModifyDBInstance
- RestoreDBInstanceFromDBSnapshot
- RestoreDBInstanceFromS3
- RestoreDBInstanceToPointInTime

To configure the processor features of a DB instance class for a DB instance by using the Amazon RDS API, include the `ProcessFeatures` parameter in the call.

The parameter has the following syntax.

```
ProcessFeatures "Name=coreCount,Value=<value>" "Name=threadsPerCore,Value=<value>"
```

Specify the number of CPU cores with the `coreCount` feature name, and specify whether multiple threads per core are enabled with the `threadsPerCore` feature name.

You can view the valid processor values for a particular instance class by running the DescribeOrderableDBInstanceOptions operation and specifying the instance class for the `DBInstanceClass` parameter.

In addition, you can use the following actions for DB instance class processor information:

- DescribeDBInstances – Shows the processor information for the specified DB instance.
- DescribeDBSnapshots – Shows the processor information for the specified DB snapshot.
- DescribeValidDBInstanceModifications – Shows the valid modifications to the processor for the specified DB instance.

Amazon RDS DB Instance Storage

DB instances for Amazon RDS for MySQL, MariaDB, PostgreSQL, Oracle, and Microsoft SQL Server use Amazon Elastic Block Store (Amazon EBS) volumes for database and log storage. Depending on the amount of storage requested, Amazon RDS automatically stripes across multiple Amazon EBS volumes to enhance performance.

Amazon RDS Storage Types

Amazon RDS provides three storage types: General Purpose SSD (also known as gp2), Provisioned IOPS SSD (also known as io1), and magnetic. They differ in performance characteristics and price, which means that you can tailor your storage performance and cost to the needs of your database workload. You can create MySQL, MariaDB, Oracle, and PostgreSQL RDS DB instances with up to 64 TiB of storage. You can create SQL Server RDS DB instances with up to 16 TiB of storage. For this amount of storage, use the Provisioned IOPS SSD and General Purpose SSD storage types.

The following list briefly describes the three storage types:

- **General Purpose SSD** – General Purpose SSD volumes offer cost-effective storage that is ideal for a broad range of workloads. These volumes deliver single-digit millisecond latencies and the ability to burst to 3,000 IOPS for extended periods of time. Baseline performance for these volumes is determined by the volume's size.

  For more information about General Purpose SSD storage, including the storage size ranges, see General Purpose SSD Storage (p. 29).
- **Provisioned IOPS** – Provisioned IOPS storage is designed to meet the needs of I/O-intensive workloads, particularly database workloads, that require low I/O latency and consistent I/O throughput.

  For more information about provisioned IOPS storage, including the storage size ranges, see Provisioned IOPS SSD Storage (p. 31).
- **Magnetic** – Amazon RDS also supports magnetic storage for backward compatibility. We recommend that you use General Purpose SSD or Provisioned IOPS for any new storage needs. The maximum amount of storage allowed for DB instances on magnetic storage is less than that of the other storage types. For more information, see Magnetic Storage (p. 32).

Several factors can affect the performance of Amazon EBS volumes, such as instance configuration, I/O characteristics, and workload demand. For more information about getting the most out of your Provisioned IOPS volumes, see Amazon EBS Volume Performance.

General Purpose SSD Storage

General Purpose SSD storage offers cost-effective storage that is acceptable for most database workloads. The following are the storage size ranges for General Purpose SSD DB instances:

- MariaDB, MySQL, Oracle, and PostgreSQL database instances: 20 GiB–64 TiB
- SQL Server for Enterprise, Standard, Web, and Express editions: 20 GiB–16 TiB

Baseline I/O performance for General Purpose SSD storage is 3 IOPS for each GiB, with a minimum of 100 IOPS. This relationship means that larger volumes have better performance. For example, baseline performance for a 100-GiB volume is 300 IOPS. Baseline performance for a 1-TiB volume is 3,000 IOPS. And baseline performance for a 5.34-TiB volume is 16,000 IOPS.

Volumes below 1 TiB in size also have ability to burst to 3,000 IOPS for extended periods of time. Burst is not relevant for volumes above 1 TiB. Instance I/O credit balance determines burst performance. For more information about instance I/O credits see, I/O Credits and Burst Performance (p. 30).

Many workloads never deplete the burst balance, making General Purpose SSD an ideal storage choice for many workloads. However, some workloads can exhaust the 3,000 IOPS burst storage credit balance, so you should plan your storage capacity to meet the needs of your workloads.

I/O Credits and Burst Performance

General Purpose SSD storage performance is governed by volume size, which dictates the base performance level of the volume and how quickly it accumulates I/O credits. Larger volumes have higher base performance levels and accumulate I/O credits faster. *I/O credits* represent the available bandwidth that your General Purpose SSD storage can use to burst large amounts of I/O when more than the base level of performance is needed. The more I/O credits your storage has for I/O, the more time it can burst beyond its base performance level and the better it performs when your workload requires more performance.

When using General Purpose SSD storage, your DB instance receives an initial I/O credit balance of 5.4 million I/O credits. This initial credit balance is enough to sustain a burst performance of 3,000 IOPS for 30 minutes. This balance is designed to provide a fast initial boot cycle for boot volumes and to provide a good bootstrapping experience for other applications. Volumes earn I/O credits at the baseline performance rate of 3 IOPS for each GiB of volume size. For example, a 100-GiB SSD volume has a baseline performance of 300 IOPS.

When your storage requires more than the base performance I/O level, it uses I/O credits in the I/O credit balance to burst to the required performance level. Such a burst goes to a maximum of 3,000 IOPS. Storage larger than 1,000 GiB has a base performance that is equal or greater than the maximum burst performance. When your storage uses fewer I/O credits than it earns in a second, unused I/O credits are added to the I/O credit balance. The maximum I/O credit balance for a DB instance using General Purpose SSD storage is equal to the initial I/O credit balance (5.4 million I/O credits).

Suppose that your storage uses all of its I/O credit balance. If so, its maximum performance remains at the base performance level until I/O demand drops below the base level and unused I/O credits are added to the I/O credit balance. (The *base performance level* is the rate at which your storage earns I/O credits.) The more storage, the greater the base performance is and the faster it replenishes the I/O credit balance.

Note
Storage conversions between magnetic storage and General Purpose SSD storage can potentially deplete your I/O credit balance, resulting in longer conversion times. For more information about scaling storage, see Working with Storage for Amazon RDS DB Instances (p. 278).

The following table lists several storage sizes. For each storage size, it lists the associated base performance of the storage, which is also the rate at which it accumulates I/O credits. The table also lists the burst duration at the 3,000 IOPS maximum, when starting with a full I/O credit balance. In addition, the table lists the time in seconds that the storage takes to refill an empty I/O credit balance.

Note
The IOPS figure reaches its maximum value at a volume storage size of 5,334 GiB.

Storage size (GiB)	Base Performance (IOPS)	Maximum Burst Duration at 3,000 IOPS (Seconds)	Seconds to Fill Empty I/O Credit Balance
1	100	1,862	54,000
100	300	2,000	18,000

Storage size (GiB)	Base Performance (IOPS)	Maximum Burst Duration at 3,000 IOPS (Seconds)	Seconds to Fill Empty I/O Credit Balance
250	750	2,400	7,200
500	1,500	3,600	3,600
750	2,250	7,200	2,400
1,000	3,000	Infinite	N/A
5,334	16,000	N/A	N/A

The burst duration of your storage depends on the size of the storage, the burst IOPS required, and the I/O credit balance when the burst begins. This relationship is shown in the equation following.

```
                              (Credit balance)
Burst duration =  ------------------------------------
                  (Burst IOPS) - 3(Storage size in GiB)
```

You might notice that your storage performance is frequently limited to the base level due to an empty I/O credit balance. If so, consider allocating more General Purpose SSD storage with a higher base performance level. Alternatively, you can switch to Provisioned IOPS storage for workloads that require sustained IOPS performance.

For workloads with steady state I/O requirements, provisioning less than 100 GiB of General Purpose SSD storage might result in higher latencies if you exhaust your I/O credit balance.

Note
In general, most workloads never exceed the I/O credit balance.

For a more detailed description of how baseline performance and I/O credit balance affect performance see Understanding Burst vs. Baseline Performance with Amazon RDS and GP2.

Provisioned IOPS SSD Storage

For a production application that requires fast and consistent I/O performance, we recommend Provisioned IOPS (input/output operations per second) storage. Provisioned IOPS storage is a storage type that delivers predictable performance, and consistently low latency. Provisioned IOPS storage is optimized for online transaction processing (OLTP) workloads that have consistent performance requirements. Provisioned IOPS helps performance tuning of these workloads.

When you create a DB instance, you specify an IOPS rate and the size of the volume. Amazon RDS provides that IOPS rate for the DB instance until you change it.

Note
Your database workload might not be able to achieve 100 percent of the IOPS that you have provisioned.

The following table shows the range of Provisioned IOPS and storage size range for each database engine.

Database Engine	Range of Provisioned IOPS	Range of Storage
MariaDB	1,000–80,000 IOPS	100 GiB–64 TiB

Database Engine	Range of Provisioned IOPS	Range of Storage
SQL Server Enterprise, Standard, and Web Editions	1,000–64,000 IOPS*	20 GiB–16 TiB
SQL Server Express Edition	1,000–64,000 IOPS*	100 GiB–16 TiB
MySQL	1,000–80,000 IOPS	100 GiB–64 TiB
Oracle	1,000–80,000 IOPS	100 GiB–64 TiB
PostgreSQL	1,000–80,000 IOPS	100 GiB–64 TiB

* Maximum IOPS of 64,000 is guaranteed only on Nitro-based instances that are on the m5, r5, and z1d instance types. Other instance families guarantee performance up to 32,000 IOPS. For more information on DB instance IOPS performance, see Amazon EBS–Optimized Instances.

Combining Provisioned IOPS Storage with Multi-AZ deployments or Read Replicas

For production OLTP use cases, we recommend that you use Multi-AZ deployments for enhanced fault tolerance with Provisioned IOPS storage for fast and predictable performance.

You can also use Provisioned IOPS SSD storage with read replicas for MySQL, MariaDB or PostgreSQL. The type of storage for a read replica is independent of that on the master DB instance. For example, you might use General Purpose SSD for read replicas with a master DB instance that uses Provisioned IOPS SSD storage to reduce costs. However, your read replica's performance in this case might differ from that of a configuration where both the master DB instance and the read replicas use Provisioned IOPS SSD storage.

Provisioned IOPS Storage Costs

With Provisioned IOPS storage, you are charged for the provisioned resources whether or not you use them in a given month.

For more information about pricing, see Amazon RDS Pricing.

Getting the Best Performance from Amazon RDS Provisioned IOPS SSD Storage

If your workload is I/O constrained, using Provisioned IOPS SSD storage can increase the number of I/O requests that the system can process concurrently. Increased concurrency allows for decreased latency because I/O requests spend less time in a queue. Decreased latency allows for faster database commits, which improves response time and allows for higher database throughput.

Provisioned IOPS SSD storage provides a way to reserve I/O capacity by specifying IOPS. However, as with any other system capacity attribute, its maximum throughput under load is constrained by the resource that is consumed first. That resource might be network bandwidth, CPU, memory, or database internal resources.

Magnetic Storage

Amazon RDS also supports magnetic storage for backward compatibility. We recommend that you use General Purpose SSD or Provisioned IOPS SSD for any new storage needs. The following are some limitations for magnetic storage:

- Doesn't allow you to scale storage when using the SQL Server database engine.
- Doesn't support storage autoscaling.
- Doesn't support elastic volumes.
- Limited to a maximum size of 3 TiB.
- Limited to a maximum of 1,000 IOPS.

Monitoring Storage Performance

Amazon RDS provides several metrics that you can use to determine how your DB instance is performing. You can view the metrics on the summary page for your instance in Amazon RDS Management Console. You can also use Amazon CloudWatch to monitor these metrics. For more information, see Viewing DB Instance Metrics (p. 356). Enhanced Monitoring provides more detailed I/O metrics; for more information, see Enhanced Monitoring (p. 362).

The following metrics are useful for monitoring storage for your DB instance:

- **IOPS** – The number of I/O operations completed each second. This metric is reported as the average IOPS for a given time interval. Amazon RDS reports read and write IOPS separately on 1-minute intervals. Total IOPS is the sum of the read and write IOPS. Typical values for IOPS range from zero to tens of thousands per second.
- **Latency** – The elapsed time between the submission of an I/O request and its completion. This metric is reported as the average latency for a given time interval. Amazon RDS reports read and write latency separately on 1-minute intervals in units of seconds. Typical values for latency are in the millisecond (ms). For example, Amazon RDS reports 2 ms as 0.002 seconds.
- **Throughput** – The number of bytes each second that are transferred to or from disk. This metric is reported as the average throughput for a given time interval. Amazon RDS reports read and write throughput separately on 1-minute intervals using units of megabytes per second (MB/s). Typical values for throughput range from zero to the I/O channel's maximum bandwidth.
- **Queue Depth** – The number of I/O requests in the queue waiting to be serviced. These are I/O requests that have been submitted by the application but have not been sent to the device because the device is busy servicing other I/O requests. Time spent waiting in the queue is a component of latency and service time (not available as a metric). This metric is reported as the average queue depth for a given time interval. Amazon RDS reports queue depth in 1-minute intervals. Typical values for queue depth range from zero to several hundred.

Measured IOPS values are independent of the size of the individual I/O operation. This means that when you measure I/O performance, you should look at the throughput of the instance, not simply the number of I/O operations.

Factors That Affect Storage Performance

Both system activities and database workload can affect storage performance.

System activities

The following system-related activities consume I/O capacity and might reduce database instance performance while in progress:

- Multi-AZ standby creation
- Read replica creation
- Changing storage types

Database workload

In some cases your database or application design results in concurrency issues, locking, or other forms of database contention. In these cases, you might not be able to use all the provisioned bandwidth directly. In addition, you may encounter the following workload-related situations:

- The throughput limit of the underlying instance type is reached.
- Queue depth is consistently less than 1 because your application is not driving enough I/O operations.
- You experience query contention in the database even though some I/O capacity is unused.

If there isn't at least one system resource that is at or near a limit, and adding threads doesn't increase the database transaction rate, the bottleneck is most likely contention in the database. The most common forms are row lock and index page lock contention, but there are many other possibilities. If this is your situation, you should seek the advice of a database performance tuning expert.

DB instance class

To get the most performance out of your Amazon RDS database instance, choose a current generation instance type with enough bandwidth to support your storage type. For example, you can choose EBS-optimized instances and instances with 10-gigabit network connectivity.

For the full list of Amazon EC2 instance types that support EBS optimization, see Instance types that support EBS optimization.

We encourage you to use the latest generation of instances to get the best performance. Previous generation DB instances have a lower instance storage limit. The following table shows the maximum storage that each DB instance class can scale to for each database engine. All values are in tebibytes (TiB).

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.m5 – Latest Generation Standard Instance Classes					
db.m5.24xlarge	64	16	64	64	64
db.m5.16xlarge	64	16	64	64	64
db.m5.12xlarge	64	16	64	64	64
db.m5.8xlarge	64	16	64	64	64
db.m5.4xlarge	64	16	64	64	64
db.m5.2xlarge	64	16	64	64	64
db.m5.xlarge	64	16	64	64	64
db.m5.large	64	16	64	64	64
db.m4 – Current Generation Standard Instance Classes					
db.m4.16xlarge	64	16	64	64	64
db.m4.10xlarge	64	16	64	64	64
db.m4.4xlarge	64	16	64	64	64
db.m4.2xlarge	64	16	64	64	64
db.m4.xlarge	64	16	64	64	64

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.m4.large	64	16	64	64	64
db.m3 – Previous Generation Standard Instance Classes					
db.m3.2xlarge	6	16	6	6	6
db.m3.xlarge	6	16	6	6	6
db.m3.large	6	16	6	6	6
db.m3.medium	32	16	32	32	32
db.r5 – Latest Generation Memory Optimized Instance Classes					
db.r5.24xlarge	64	16	64	64	64
db.r5.16xlarge	64	16	64	64	64
db.r5.12xlarge	64	16	64	64	64
db.r5.8xlarge	64	16	64	64	64
db.r5.4xlarge	64	16	64	64	64
db.r5.2xlarge	64	16	64	64	64
db.r5.xlarge	64	16	64	64	64
db.r5.large	64	16	64	64	64
db.r4 – Current Generation Memory Optimized Instance Classes					
db.r4.16xlarge	64	16	64	64	64
db.r4.8xlarge	64	16	64	64	64
db.r4.4xlarge	64	16	64	64	64
db.r4.2xlarge	64	16	64	64	64
db.r4.xlarge	64	16	64	64	64
db.r4.large	64	16	64	64	64
db.r3 – Previous Generation Memory Optimized Instance Classes					
db.r3.8xlarge	64	16	64	64	64
db.r3.4xlarge	64	16	64	64	64
db.r3.2xlarge	64	16	64	64	64
db.r3.xlarge	64	16	64	64	64
db.r3.large	64	16	64	64	64
db.t3 – Latest Generation Burstable Performance Instance Classes					
db.t3.2xlarge	16	16	16	64	64

Instance Class	MariaDB	Microsoft SQL Server	MySQL	Oracle	PostgreSQL
db.t3.xlarge	16	16	16	64	64
db.t3.large	16	16	16	64	64
db.t3.medium	16	16	16	32	32
db.t3.small	16	16	16	32	16
db.t3.micro	16	16	16	32	16
db.t2 – Current Generation Burstable Performance Instance Classes					
db.t2.2xlarge	64	16	64	64	64
db.t2.xlarge	64	16	64	64	64
db.t2.large	64	16	64	64	64
db.t2.medium	32	16	32	32	32
db.t2.small	16	16	16	16	16
db.t2.micro	16	16	16	16	16
db.x1e – Latest Generation Memory Optimized Instance Classes					
db.x1e.32xlarge		16		64	
db.x1e.16xlarge		16		64	
db.x1e.8xlarge		16		64	
db.x1e.4xlarge		16		64	
db.x1e.2xlarge		16		64	
db.x1e.xlarge		16		64	
db.x1 – Current Generation Memory Optimized Instance Classes					
db.x1.32xlarge		16		64	
db.x1.16xlarge		16		64	

For Oracle, scaling up to 80,000 IOPS is only supported on the following instance classes.

- db.m5.24xlarge
- db.r5.24xlarge
- db.x1.32xlarge
- db.x1e.32xlarge

For more details on all instance classes supported, see Previous Generation DB Instances.

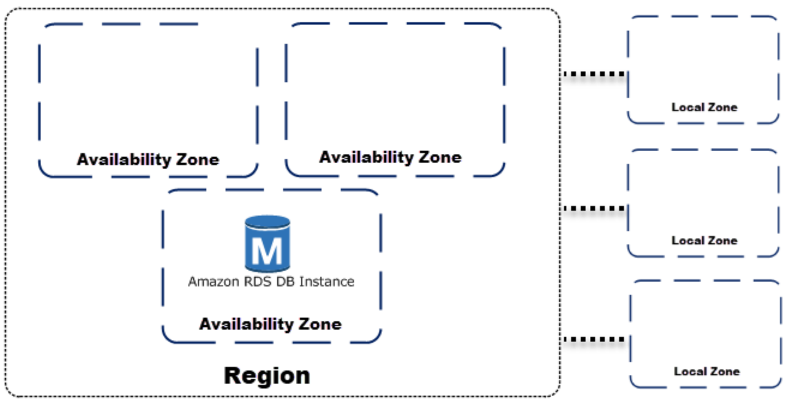
Regions, Availability Zones, and Local Zones

Amazon cloud computing resources are hosted in multiple locations world-wide. These locations are composed of AWS Regions, Availability Zones, and Local Zones. Each *AWS Region* is a separate geographic area. Each AWS Region has multiple, isolated locations known as *Availability Zones*.

> **Note**
> For information about finding the Availability Zones for an AWS Region, see Describing Your Regions, Availability Zones, and Local Zones in the Amazon EC2 documentation.

By using Local Zones, you can place resources, such as compute and storage, in multiple locations closer to your users. Amazon RDS enables you to place resources, such as DB instances, and data in multiple locations. Resources aren't replicated across AWS Regions unless you do so specifically.

Amazon operates state-of-the-art, highly-available data centers. Although rare, failures can occur that affect the availability of instances that are in the same location. If you host all your instances in a single location that is affected by such a failure, none of your instances is available.



It is important to remember that each AWS Region is completely independent. Any Amazon RDS activity you initiate (for example, creating database instances or listing available database instances) runs only in your current default AWS Region. The default AWS Region can be changed in the console, by setting the EC2_REGION environment variable, or it can be overridden by using the `--region` parameter with the AWS Command Line Interface (AWS CLI). For more information, see Configuring the AWS Command Line Interface, specifically the sections about environment variables and command line options.

Amazon RDS supports a special AWS Region called AWS GovCloud (US-West) that is designed to allow US government agencies and customers to move more sensitive workloads into the cloud. AWS GovCloud (US-West) addresses the US government's specific regulatory and compliance requirements. For more information about AWS GovCloud (US-West), see What Is AWS GovCloud (US-West)?

To create or work with an Amazon RDS DB instance in a specific AWS Region, use the corresponding regional service endpoint.

AWS Regions

Each AWS Region is designed to be isolated from the other AWS Regions. This design achieves the greatest possible fault tolerance and stability.

When you view your resources, you see only the resources that are tied to the AWS Region that you specified. This is because AWS Regions are isolated from each other, and we don't automatically replicate resources across AWS Regions.

Availability Zones

When you create a DB instance, you can choose an Availability Zone or have AWS choose one for you. An Availability Zone is represented by an AWS Region code followed by a letter identifier (for example, `us-east-1a`).

In some cases, you might distribute your DB instances across multiple Availability Zones in a Multi-AZ deployment. In such cases, if one DB instance fails, you can design your application so that a DB instance in another Availability Zone can handle requests. For more information about Multi-AZ deployments, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

Local Zones

A *Local Zone* is an extension of an AWS Region that is geographically close to your users. You can extend any VPC from the parent AWS Region into Local Zones by creating a new subnet and assigning it to the AWS Local Zone. When you create a subnet in a Local Zone, your VPC is extended to that Local Zone. The subnet in the Local Zone operates the same as other subnets in your VPC.

When you create a DB instance, you can choose a subnet in a Local Zone. Local Zones have their own connections to the internet and support AWS Direct Connect. Thus, resources created in a Local Zone can serve local users with very low-latency communications. For more information, see AWS Local Zones.

A Local Zone is represented by an AWS Region code followed by an identifier that indicates the location, for example `us-west-2-lax-1a`.

To use a Local Zone

1. Enable the Local Zone in the Amazon EC2 console.

   For more information, see Enabling Local Zones in the *Amazon EC2 User Guide for Linux Instances.*
2. Create a subnet in the Local Zone.

   For more information, see Creating a Subnet in Your VPC in the *Amazon VPC User Guide.*
3. Create a DB subnet group in the Local Zone.

   When you create a DB subnet group, choose the Availability Zone group for the Local Zone.

   For more information, see Creating a DB Instance in a VPC (p. 1444).
4. Create a DB instance that uses the DB subnet group in the Local Zone.

   For more information, see Creating an Amazon RDS DB Instance (p. 136).

> **Important**
> Currently, Local Zones are only available in the US West (Oregon) Region. In this AWS Region, the Los Angeles AWS Local Zone is available.

Region Availability

The following table shows the AWS Regions where Amazon RDS is currently available and the endpoint for each Region.

Region Name	Region	Endpoint	Protocol	
US East (Ohio)	us-east-2	rds.us-east-2.amazonaws.com	HTTPS	

Region Name	Region	Endpoint	Protocol	
		rds-fips.us-east-2.amazonaws.com	HTTPS	
US East (N. Virginia)	us-east-1	rds.us-east-1.amazonaws.com rds-fips.us-east-1.amazonaws.com	HTTPS HTTPS	
US West (N. California)	us-west-1	rds.us-west-1.amazonaws.com rds-fips.us-west-1.amazonaws.com	HTTPS HTTPS	
US West (Oregon)	us-west-2	rds.us-west-2.amazonaws.com rds-fips.us-west-2.amazonaws.com	HTTPS HTTPS	
Africa (Cape Town)	af-south-1	rds.af-south-1.amazonaws.com	HTTPS	
Asia Pacific (Hong Kong)	ap-east-1	rds.ap-east-1.amazonaws.com	HTTPS	
Asia Pacific (Mumbai)	ap-south-1	rds.ap-south-1.amazonaws.com	HTTPS	
Asia Pacific (Osaka-Local)	ap-northeast-3	rds.ap-northeast-3.amazonaws.com	HTTPS	
Asia Pacific (Seoul)	ap-northeast-2	rds.ap-northeast-2.amazonaws.com	HTTPS	
Asia Pacific (Singapore)	ap-southeast-1	rds.ap-southeast-1.amazonaws.com	HTTPS	
Asia Pacific (Sydney)	ap-southeast-2	rds.ap-southeast-2.amazonaws.com	HTTPS	
Asia Pacific (Tokyo)	ap-northeast-1	rds.ap-northeast-1.amazonaws.com	HTTPS	
Canada (Central)	ca-central-1	rds.ca-central-1.amazonaws.com rds-fips.ca-central-1.amazonaws.com	HTTPS HTTPS	
China (Beijing)	cn-north-1	rds.cn-north-1.amazonaws.com.cn	HTTPS	
China (Ningxia)	cn-northwest-1	rds.cn-northwest-1.amazonaws.com.cn	HTTPS	

Region Name	Region	Endpoint	Protocol	
Europe (Frankfurt)	eu-central-1	rds.eu-central-1.amazonaws.com	HTTPS	
Europe (Ireland)	eu-west-1	rds.eu-west-1.amazonaws.com	HTTPS	
Europe (London)	eu-west-2	rds.eu-west-2.amazonaws.com	HTTPS	
Europe (Milan)	eu-south-1	rds.eu-south-1.amazonaws.com	HTTPS	
Europe (Paris)	eu-west-3	rds.eu-west-3.amazonaws.com	HTTPS	
Europe (Stockholm)	eu-north-1	rds.eu-north-1.amazonaws.com	HTTPS	
Middle East (Bahrain)	me-south-1	rds.me-south-1.amazonaws.com	HTTPS	
South America (São Paulo)	sa-east-1	rds.sa-east-1.amazonaws.com	HTTPS	
AWS GovCloud (US-East)	us-gov-east-1	rds.us-gov-east-1.amazonaws.com rds.us-gov-east-1.amazonaws.com	HTTPS HTTPS	
AWS GovCloud (US)	us-gov-west-1	rds.us-gov-west-1.amazonaws.com rds.us-gov-west-1.amazonaws.com	HTTPS HTTPS	

If you do not explicitly specify an endpoint, the US West (Oregon) endpoint is the default.

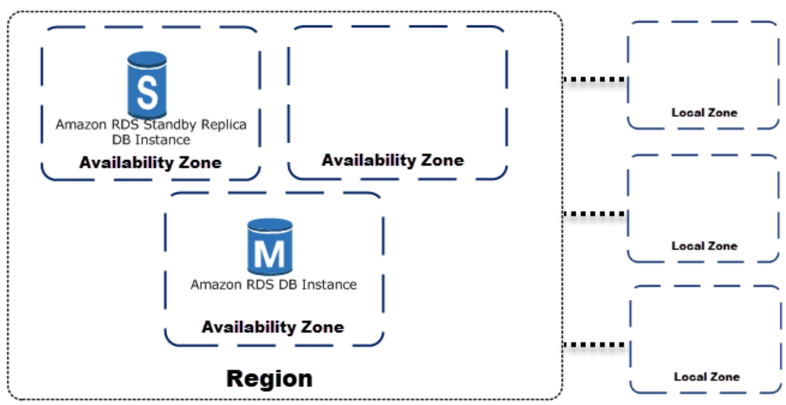
When you work with a DB instance using the AWS CLI or API operations, make sure that you specify its regional endpoint.

High Availability (Multi-AZ) for Amazon RDS

Amazon RDS provides high availability and failover support for DB instances using Multi-AZ deployments. Amazon RDS uses several different technologies to provide failover support. Multi-AZ deployments for MariaDB, MySQL, Oracle, and PostgreSQL DB instances use Amazon's failover technology. SQL Server DB instances use SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs).

In a Multi-AZ deployment, Amazon RDS automatically provisions and maintains a synchronous standby replica in a different Availability Zone. The primary DB instance is synchronously replicated across Availability Zones to a standby replica to provide data redundancy, eliminate I/O freezes, and minimize latency spikes during system backups. Running a DB instance with high availability can enhance availability during planned system maintenance, and help protect your databases against DB instance failure and Availability Zone disruption. For more information on Availability Zones, see Regions, Availability Zones, and Local Zones (p. 37).

Note
The high-availability feature is not a scaling solution for read-only scenarios; you cannot use a standby replica to serve read traffic. To service read-only traffic, you should use a read replica. For more information, see Working with Read Replicas (p. 250).



Using the RDS console, you can create a Multi-AZ deployment by simply specifying Multi-AZ when creating a DB instance. You can use the console to convert existing DB instances to Multi-AZ deployments by modifying the DB instance and specifying the Multi-AZ option. You can also specify a Multi-AZ deployment with the AWS CLI or Amazon RDS API. Use the create-db-instance or modify-db-instance CLI command, or the CreateDBInstance or ModifyDBInstance API operation.

The RDS console shows the Availability Zone of the standby replica (called the secondary AZ). You can also use the describe-db-instances CLI command or the DescribeDBInstances API operation to find the secondary AZ.

DB instances using Multi-AZ deployments can have increased write and commit latency compared to a Single-AZ deployment, due to the synchronous data replication that occurs. You might have a change in latency if your deployment fails over to the standby replica, although AWS is engineered with low-latency network connectivity between Availability Zones. For production workloads, we recommend that you use Provisioned IOPS and DB instance classes that are optimized for Provisioned IOPS for fast, consistent performance. For more information about DB instance classes, see DB Instance Classes (p. 7).

Modifying a DB Instance to Be a Multi-AZ Deployment

If you have a DB instance in a Single-AZ deployment and modify it to a Multi-AZ deployment (for engines other than Amazon Aurora), Amazon RDS takes several steps. First, Amazon RDS takes a snapshot of the primary DB instance from your deployment and then restores the snapshot into another Availability Zone. Amazon RDS then sets up synchronous replication between your primary DB instance and the new instance.

For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Important

This action avoids downtime when you convert from Single-AZ to Multi-AZ, but you can experience a performance impact during and after converting to Multi-AZ. This impact can be significant for large write-intensive DB instances.

To enable Multi-AZ for a DB instance, RDS takes a snapshot of the primary DB instance's EBS volume and restores it on the newly created standby replica, and then synchronizes both volumes. New volumes created from existing EBS snapshots load lazily in the background. This capability permits large volumes to be restored from a snapshot quickly, but there is the possibility of added latency during and after the modification is complete. For more information, see Restoring an Amazon EBS Volume from a Snapshot in the Amazon EC2 documentation.

After the modification is complete, Amazon RDS triggers an event (RDS-EVENT-0025) that indicates the process is complete. You can monitor Amazon RDS events; for more information about events, see Using Amazon RDS Event Notification (p. 429).

Failover Process for Amazon RDS

In the event of a planned or unplanned outage of your DB instance, Amazon RDS automatically switches to a standby replica in another Availability Zone if you have enabled Multi-AZ. The time it takes for the failover to complete depends on the database activity and other conditions at the time the primary DB instance became unavailable. Failover times are typically 60–120 seconds. However, large transactions or a lengthy recovery process can increase failover time. When the failover is complete, it can take additional time for the RDS console to reflect the new Availability Zone.

Note

You can force a failover manually when you reboot a DB instance. For more information, see Rebooting a DB Instance (p. 247).

Amazon RDS handles failovers automatically so you can resume database operations as quickly as possible without administrative intervention. The primary DB instance switches over automatically to the standby replica if any of the following conditions occur:

- An Availability Zone outage
- The primary DB instance fails
- The DB instance's server type is changed
- The operating system of the DB instance is undergoing software patching
- A manual failover of the DB instance was initiated using **Reboot with failover**

There are several ways to determine if your Multi-AZ DB instance has failed over:

- DB event subscriptions can be set up to notify you by email or SMS that a failover has been initiated. For more information about events, see Using Amazon RDS Event Notification (p. 429).
- You can view your DB events by using the Amazon RDS console or API operations.

- You can view the current state of your Multi-AZ deployment by using the Amazon RDS console and API operations.

For information on how you can respond to failovers, reduce recovery time, and other best practices for Amazon RDS, see Best Practices for Amazon RDS (p. 125).

Setting the JVM TTL for DNS Name Lookups

The failover mechanism automatically changes the Domain Name System (DNS) record of the DB instance to point to the standby DB instance. As a result, you need to re-establish any existing connections to your DB instance. In a Java virtual machine (JVM) environment, due to how the Java DNS caching mechanism works, you might need to reconfigure JVM settings.

The JVM caches DNS name lookups. When the JVM resolves a hostname to an IP address, it caches the IP address for a specified period of time, known as the *time-to-live* (TTL).

Because AWS resources use DNS name entries that occasionally change, we recommend that you configure your JVM with a TTL value of no more than 60 seconds. Doing this makes sure that when a resource's IP address changes, your application can receive and use the resource's new IP address by requerying the DNS.

On some Java configurations, the JVM default TTL is set so that it never refreshes DNS entries until the JVM is restarted. Thus, if the IP address for an AWS resource changes while your application is still running, it can't use that resource until you manually restart the JVM and the cached IP information is refreshed. In this case, it's crucial to set the JVM's TTL so that it periodically refreshes its cached IP information.

> **Note**
> The default TTL can vary according to the version of your JVM and whether a security manager is installed. Many JVMs provide a default TTL less than 60 seconds. If you're using such a JVM and not using a security manager, you can ignore the rest of this topic. For more information on security managers in Oracle, see The Security Manager in the Oracle documentation.

To modify the JVM's TTL, set the `networkaddress.cache.ttl` property value. Use one of the following methods, depending on your needs:

- To set the property value globally for all applications that use the JVM, set `networkaddress.cache.ttl` in the `$JAVA_HOME/jre/lib/security/java.security` file.

```
networkaddress.cache.ttl=60
```

- To set the property locally for your application only, set `networkaddress.cache.ttl` in your application's initialization code before any network connections are established.

```
java.security.Security.setProperty("networkaddress.cache.ttl" , "60");
```

DB Instance Billing for Amazon RDS

Amazon RDS instances are billed based on the following components:

- DB instance hours (per hour) – Based on the DB instance class of the DB instance (for example, db.t2.small or db.m4.large). Pricing is listed on a per-hour basis, but bills are calculated down to the second and show times in decimal form. RDS usage is billed in one second increments, with a minimum of 10 minutes. For more information, see DB Instance Classes (p. 7).
- Storage (per GiB per month) – Storage capacity that you have provisioned to your DB instance. If you scale your provisioned storage capacity within the month, your bill is pro-rated. For more information, see Amazon RDS DB Instance Storage (p. 29).
- I/O requests (per 1 million requests per month) – Total number of storage I/O requests that you have made in a billing cycle, for Amazon RDS magnetic storage only.
- Provisioned IOPS (per IOPS per month) – Provisioned IOPS rate, regardless of IOPS consumed, for Amazon RDS Provisioned IOPS (SSD) storage only. Provisioned storage for EBS volumes are billed in one second increments, with a minimum of 10 minutes.
- Backup storage (per GiB per month) – *Backup storage* is the storage that is associated with automated database backups and any active database snapshots that you have taken. Increasing your backup retention period or taking additional database snapshots increases the backup storage consumed by your database. Per second billing doesn't apply to backup storage (metered in GB-month).

  For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).
- Data transfer (per GB) – Data transfer in and out of your DB instance from or to the internet and other AWS Regions.

Amazon RDS provides the following purchasing options to enable you to optimize your costs based on your needs:

- **On-Demand Instances** – Pay by the hour for the DB instance hours that you use. Pricing is listed on a per-hour basis, but bills are calculated down to the second and show times in decimal form. RDS usage is now billed in one second increments, with a minimum of 10 minutes.
- **Reserved Instances** – Reserve a DB instance for a one-year or three-year term and get a significant discount compared to the on-demand DB instance pricing. With Reserved Instance usage, you can launch, delete, start, or stop multiple instances within an hour and get the Reserved Instance benefit for all of the instances.

For Amazon RDS pricing information, see the Amazon RDS product page.

Topics

On-Demand DB Instances for Amazon RDS

Amazon RDS on-demand DB instances are billed based on the class of the DB instance (for example, db.t2.small or db.m4.large). For Amazon RDS pricing information, see the Amazon RDS product page.

Billing starts for a DB instance as soon as the DB instance is available. Pricing is listed on a per-hour basis, but bills are calculated down to the second and show times in decimal form. Amazon RDS usage is billed in one-second increments, with a minimum of 10 minutes. In the case of billable configuration change, such as scaling compute or storage capacity, you're charged a 10-minute minimum. Billing continues until the DB instance terminates, which occurs when you delete the DB instance or if the DB instance fails.

If you no longer want to be charged for your DB instance, you must stop or delete it to avoid being billed for additional DB instance hours. For more information about the DB instance states for which you are billed, see DB Instance Status (p. 359).

Stopped DB Instances

While your DB instance is stopped, you're charged for provisioned storage, including Provisioned IOPS. You are also charged for backup storage, including storage for manual snapshots and automated backups within your specified retention window. You aren't charged for DB instance hours.

Multi-AZ DB Instances

If you specify that your DB instance should be a Multi-AZ deployment, you're billed according to the Multi-AZ pricing posted on the Amazon RDS pricing page.

Reserved DB Instances for Amazon RDS

Using reserved DB instances, you can reserve a DB instance for a one- or three-year term. Reserved DB instances provide you with a significant discount compared to on-demand DB instance pricing. Reserved DB instances are not physical instances, but rather a billing discount applied to the use of certain on-demand DB instances in your account. Discounts for reserved DB instances are tied to instance type and AWS Region.

The general process for working with reserved DB instances is: First get information about available reserved DB instance offerings, then purchase a reserved DB instance offering, and finally get information about your existing reserved DB instances.

Overview of Reserved DB Instances

When you purchase a reserved DB instance in Amazon RDS, you purchase a commitment to getting a discounted rate, on a specific DB instance type, for the duration of the reserved DB instance. To use an Amazon RDS reserved DB instance, you create a new DB instance just like you do for an on-demand instance. The new DB instance that you create must match the specifications of the reserved DB instance. If the specifications of the new DB instance match an existing reserved DB instance for your account, you are billed at the discounted rate offered for the reserved DB instance. Otherwise, the DB instance is billed at an on-demand rate.

For more information about reserved DB instances, including pricing, see Amazon RDS Reserved Instances.

Offering Types

Reserved DB instances are available in three varieties—No Upfront, Partial Upfront, and All Upfront—that let you optimize your Amazon RDS costs based on your expected usage.

No Upfront

This option provides access to a reserved DB instance without requiring an upfront payment. Your No Upfront reserved DB instance bills a discounted hourly rate for every hour within the term, regardless of usage, and no upfront payment is required. This option is only available as a one-year reservation.

Partial Upfront

This option requires a part of the reserved DB instance to be paid upfront. The remaining hours in the term are billed at a discounted hourly rate, regardless of usage. This option is the replacement for the previous Heavy Utilization option.

All Upfront

Full payment is made at the start of the term, with no other costs incurred for the remainder of the term regardless of the number of hours used.

If you are using consolidated billing, all the accounts in the organization are treated as one account. This means that all accounts in the organization can receive the hourly cost benefit of reserved DB instances that are purchased by any other account. For more information about consolidated billing, see Amazon RDS Reserved DB Instances in the *AWS Billing and Cost Management User Guide*.

Size-Flexible Reserved DB Instances

When you purchase a reserved DB instance, one thing that you specify is the instance class, for example db.m4.large. For more information about instance classes, see DB Instance Classes (p. 7).

If you have a DB instance, and you need to scale it to larger capacity, your reserved DB instance is automatically applied to your scaled DB instance. That is, your reserved DB instances are automatically applied across all DB instance class sizes. Size-flexible reserved DB instances are available for DB instances with the same AWS Region and database engine. Size-flexible reserved DB instances can only scale in their instance class type. For example, a reserved DB instance for a db.m4.large can apply to a db.m4.xlarge, but not to a db.m5.large, because db.m4 and db.m5 are different instance class types. Reserved DB instance benefits also apply for both Multi-AZ and Single-AZ configurations. Flexibility means that you can move freely between configurations within the same DB instance class type. For example, you can move from a Single-AZ deployment running on one large DB instance class to a Multi-AZ deployment running on two small DB instance classes.

Size-flexible reserved DB instances are available for the following Amazon RDS database engines:

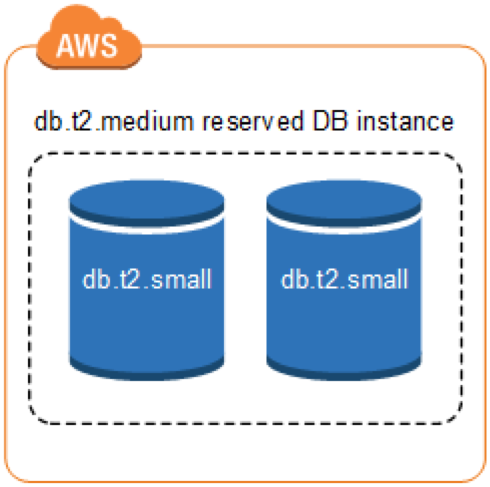
- MariaDB
- MySQL
- Oracle, Bring Your Own License
- PostgreSQL

For details about using size-flexible reserved instances with Aurora, see Reserved DB Instances for Aurora.

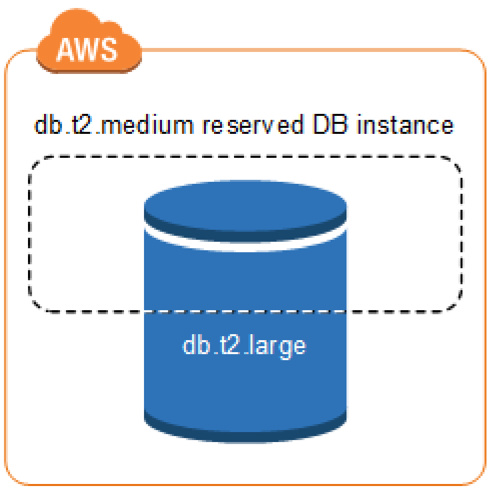
You can compare usage for different reserved DB instance sizes by using normalized units. For example, one unit of usage on two db.m3.large DB instances is equivalent to eight normalized units of usage on one db.m3.small. The following table shows the number of normalized units for each DB instance size.

Instance Size	Single-AZ Normalized Units	Multi-AZ Normalized Units
micro	0.5	1
small	1	2
medium	2	4
large	4	8
xlarge	8	16
2xlarge	16	32
4xlarge	32	64
8xlarge	64	128
10xlarge	80	160
16xlarge	128	256

For example, suppose that you purchase a `db.t2.medium` reserved DB instance, and you have two running `db.t2.small` DB instances in your account in the same AWS Region. In this case, the billing benefit is applied in full to both instances.



Alternatively, if you have one `db.t2.large` instance running in your account in the same AWS Region, the billing benefit is applied to 50 percent of the usage of the DB instance.



Reserved DB Instance Billing Example

The price for a reserved DB instance doesn't include regular costs associated with storage, backups, and I/O. The following example illustrates the total cost per month for a reserved DB instance:

- An Amazon RDS MySQL reserved Single-AZ db.r4.large DB instance class in US East (N. Virginia) with the No Upfront option at a cost of $0.12 for the instance, or $90 per month
- 400 GiB of General Purpose SSD (gp2) storage at a cost of 0.115 per GiB per month, or $45.60 per month
- 600 GiB of backup storage at $0.095, or $19 per month (400 GiB free)

Add all of these options ($90 + $45.60 + $19) with the reserved DB instance, and the total cost per month is $154.60.

If you chose to use an on-demand DB instance instead of a reserved DB instance, an Amazon RDS MySQL Single-AZ db.r4.large DB instance class in US East (N. Virginia) costs $0.1386 per hour, or $101.18 per month. So, for an on-demand DB instance, add all of these options ($101.18 + $45.60 + $19), and the total cost per month is $165.78.

Note

The prices in this example are sample prices and might not match actual prices. For Amazon RDS pricing information, see the Amazon RDS product page.

Deleting a Reserved DB Instance

The terms for a reserved DB instance involve a one-year or three-year commitment. You can't cancel a reserved DB instance. However, you can delete a DB instance that is covered by a reserved DB instance discount. The process for deleting a DB instance that is covered by a reserved DB instance discount is the same as for any other DB instance.

Your upfront payment for a reserved DB instance reserves the resources for your use. Because these resources are reserved for you, you are billed for the resources regardless of whether you use them.

If you delete a DB instance that is covered by a reserved DB instance discount, you can launch another DB instance with compatible specifications. In this case, you continue to get the discounted rate during the reservation term (one or three years).

Console

You can use the AWS Management Console to work with reserved DB instances as shown in the following procedures.

To get pricing and information about available reserved DB instance offerings

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Reserved instances**.
3. Choose **Purchase Reserved DB Instance**.
4. For **Product description**, choose the DB engine and licensing type.
5. For **DB instance class**, choose the DB instance class.
6. For **Multi-AZ deployment**, choose whether you want a Multi-AZ deployment.
7. For **Term**, choose the length of time you want the DB instance reserved.
8. For **Offering type**, choose the offering type.

   After you select the offering type, you can see the pricing information.

   Important

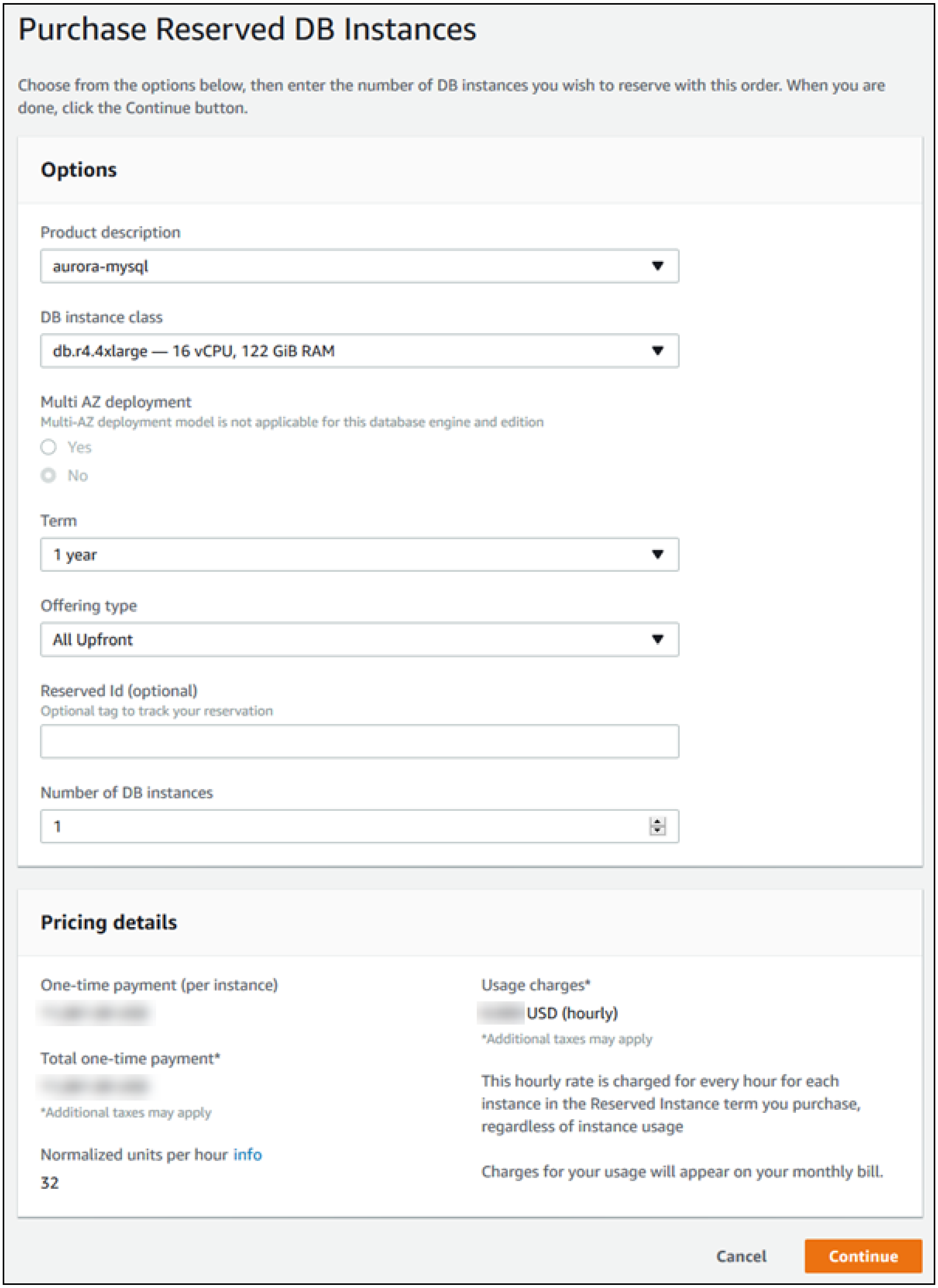
   Choose **Cancel** to avoid purchasing the reserved DB instance and incurring any charges.

After you have information about the available reserved DB instance offerings, you can use the information to purchase an offering as shown in the following procedure.

To purchase a reserved DB instance

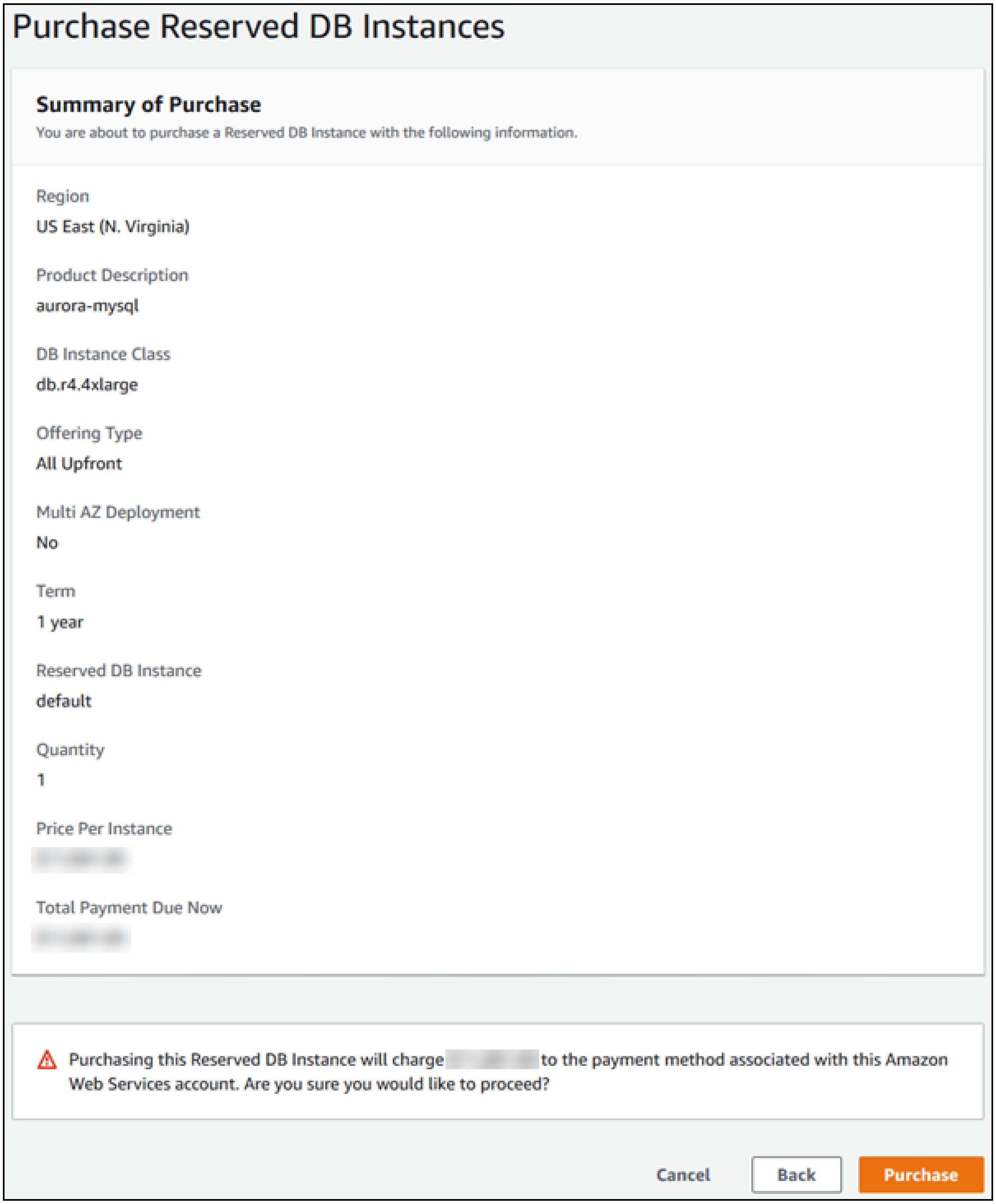
1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Reserved instances**.
3. Choose **Purchase Reserved DB Instance**.
4. For **Product description**, choose the DB engine and licensing type.
5. For **DB instance class**, choose the DB instance class.
6. For **Multi-AZ deployment**, choose whether you want a Multi-AZ deployment.
7. For **Term**, choose the length of time you want the DB instance reserved.
8. For **Offering type**, choose the offering type.

After you choose the offering type, you can see the pricing information, as shown following.


Purchase Reserved DB Instances
Choose from the options below, then enter the number of DB instances you wish to reserve with this order. When you are done, click the Continue button.
Options
Product description
aurora-mysql
DB instance class
db.r4.4xlarge — 16 vCPU, 122 GiB RAM
Multi AZ deployment
Multi-AZ deployment model is not applicable for this database engine and edition
Yes
No
Term
1 year
Offering type
All Upfront
Reserved Id (optional)
Optional tag to track your reservation
Number of DB instances
1
Pricing details
One-time payment (per instance)
Total one-time payment*
*Additional taxes may apply
Normalized units per hour info
32
Usage charges*
USD (hourly)
*Additional taxes may apply
This hourly rate is charged for every hour for each instance in the Reserved Instance term you purchase, regardless of instance usage
Charges for your usage will appear on your monthly bill.
Cancel
Continue

9. (Optional) You can assign your own identifier to the reserved DB instances that you purchase to help you track them. For **Reserved Id**, type an identifier for your reserved DB instance.
10. Choose **Continue**.

    The **Purchase Reserved DB Instance** dialog box appears, with a summary of the reserved DB instance attributes that you've selected and the payment due, as shown following.



11. On the confirmation page, review your reserved DB instance. If the information is correct, choose **Purchase** to purchase the reserved DB instance.

    Alternatively, choose **Back** to edit your reserved DB instance.

After you have purchased reserved DB instances, you can get information about your reserved DB instances as shown in the following procedure.

To get information about reserved DB instances for your AWS account

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the **Navigation** pane, choose **Reserved instances**.

   The reserved DB instances for your account appear. To see detailed information about a particular reserved DB instance, choose that instance in the list. You can then see detailed information about that instance in the detail pane at the bottom of the console.

AWS CLI

You can use the AWS CLI to work with reserved DB instances as shown in the following examples.

Example Get Available Reserved DB Instance Offerings

To get information about available reserved DB instance offerings, call the AWS CLI command `describe-reserved-db-instances-offerings`.

```
aws rds describe-reserved-db-instances-offerings
```

This call returns output similar to the following:

```

OFFERING  OfferingId                            Class         Multi-AZ  Duration  Fixed
 Price  Usage Price  Description  Offering Type
OFFERING  438012d3-4052-4cc7-b2e3-8d3372e0e706  db.m1.large   y         1y        1820.00
 USD  0.368 USD    mysql         Partial  Upfront
OFFERING  649fd0c8-cf6d-47a0-bfa6-060f8e75e95f  db.m1.small   n         1y         227.50
 USD  0.046 USD    mysql         Partial  Upfront
OFFERING  123456cd-ab1c-47a0-bfa6-12345667232f  db.m1.small   n         1y         162.00
 USD   0.00 USD    mysql         All      Upfront
    Recurring Charges:   Amount  Currency  Frequency
    Recurring Charges:   0.123   USD       Hourly
OFFERING  123456cd-ab1c-37a0-bfa6-12345667232d  db.m1.large   y         1y         700.00
 USD   0.00 USD    mysql         All      Upfront
    Recurring Charges:   Amount  Currency  Frequency
    Recurring Charges:   1.25    USD       Hourly
OFFERING  123456cd-ab1c-17d0-bfa6-12345667234e  db.m1.xlarge  n         1y        4242.00
 USD   2.42 USD    mysql         No       Upfront
```

After you have information about the available reserved DB instance offerings, you can use the information to purchase an offering as shown in the following example.

Example Purchase a Reserved DB Instance

To purchase a reserved DB instance, use the AWS CLI command `purchase-reserved-db-instances-offering` with the following parameters:

- `--reserved-db-instances-offering-id` – the id of the offering that you want to purchase. See the preceding example to get the offering ID.
- `--reserved-db-instance-id` – you can assign your own identifier to the reserved DB instances that you purchase to help you track them.

The following example purchases the reserved DB instance offering with ID *649fd0c8-cf6d-47a0-bfa6-060f8e75e95f*, and assigns the identifier of *MyReservation*.

For Linux, macOS, or Unix:

```
aws rds purchase-reserved-db-instances-offering \
    --reserved-db-instances-offering-id 649fd0c8-cf6d-47a0-bfa6-060f8e75e95f \
    --reserved-db-instance-id MyReservation
```

For Windows:

```
aws rds purchase-reserved-db-instances-offering ^
    --reserved-db-instances-offering-id 649fd0c8-cf6d-47a0-bfa6-060f8e75e95f ^
    --reserved-db-instance-id MyReservation
```

The command returns output similar to the following:

```
RESERVATION  ReservationId      Class        Multi-AZ  Start Time                Duration
 Fixed Price  Usage Price  Count  State           Description  Offering Type
RESERVATION  MyReservation      db.m1.small  y         2011-12-19T00:30:23.247Z  1y
 455.00 USD   0.092 USD    1      payment-pending  mysql        Partial  Upfront
```

After you have purchased reserved DB instances, you can get information about your reserved DB instances as shown in the following example.

Example Get Your Reserved DB Instances

To get information about reserved DB instances for your AWS account, call the AWS CLI command `describe-reserved-db-instances`.

```
aws rds describe-reserved-db-instances
```

The command returns output similar to the following:

```
RESERVATION  ReservationId     Class        Multi-AZ  Start Time                Duration
 Fixed Price  Usage Price  Count  State    Description  Offering Type
RESERVATION  MyReservation     db.m1.small  y         2011-12-09T23:37:44.720Z  1y
 455.00 USD   0.092 USD    1      retired  mysql        Partial  Upfront
```

RDS API

You can use the RDS API to work with reserved DB instances as shown in the following examples.

Example Get Available Reserved DB Instance Offerings

To get information about available reserved DB instance offerings, call the Amazon RDS API function `DescribeReservedDBInstancesOfferings`.

```
https://rds.us-east-1.amazonaws.com/
   ?Action=DescribeReservedDBInstancesOfferings
   &SignatureMethod=HmacSHA256
   &SignatureVersion=4
```

```
&Version=2014-09-01
&X-Amz-Algorithm=AWS4-HMAC-SHA256
&X-Amz-Credential=AKIADQKE4SARGYLE/20140411/us-east-1/rds/aws4_request
&X-Amz-Date=20140411T203327Z
&X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
&X-Amz-Signature=545f04acffeb4b80d2e778526b1c9da79d0b3097151c24f28e83e851d65422e2
```

This call returns output similar to the following:

```
<DescribeReservedDBInstancesOfferingsResponse xmlns="http://rds.amazonaws.com/
doc/2014-10-31/">
  <DescribeReservedDBInstancesOfferingsResult>
    <ReservedDBInstancesOfferings>
      <ReservedDBInstancesOffering>
        <Duration>31536000</Duration>
        <OfferingType>Partial Upfront</OfferingType>
        <CurrencyCode>USD</CurrencyCode>
        <RecurringCharges/>
        <FixedPrice>1820.0</FixedPrice>
        <ProductDescription>mysql</ProductDescription>
        <UsagePrice>0.368</UsagePrice>
        <MultiAZ>true</MultiAZ>
        <ReservedDBInstancesOfferingId>438012d3-4052-4cc7-b2e3-8d3372e0e706</
ReservedDBInstancesOfferingId>
        <DBInstanceClass>db.m1.large</DBInstanceClass>
      </ReservedDBInstancesOffering>
      <ReservedDBInstancesOffering>
        <Duration>31536000</Duration>
        <OfferingType>Partial Upfront</OfferingType>
        <CurrencyCode>USD</CurrencyCode>
        <RecurringCharges/>
        <FixedPrice>227.5</FixedPrice>
        <ProductDescription>mysql</ProductDescription>
        <UsagePrice>0.046</UsagePrice>
        <MultiAZ>false</MultiAZ>
        <ReservedDBInstancesOfferingId>649fd0c8-cf6d-47a0-bfa6-060f8e75e95f</
ReservedDBInstancesOfferingId>
        <DBInstanceClass>db.m1.small</DBInstanceClass>
      </ReservedDBInstancesOffering>
    </ReservedDBInstancesOfferings>
  </DescribeReservedDBInstancesOfferingsResult>
  <ResponseMetadata>
    <RequestId>5e4ec40b-2978-11e1-9e6d-771388d6ed6b</RequestId>
  </ResponseMetadata>
</DescribeReservedDBInstancesOfferingsResponse>
```

After you have information about the available reserved DB instance offerings, you can use the information to purchase an offering as shown in the following example.

Example Purchase a Reserved DB Instance

To purchase a reserved DB instance, call the Amazon RDS API operation `PurchaseReservedDBInstancesOffering` with the following parameters:

- `--reserved-db-instances-offering-id` – the id of the offering that you want to purchase. See the preceding example to get the offering ID.
- `--reserved-db-instance-id` – you can assign your own identifier to the reserved DB instances that you purchase to help you track them.

The following example purchases the reserved DB instance offering with ID *`649fd0c8-cf6d-47a0-bfa6-060f8e75e95f`*, and assigns the identifier of *`MyReservation`*.

```
https://rds.us-east-1.amazonaws.com/
   ?Action=PurchaseReservedDBInstancesOffering
   &ReservedDBInstanceId=MyReservation
   &ReservedDBInstancesOfferingId=438012d3-4052-4cc7-b2e3-8d3372e0e706
   &DBInstanceCount=10
   &SignatureMethod=HmacSHA256
   &SignatureVersion=4
   &Version=2014-09-01
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20140415/us-east-1/rds/aws4_request
   &X-Amz-Date=20140415T232655Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=c2ac761e8c8f54a8c0727f5a87ad0a766fbb0024510b9aa34ea6d1f7df52fb11
```

This call returns output similar to the following:

```
<PurchaseReservedDBInstancesOfferingResponse xmlns="http://rds.amazonaws.com/
doc/2014-10-31/">
  <PurchaseReservedDBInstancesOfferingResult>
    <ReservedDBInstance>
      <OfferingType>Partial Upfront</OfferingType>
      <CurrencyCode>USD</CurrencyCode>
      <RecurringCharges/>
      <ProductDescription>mysql</ProductDescription>
      <ReservedDBInstancesOfferingId>649fd0c8-cf6d-47a0-bfa6-060f8e75e95f</
ReservedDBInstancesOfferingId>
      <MultiAZ>true</MultiAZ>
      <State>payment-pending</State>
      <ReservedDBInstanceId>MyReservation</ReservedDBInstanceId>
      <DBInstanceCount>10</DBInstanceCount>
      <StartTime>2011-12-18T23:24:56.577Z</StartTime>
      <Duration>31536000</Duration>
      <FixedPrice>123.0</FixedPrice>
      <UsagePrice>0.123</UsagePrice>
      <DBInstanceClass>db.m1.small</DBInstanceClass>
    </ReservedDBInstance>
  </PurchaseReservedDBInstancesOfferingResult>
  <ResponseMetadata>
    <RequestId>7f099901-29cf-11e1-bd06-6fe008f046c3</RequestId>
  </ResponseMetadata>
</PurchaseReservedDBInstancesOfferingResponse>
```

After you have purchased reserved DB instances, you can get information about your reserved DB instances as shown in the following example.

Example Get Your Reserved DB Instances

To get information about reserved DB instances for your AWS account, call the Amazon RDS API operation `DescribeReservedDBInstances`.

```
https://rds.us-west-2.amazonaws.com/
   ?Action=DescribeReservedDBInstances
   &SignatureMethod=HmacSHA256
   &SignatureVersion=4
   &Version=2014-09-01
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20140420/us-west-2/rds/aws4_request
   &X-Amz-Date=20140420T162211Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=3312d17a4c43bcd209bc22a0778dd23e73f8434254abbd7ac53b89ade3dae88e
```

The API returns output similar to the following:

```
<DescribeReservedDBInstancesResponse xmlns="http://rds.amazonaws.com/doc/2014-10-31/">
  <DescribeReservedDBInstancesResult>
    <ReservedDBInstances>
      <ReservedDBInstance>
        <OfferingType>Partial Upfront</OfferingType>
        <CurrencyCode>USD</CurrencyCode>
        <RecurringCharges/>
        <ProductDescription>mysql</ProductDescription>
        <ReservedDBInstancesOfferingId>649fd0c8-cf6d-47a0-bfa6-060f8e75e95f</
ReservedDBInstancesOfferingId>
        <MultiAZ>false</MultiAZ>
        <State>payment-failed</State>
        <ReservedDBInstanceId>MyReservation</ReservedDBInstanceId>
        <DBInstanceCount>1</DBInstanceCount>
        <StartTime>2010-12-15T00:25:14.131Z</StartTime>
        <Duration>31536000</Duration>
        <FixedPrice>227.5</FixedPrice>
        <UsagePrice>0.046</UsagePrice>
        <DBInstanceClass>db.m1.small</DBInstanceClass>
      </ReservedDBInstance>
      <ReservedDBInstance>
        <OfferingType>Partial Upfront</OfferingType>
        <CurrencyCode>USD</CurrencyCode>
        <RecurringCharges/>
        <ProductDescription>mysql</ProductDescription>
        <ReservedDBInstancesOfferingId>649fd0c8-cf6d-47a0-bfa6-060f8e75e95f</
ReservedDBInstancesOfferingId>
        <MultiAZ>false</MultiAZ>
        <State>payment-failed</State>
        <ReservedDBInstanceId>MyReservation</ReservedDBInstanceId>
        <DBInstanceCount>1</DBInstanceCount>
        <StartTime>2010-12-15T01:07:22.275Z</StartTime>
        <Duration>31536000</Duration>
        <FixedPrice>227.5</FixedPrice>
        <UsagePrice>0.046</UsagePrice>
        <DBInstanceClass>db.m1.small</DBInstanceClass>
      </ReservedDBInstance>
    </ReservedDBInstances>
  </DescribeReservedDBInstancesResult>
  <ResponseMetadata>
    <RequestId>23400d50-2978-11e1-9e6d-771388d6ed6b</RequestId>
  </ResponseMetadata>
</DescribeReservedDBInstancesResponse>
```

Setting Up for Amazon RDS

Complete the tasks in this section to set up Amazon Relational Database Service (Amazon RDS) for the first time. If you already have an AWS account, know your Amazon RDS requirements, and prefer to use the defaults for IAM and VPC security groups, skip ahead to Getting Started (p. 4).

A couple things you should know about Amazon Web Services (AWS):

- When you sign up for AWS, your AWS account automatically has access to all services in AWS, including Amazon RDS. However, you are charged only for the services that you use.
- With Amazon RDS, you pay only for the RDS instances that are active. The Amazon RDS DB instance that you create is live (not running in a sandbox). You incur the standard Amazon RDS usage fees for the instance until you terminate it. For more information about Amazon RDS usage rates, see the Amazon RDS product page.

Topics

Sign Up for AWS

If you have an AWS account already, skip to the next section, Create an IAM User (p. 58).

If you don't have an AWS account, you can use the following procedure to create one. If you are a new AWS customer, you can get started with Amazon RDS for free; for more information, see AWS Free Usage Tier.

To create a new AWS account

1. Open https://portal.aws.amazon.com/billing/signup.
2. Follow the online instructions.

   Part of the sign-up procedure involves receiving a phone call and entering a verification code on the phone keypad.

Create an IAM User

After you create an AWS account and successfully connect to the AWS Management Console, you can create an AWS Identity and Access Management (IAM) user. Instead of signing in with your AWS root account, we recommend that you use an IAM administrative user with Amazon RDS.

One way to do this is to create a new IAM user and grant it administrator permissions. Alternatively, you can add an existing IAM user to an IAM group with Amazon RDS administrative permissions. You can then access AWS from a special URL using the credentials for the IAM user.

If you signed up for AWS but haven't created an IAM user for yourself, you can create one using the IAM console.

To create an administrator user for yourself and add the user to an administrators group (console)

1. Use your AWS account email address and password to sign in as the *AWS account root user* to the IAM console at https://console.aws.amazon.com/iam/.

   Note
   We strongly recommend that you adhere to the best practice of using the **`Administrator`** IAM user below and securely lock away the root user credentials. Sign in as the root user only to perform a few account and service management tasks.
2. In the navigation pane, choose **Users** and then choose **Add user**.
3. For **User name**, enter **`Administrator`**.
4. Select the check box next to **AWS Management Console access**. Then select **Custom password**, and then enter your new password in the text box.
5. (Optional) By default, AWS requires the new user to create a new password when first signing in. You can clear the check box next to **User must create a new password at next sign-in** to allow the new user to reset their password after they sign in.
6. Choose **Next: Permissions**.
7. Under **Set permissions**, choose **Add user to group**.
8. Choose **Create group**.
9. In the **Create group** dialog box, for **Group name** enter **`Administrators`**.
10. Choose **Filter policies**, and then select **AWS managed -job function** to filter the table contents.
11. In the policy list, select the check box for **AdministratorAccess**. Then choose **Create group**.

    Note
    You must activate IAM user and role access to Billing before you can use the `AdministratorAccess` permissions to access the AWS Billing and Cost Management console. To do this, follow the instructions in step 1 of the tutorial about delegating access to the billing console.
12. Back in the list of groups, select the check box for your new group. Choose **Refresh** if necessary to see the group in the list.
13. Choose **Next: Tags**.
14. (Optional) Add metadata to the user by attaching tags as key-value pairs. For more information about using tags in IAM, see Tagging IAM Entities in the *IAM User Guide*.
15. Choose **Next: Review** to see the list of group memberships to be added to the new user. When you are ready to proceed, choose **Create user**.

You can use this same process to create more groups and users and to give your users access to your AWS account resources. To learn about using policies that restrict user permissions to specific AWS resources, see Access Management and Example Policies.

To sign in as the new IAM user, first sign out of the AWS Management Console. Then use the following URL, where *`your_aws_account_id`* is your AWS account number without the hyphens. For example, if your AWS account number is `1234-5678-9012`, your AWS account ID is `123456789012`.

```
https://your_aws_account_id.signin.aws.amazon.com/console/
```

Type the IAM user name and password that you just created. When you're signed in, the navigation bar displays "*your_user_name @ your_aws_account_id*".

If you don't want the URL for your sign-in page to contain your AWS account ID, you can create an account alias. From the IAM dashboard, choose **Customize** and type an alias, such as your company name. To sign in after you create an account alias, use the following URL.

```
https://your_account_alias.signin.aws.amazon.com/console/
```

To verify the sign-in link for IAM users for your account, open the IAM console and check under **AWS Account Alias** on the dashboard.

You can also create access keys for your AWS account. These access keys can be used to access AWS through the AWS Command Line Interface (AWS CLI) or through the Amazon RDS API. For more information, see Managing Access Keys for Your AWS Account, Installing the AWS Command Line Interface, and the *Amazon RDS API Reference.*

Determine Requirements

The basic building block of Amazon RDS is the DB instance. In a DB instance, you create your databases. A DB instance provides a network address called an *endpoint*. Your applications use this endpoint to connect to your DB instance. When you create a DB instance, you specify details like storage, memory, database engine and version, network configuration, security, and maintenance periods. You control network access to a DB instance through a security group.

Before you create a DB instance and a security group, you must know your DB instance and network needs. Here are some important things to consider:

- **Resource requirements** – What are the memory and processor requirements for your application or service? You use these settings to help you determine what DB instance class to use. For specifications about DB instance classes, see DB Instance Classes (p. 7).
- **VPC, subnet, and security group –** Your DB instance is most likely in a virtual private cloud (VPC). To connect to your DB instance, you need to set up security group rules. These rules are set up differently depending on what kind of VPC you use and how you use it: in a default VPC, in a user-defined VPC, or outside of a VPC.

  Note
  Some legacy accounts don't use a VPC. If you are accessing a new AWS Region or you are a new RDS user (after 2013), you are most likely creating a DB instance inside a VPC.

  For information on how to determine if your account has a default VPC in a particular AWS Region, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).

  The following list describes the rules for each VPC option:
  - **Default VPC** – If your AWS account has a default VPC in the current AWS Region, that VPC is configured to support DB instances. If you specify the default VPC when you create the DB instance, do the following:
    - Create a *VPC security group* that authorizes connections from the application or service to the Amazon RDS DB instance with the database. Use the Amazon EC2 API or the **Security Group** option on the VPC console to create VPC security groups. For information, see Step 4: Create a VPC Security Group (p. 1447).
    - Specify the default DB subnet group. If this is the first DB instance you have created in this AWS Region, Amazon RDS creates the default DB subnet group when it creates the DB instance.
  - **User-defined VPC –** If you want to specify a user-defined VPC when you create a DB instance, be aware of the following:
    - Make sure to create a *VPC security group* that authorizes connections from the application or service to the Amazon RDS DB instance with the database. Use the Amazon EC2 API or the **Security Group** option on the VPC console to create VPC security groups. For information, see Step 4: Create a VPC Security Group (p. 1447).
    - The VPC must meet certain requirements in order to host DB instances, such as having at least two subnets, each in a separate availability zone. For information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

- Make sure to specify a DB subnet group that defines which subnets in that VPC can be used by the DB instance. For information, see the DB subnet group section in Working with a DB Instance in a VPC (p. 1442).
- **No VPC –** If your AWS account doesn't have a default VPC and you don't specify a user-defined VPC, create a DB security group. A *DB security group* authorizes connections from the devices and Amazon RDS instances running the applications or utilities to access the databases in the DB instance. For more information, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).

- **High availability:** Do you need failover support? On Amazon RDS, a Multi-AZ deployment creates a primary DB instance and a secondary standby DB instance in another Availability Zone for failover support. We recommend Multi-AZ deployments for production workloads to maintain high availability. For development and test purposes, you can use a deployment that isn't Multi-AZ. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).
- **IAM policies:** Does your AWS account have policies that grant the permissions needed to perform Amazon RDS operations? If you are connecting to AWS using IAM credentials, your IAM account must have IAM policies that grant the permissions required to perform Amazon RDS operations. For more information, see Identity and Access Management in Amazon RDS (p. 1371).
- **Open ports:** What TCP/IP port does your database listen on? The firewall at some companies might block connections to the default port for your database engine. If your company firewall blocks the default port, choose another port for the new DB instance. When you create a DB instance that listens on a port you specify, you can change the port by modifying the DB instance.
- **AWS Region:** What AWS Region do you want your database in? Having your database in close proximity to your application or web service can reduce network latency.
- **DB disk subsystem:** What are your storage requirements? Amazon RDS provides three storage types:
  - Magnetic (Standard Storage)
  - General Purpose (SSD)
  - Provisioned IOPS (PIOPS)

  Magnetic storage offers cost-effective storage that is ideal for applications with light or burst I/O requirements. General purpose, SSD-backed storage, also called *gp2*, can provide faster access than disk-based storage. Provisioned IOPS storage is designed to meet the needs of I/O-intensive workloads, particularly database workloads, which are sensitive to storage performance and consistency in random access I/O throughput. For more information on Amazon RDS storage, see Amazon RDS DB Instance Storage (p. 29).

When you have the information you need to create the security group and the DB instance, continue to the next step.

Provide Access to Your DB Instance in Your VPC by Creating a Security Group

VPC security groups provide access to DB instances in a VPC. They act as a firewall for the associated DB instance, controlling both inbound and outbound traffic at the instance level. DB instances are created by default with a firewall and a default security group that protect the DB instance.

Before you can connect to your DB instance, you must add rules to security group that enable you to connect. Use your network and configuration information to create rules to allow access to your DB instance.

> **Note**
> If your legacy DB instance was created before March 2013 and isn't in a VPC, it might not have associated security groups. If your DB instance was created after this date, it might be inside a default VPC.

For example, suppose that you have an application that accesses a database on your DB instance in a VPC. In this case, you must add a custom TCP rule that specifies the port range and IP addresses that your application uses to access the database. If you have an application on an Amazon EC2 instance, you can use the security group that you set up for the Amazon EC2 instance.

To create a VPC security group

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc.
2. In the top right corner of the AWS Management Console, choose the AWS Region where you want to create your VPC security group and DB instance. In the list of Amazon VPC resources for that AWS Region, you should see at least one VPC and several subnets. If you don't, you don't have a default VPC in that AWS Region.
3. In the navigation pane, choose **Security Groups**.
4. Choose **Create Security Group**.
5. In the **Create Security Group** window, type **Name tag**, **Group name**, and **Description** values for your security group. For **VPC**, choose the VPC that you want to create your DB instance in. Choose **Yes, Create**.
6. The VPC security group that you created should still be selected. If not, locate it in the list, and choose it. The details pane at the bottom of the console window displays the details for the security group, and tabs for working with inbound and outbound rules. Choose the **Inbound Rules** tab.
7. On the **Inbound Rules** tab, choose **Edit**.

    a. For **Type**, choose **Custom TCP Rule**.
    b. For **Port Range**, type the port value to use for your DB instance.
    c. For **Source**, choose a security group name or type the IP address range (CIDR value) from where you access the instance. If you choose **My IP**, this allows access to the DB instance from the IP address detected in your browser.
8. Choose **Add another rule** if you need to add more IP addresses or different port ranges.
9. (Optional) Use the **Outbound Rules** tab to add rules for outbound traffic. By default, all outbound traffic is allowed.

You can use the VPC security group that you just created as the security group for your DB instance when you create it. If your DB instance isn't going to be in a VPC, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419) to create a DB security group to use when you create your DB instance.

> **Note**
> If you use a default VPC, a default subnet group spanning all of the VPC's subnets is created for you. When you create a DB instance, you can select the default VPC and use **default** for **DB Subnet Group**.

Once you have completed the setup requirements, you can launch a DB instance using your requirements and security group. For information on creating a DB instance, see the relevant documentation in the following table.

Database Engine	Documentation
MariaDB	Creating a MariaDB DB Instance and Connecting to a Database on a MariaDB DB Instance (p. 64)
Microsoft SQL Server	Creating a Microsoft SQL Server DB Instance and Connecting to a DB Instance (p. 71)
MySQL	Creating a MySQL DB Instance and Connecting to a Database on a MySQL DB Instance (p. 78)

Database Engine	Documentation
Oracle	Creating an Oracle DB Instance and Connecting to a Database on an Oracle DB Instance (p. 85)
PostgreSQL	Creating a PostgreSQL DB Instance and Connecting to a Database on a PostgreSQL DB Instance (p. 91)

Getting Started with Amazon RDS

In the following examples, you can find how to create and connect to a DB instance using Amazon Relational Database Service (Amazon RDS). You can create a DB instance that uses MariaDB, MySQL, Microsoft SQL Server, Oracle, or PostgreSQL.

Important
Before you can create or connect to a DB instance, you must complete the tasks in Setting Up for Amazon RDS (p. 58).

Creating a DB instance and connecting to a database on a DB instance is slightly different for each of the DB engines. Choose one of the following DB engines that you want to use for detailed information on creating and connecting to the DB instance. After you have created and connected to your DB instance, there are instructions to help you delete the DB instance.

Topics

Creating a MariaDB DB Instance and Connecting to a Database on a MariaDB DB Instance

The easiest way to create a MariaDB DB instance is to use the Amazon RDS console. After you create the DB instance, you can use command line tools such as mysql or standard graphical tools such as HeidiSQL to connect to a database on the DB instance.

Important
Before you can create or connect to a DB instance, you must complete the tasks in Setting Up for Amazon RDS (p. 58).

Topics

Creating a MariaDB DB Instance

The basic building block of Amazon RDS is the DB instance. This environment is where you run your MariaDB databases.

Console

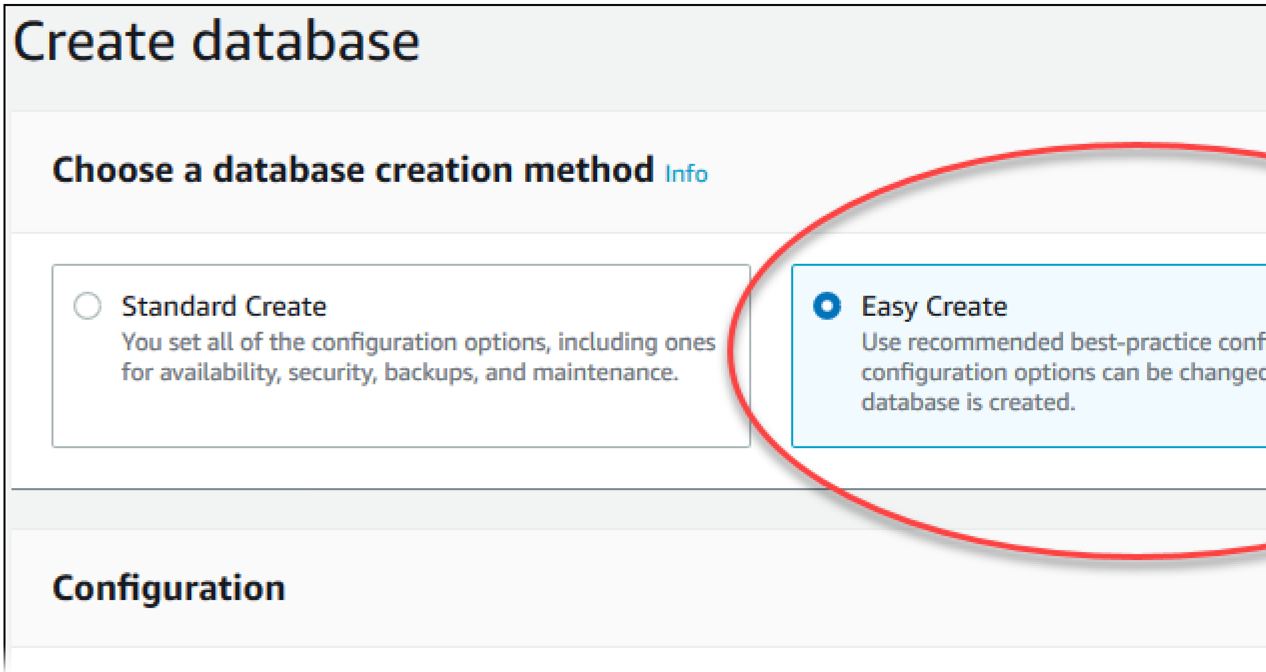
You can create a DB instance running MariaDB with the AWS Management Console with **Easy Create** enabled or not enabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

In this example, you use **Easy Create** to create a DB instance running the MariaDB database engine with a db.t2.micro DB instance class.

> **Note**
> For information about creating DB instances with **Easy Create** not enabled, see Creating an Amazon RDS DB Instance (p. 136).

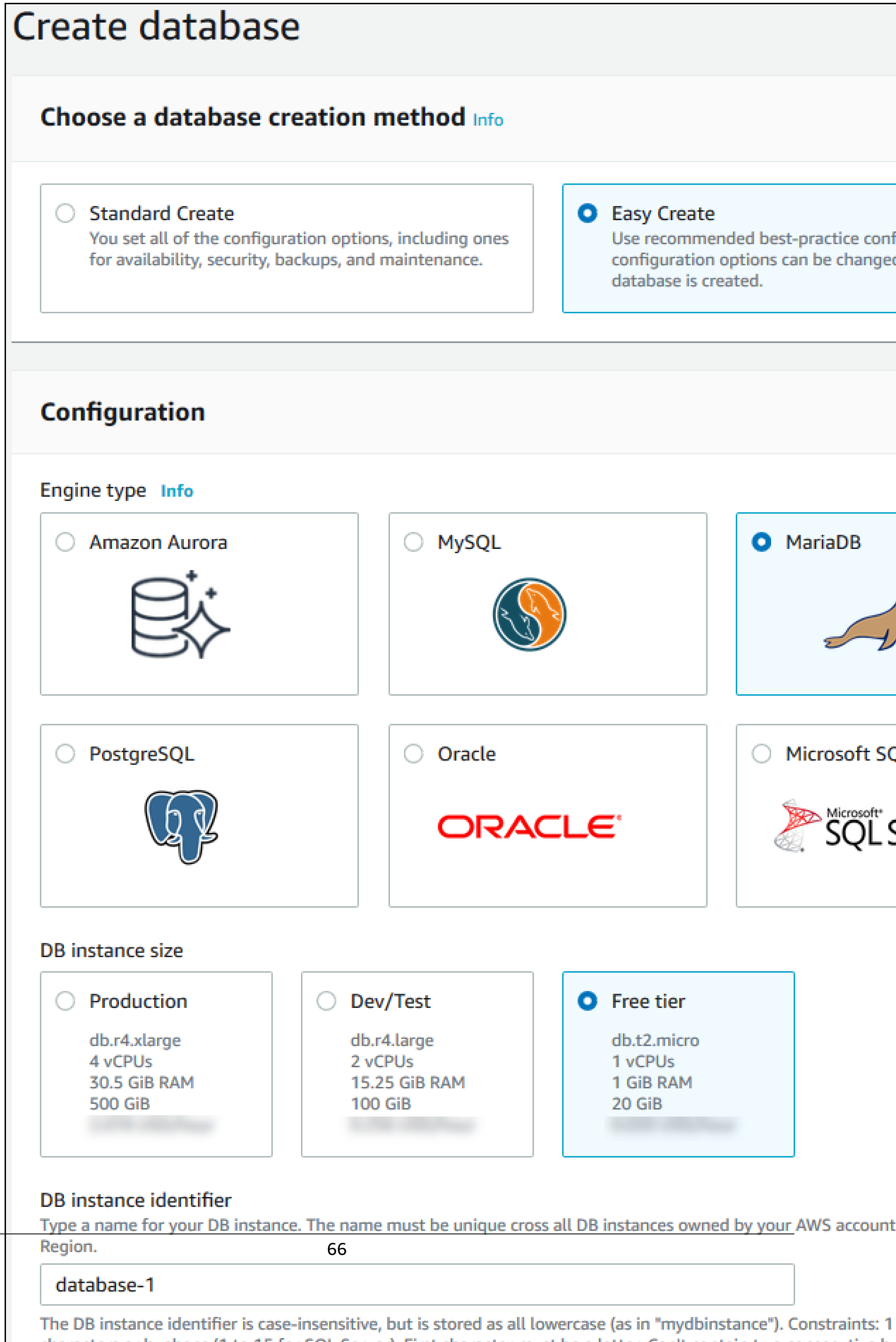
To create a MariaDB DB instance with Easy Create enabled

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database** and make sure that **Easy Create** is chosen.



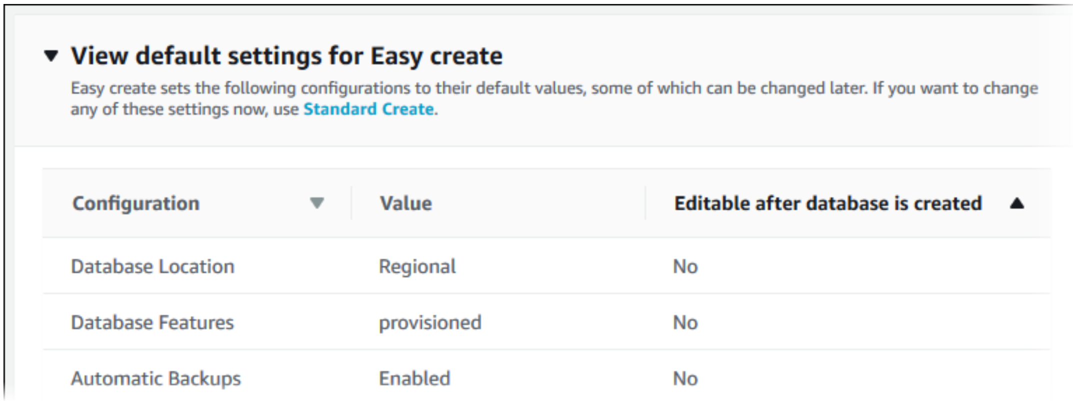
5. In **Configuration**, choose **MariaDB**.
6. For **DB instance size**, choose **Free tier**.
7. For **DB instance identifier**, enter a name for the DB instance, or leave the default name.
8. For **Master username**, enter a name for the master user, or leave the default name.

   The **Create database** page should look similar to the following image.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice conf
configuration options can be changed
database is created.
Configuration
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft SQ
Microsoft
SQL S
DB instance size
Production
db.r4.xlarge
4 vCPUs
30.5 GiB RAM
500 GiB
Dev/Test
db.r4.large
2 vCPUs
15.25 GiB RAM
100 GiB
Free tier
db.t2.micro
1 vCPUs
1 GiB RAM
20 GiB
DB instance identifier
Type a name for your DB instance. The name must be unique cross all DB instances owned by your AWS account
Region.
database-1
The DB instance identifier is case-insensitive, but is stored as all lowercase (as in "mydbinstance"). Constraints: 1

9. To use an automatically generated master password for the DB instance, make sure that the **Auto generate a password** check box is chosen.

   To enter your master password, clear the **Auto generate a password** check box, and then enter the same password in **Master password** and **Confirm password**.
10. (Optional) Open **View default settings for Easy create**.



▼ View default settings for Easy create

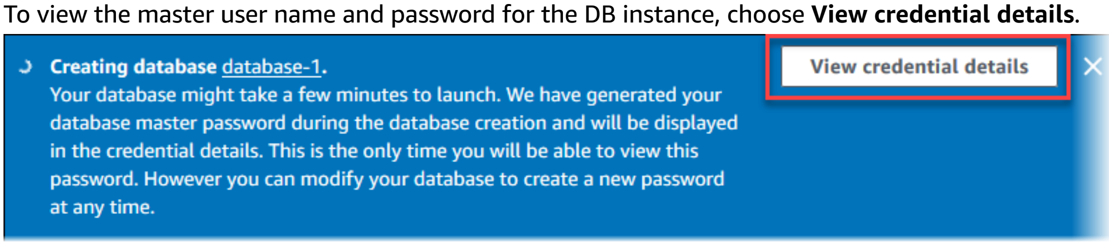
Easy create sets the following configurations to their default values, some of which can be changed later. If you want to change any of these settings now, use Standard Create.

Configuration	Value	Editable after database is created
Database Location	Regional	No
Database Features	provisioned	No
Automatic Backups	Enabled	No

   You can examine the default settings used when **Easy Create** is enabled. If you want to change one or more settings during database creation, choose **Standard Create** to set them. The **Editable after database creation** column shows which options you can change after database creation. To change a setting with **No** in that column, use **Standard Create**. For settings with **Yes** in that column, you can either use **Standard Create** or modify the DB instance after it's created to change the setting.
11. Choose **Create database**.

   If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

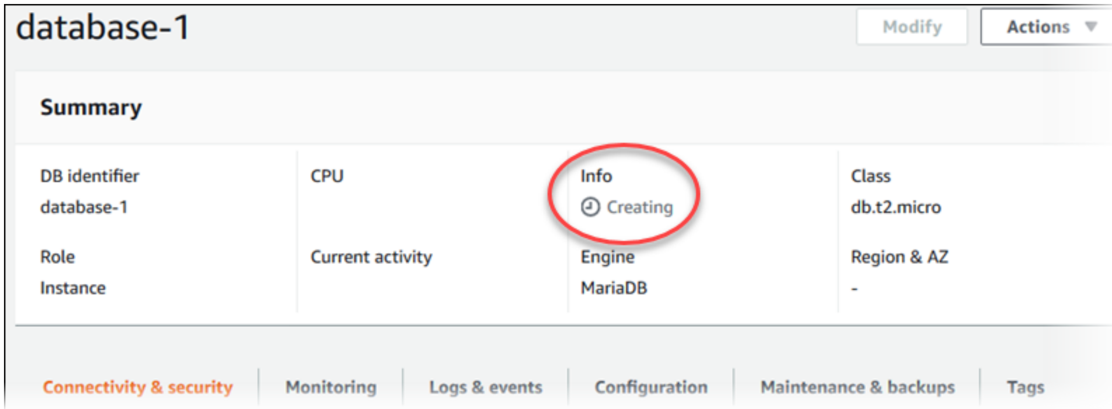
   To view the master user name and password for the DB instance, choose **View credential details**.



   To connect to the DB instance as the master user, use the user name and password that appear.

   Important
   You can't view the master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, you can modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
12. For **Databases**, choose the name of the new Maria DB instance.

   On the RDS console, the details for new DB instance appear. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.



Connecting to a Database on a DB Instance Running the MariaDB Database Engine

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to a database on the DB instance. In this example, you connect to a database on a Maria DB instance using the mysql command-line tool. One GUI-based application you can use to connect is HeidiSQL. For more information, see the Download HeidiSQL page. For more information on using MariaDB, see the MariaDB documentation.

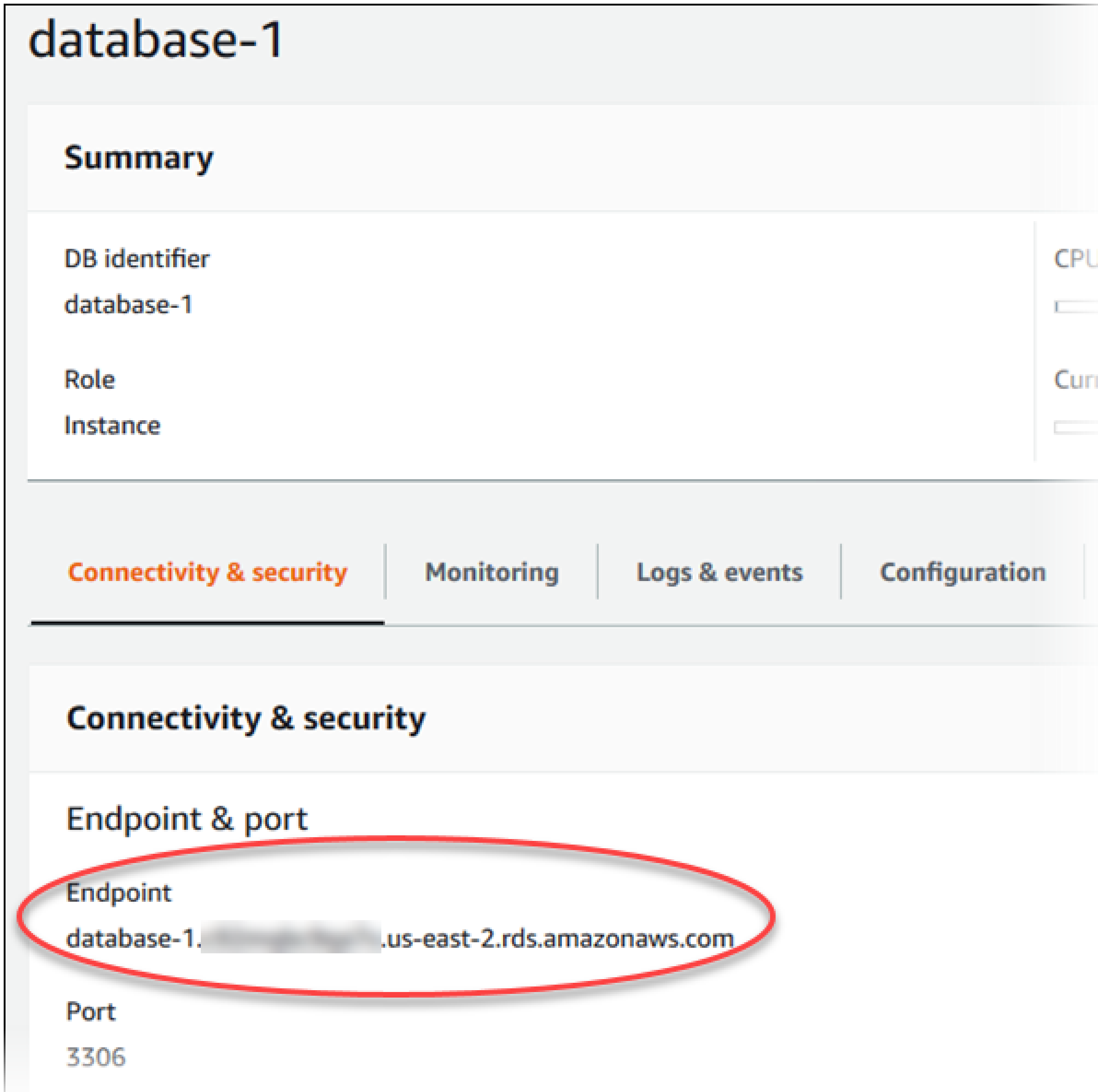
To connect to a database on a DB instance using the `mysql` command-line tool

1. Find the endpoint (DNS name) and port number for your DB instance.

   a. Open the RDS console and then choose **Databases** to display a list of your DB instances.

   b. Choose the Maria DB instance name to display its details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also note the port number. You need both the endpoint and the port number to connect to the DB instance.



2. Enter the following command at a command prompt on a client computer to connect to a database on a Maria DB instance. Substitute the DNS name (endpoint) for your DB instance for *<endpoint>*, the master user name you used for *<mymasteruser>*, and provide the master password you used when prompted for a password.

```
PROMPT> mysql -h <endpoint> -P 3306 -u <mymasteruser>  -p
```

After you enter the password for the user, you should see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 272
Server version: 5.5.5-10.0.17-MariaDB-log MariaDB Server

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```

```
affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql >
```

For more information about connecting to a MariaDB DB instance, see Connecting to a DB Instance Running the MariaDB Database Engine (p. 509). For information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Deleting a DB Instance

After you have connected to the sample DB instance that you created, you should delete the DB instance so you are no longer charged for it.

To delete a DB instance with no final DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance you want to delete.
4. For **Actions**, choose **Delete**.
5. For **Create final snapshot?**, choose **No**, and select the acknowledgment.
6. Choose **Delete**.

Creating a Microsoft SQL Server DB Instance and Connecting to a DB Instance

The basic building block of Amazon RDS is the DB instance. Your Amazon RDS DB instance is similar to your on-premises Microsoft SQL Server. After you create your SQL Server DB instance, you can add one or more custom databases to it.

> **Important**
> You must have an AWS account before you can create a DB instance. If you don't have an AWS account, open https://aws.amazon.com/, and then choose **Create an AWS Account**.

In this topic, you create a sample SQL Server DB instance. You then connect to the DB instance and run a simple query. Finally, you delete the sample DB instance.

Creating a Sample SQL Server DB Instance

The DB instance is where you run your Microsoft SQL Server databases.

Console

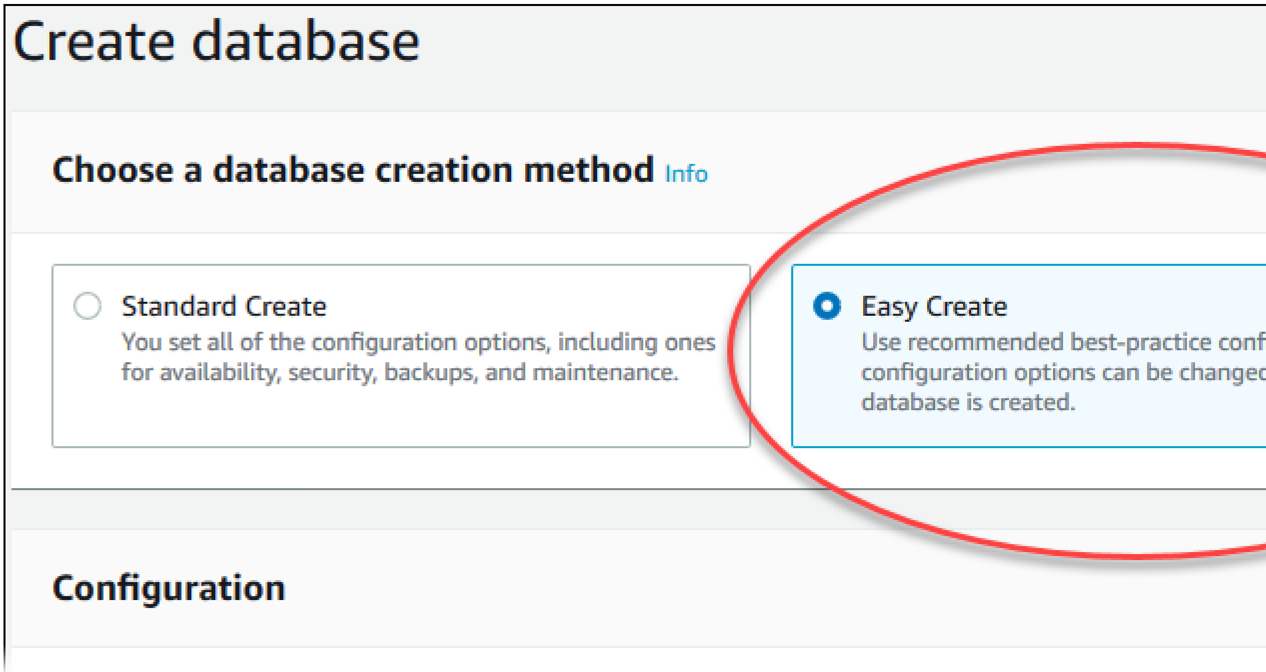
You can create a DB instance running Microsoft SQL Server with the AWS Management Console with **Easy Create** enabled or not enabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

For this example, you use **Easy Create** to create a DB instance running the Microsoft SQL Server database engine with a db.t2.micro DB instance class.

> **Note**
> For information about creating DB instances with **Easy Create** not enabled, see Creating an Amazon RDS DB Instance (p. 136).

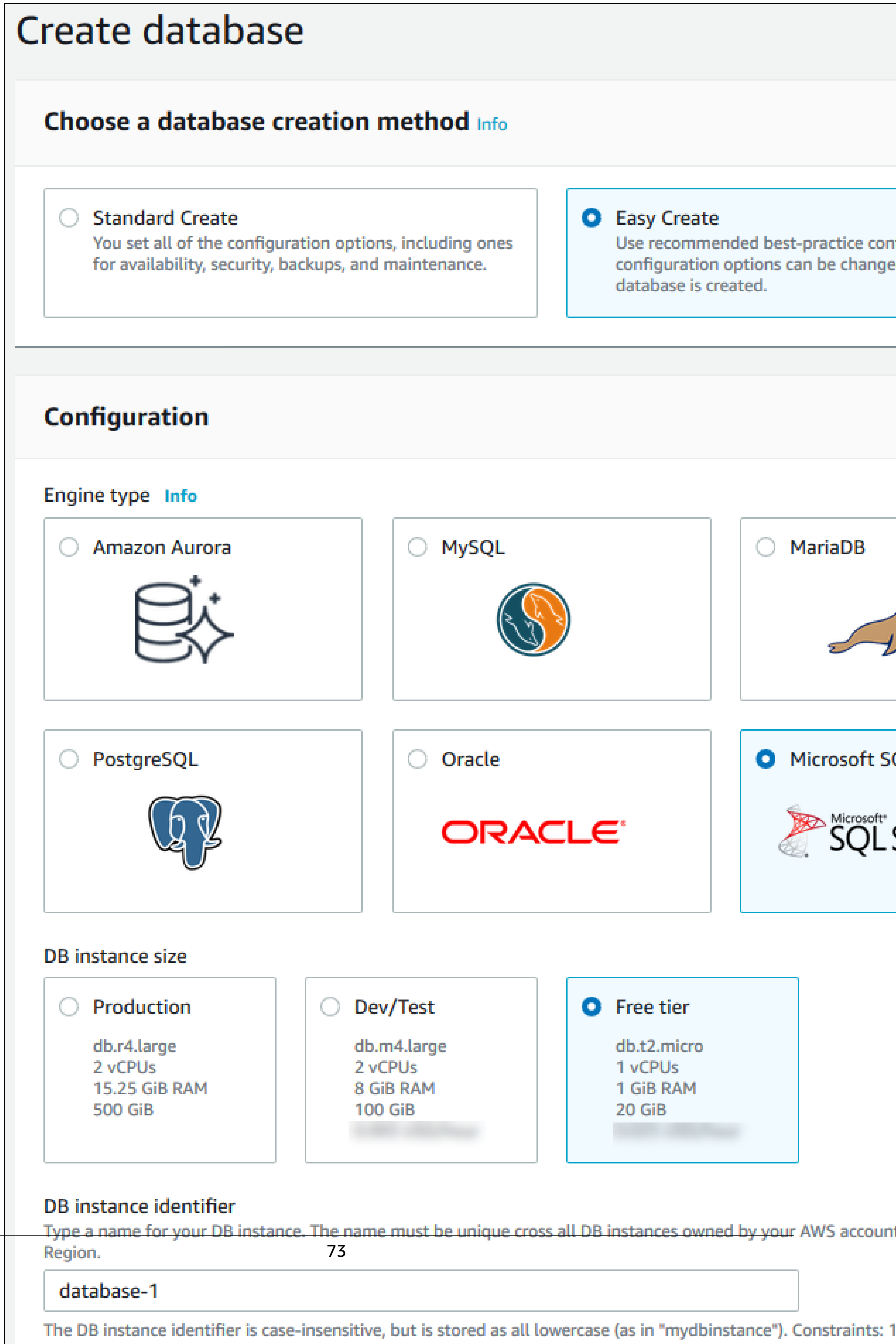
To create a Microsoft SQL Server DB instance with Easy Create enabled

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database** and make sure that **Easy Create** is chosen.



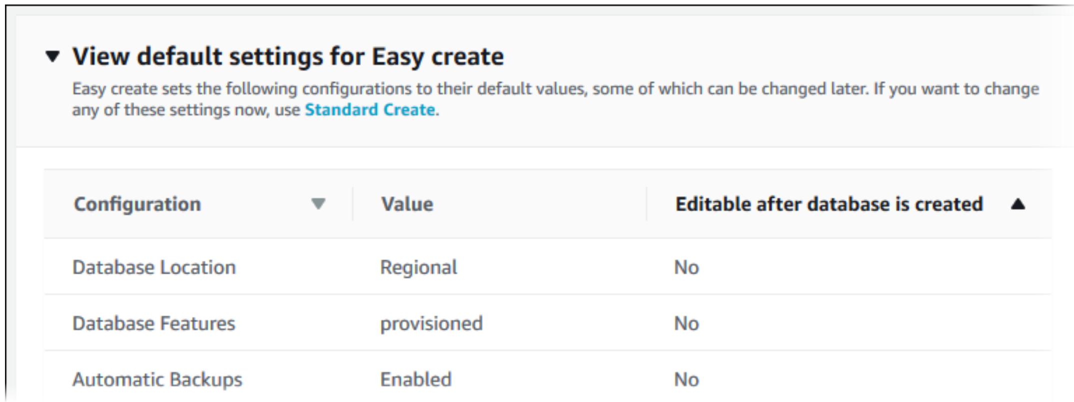
5. In **Configuration**, choose **Microsoft SQL Server**.
6. For **DB instance size**, choose **Free tier**.
7. For **DB instance identifier**, enter a name for the DB instance, or leave the default name.
8. For **Master username**, enter a name for the master user, or leave the default name.

   The **Create database** page should look similar to the following image.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice co
configuration options can be change
database is created.
Configuration
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft S
Microsoft
SQL
DB instance size
Production
db.r4.large
2 vCPUs
15.25 GiB RAM
500 GiB
Dev/Test
db.m4.large
2 vCPUs
8 GiB RAM
100 GiB
Free tier
db.t2.micro
1 vCPUs
1 GiB RAM
20 GiB
DB instance identifier
Type a name for your DB instance. The name must be unique cross all DB instances owned by your AWS accoun
Region.
database-1
The DB instance identifier is case-insensitive, but is stored as all lowercase (as in "mydbinstance"). Constraints: 1

9. To use an automatically generated master password for the DB instance, make sure that the **Auto generate a password** check box is chosen.

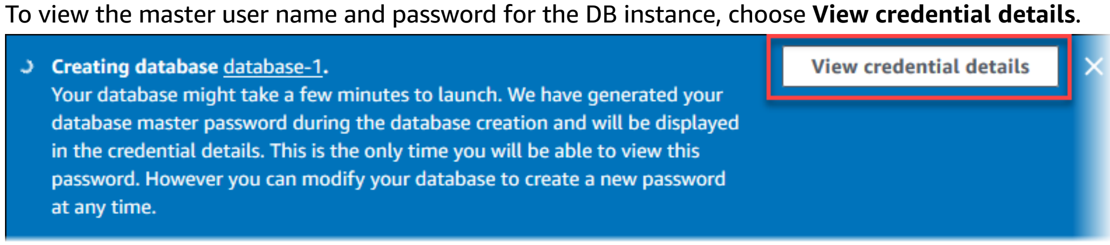
   To enter your master password, clear the **Auto generate a password** check box, and then enter the same password in **Master password** and **Confirm password**.
10. (Optional) Open **View default settings for Easy create**.



   You can examine the default settings used when **Easy Create** is enabled. If you want to change one or more settings during database creation, choose **Standard Create** to set them. The **Editable after database creation** column shows which options you can change after database creation. To change a setting with **No** in that column, use **Standard Create**. For settings with **Yes** in that column, you can either use **Standard Create** or modify the DB instance after it's created to change the setting.
11. Choose **Create database**.

   If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

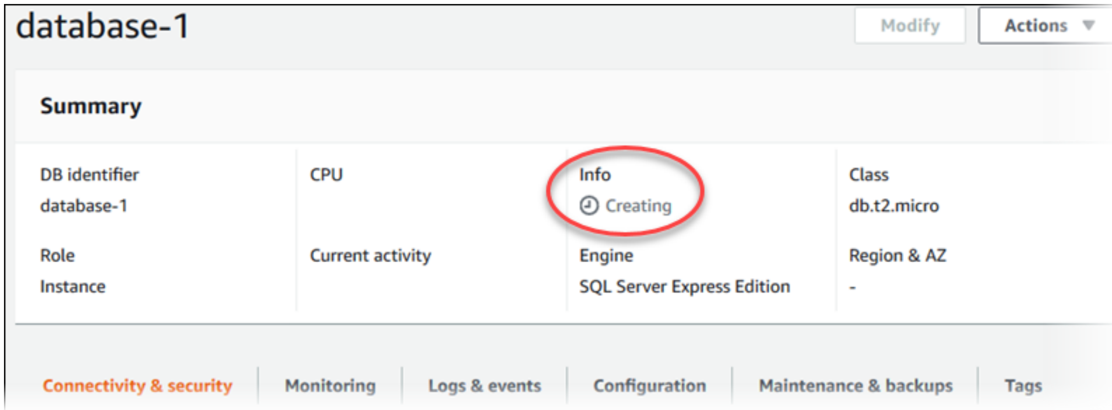
   To view the master user name and password for the DB instance, choose **View credential details**.



   To connect to the DB instance as the master user, use the user name and password that appear.

   Important
   You can't view the master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, you can modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
12. For **Databases**, choose the name of the new Microsoft SQL Server DB instance.

   On the RDS console, the details for new DB instance appear. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.



Connecting to Your Sample SQL Server DB Instance

In this procedure, you connect to your sample DB instance by using Microsoft SQL Server Management Studio (SSMS).

Before you begin, your database should have a status of **Available**. If it has a status of **Creating** or **Backup-up**, wait until it's **Available**. The status updates without requiring you to refresh the page. This process can take up to 20 minutes.

Also, make sure you have SSMS installed. If you can also connect to SQL Server on RDS by using a different tools, such as an add-in for your development environment or some other database tool. However, this tutorial only covers using SSMS. To download a stand-alone version of this SSMS, see Download SQL Server Management Studio (SSMS) in the Microsoft documentation.

To connect to a DB instance using SSMS

1. Find the DNS name and port number for your DB instance.

   a. Open the RDS console, and then choose **Databases** to display a list of your DB instances.

   b. Hover your mouse cursor over the name **sample-instance**, which is blue. When you do this, the mouse cursor changes into a selection icon (for example, a pointing hand). Also, the DB instance name, becomes underlined.

      Click on the DB instance name to choose it. The screen changes to display the information for the DB instance you choose.

   c. On the **Connectivity** tab, which opens by default, copy the endpoint. The **Endpoint** looks something like this: `sample-instance.abc2defghije.us-west-2.rds.amazonaws.com`. Also, take note of the port number. The default port for SQL Server is 1433. If yours is different, write it down.

2. Start SQL Server Management Studio.

   The **Connect to Server** dialog box appears.

3. Provide the information for your sample DB instance.

   a. For **Server type**, choose **Database Engine**.

   b. For **Server name**, enter the DNS name, followed by a comma and the port number (the default port is 1433). For example, your server name should look like the following.

```
sample-instance.abc2defghije.us-west-2.rds.amazonaws.com,1433
```

c. For **Authentication**, choose **SQL Server Authentication**.

d. For **Login**, enter the user name that you chose to use for your sample DB instance. This is also known as the master user name.

e. For **Password**, enter the password that you chose earlier for your sample DB instance. This is also known as the master user password.

4. Choose **Connect**.

   After a few moments, SSMS connects to your DB instance.

   If you can't connect to your DB instance, see Troubleshooting Connections to Your SQL Server DB Instance (p. 567).

Exploring Your Sample SQL Server DB Instance

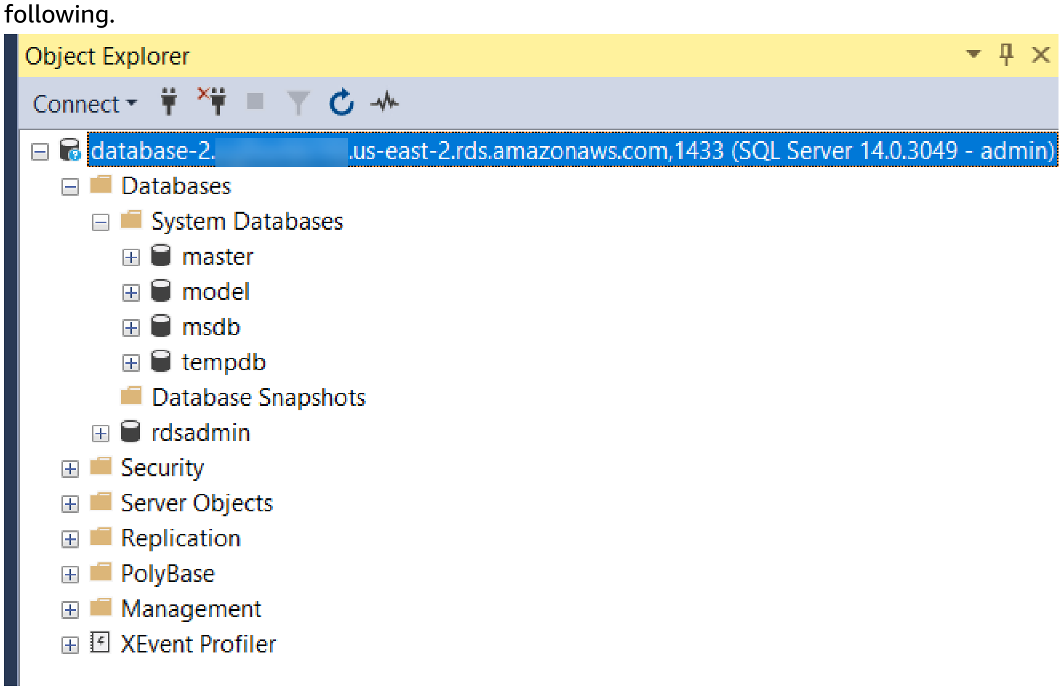
In this procedure, you continue the previous procedure and explore your sample DB instance by using Microsoft SQL Server Management Studio (SSMS).

To explore a DB instance using SSMS

1. Your SQL Server DB instance comes with SQL Server's standard built-in system databases (master, model, msdb, and tempdb). To explore the system databases, do the following:

   a. In SSMS, on the **View** menu, choose **Object Explorer**.

   b. Expand your DB instance, expand **Databases**, and then expand **System Databases** as shown following.



2. Your SQL Server DB instance also comes with a database named `rdsadmin`. Amazon RDS uses this database to store the objects that it uses to manage your database. The `rdsadmin` database also includes stored procedures that you can run to perform advanced tasks.

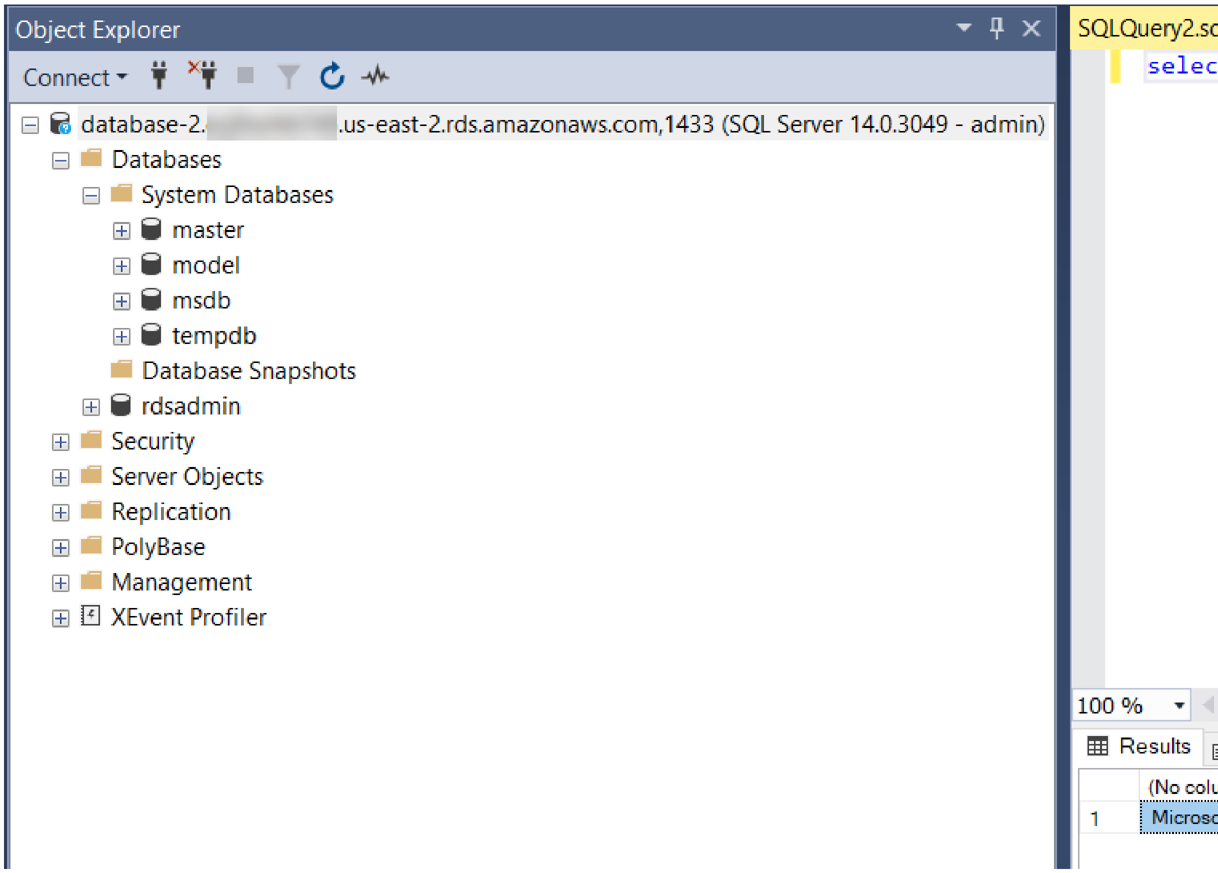
3. You can now start creating your own databases and running queries against your DB instance and databases as usual. To run a test query against your sample DB instance, do the following:

   a. In SSMS, on the **File** menu point to **New** and then choose **Query with Current Connection**.

b. Enter the following SQL query.

```
select @@VERSION
```

c. Run the query. SSMS returns the SQL Server version of your Amazon RDS DB instance.



Deleting Your Sample DB Instance

After you are done exploring the sample DB instance that you created, you should delete the DB instance so that you are no longer charged for it.

To delete a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the button next to **sample-instance**, or whatever you named your sample DB instance.
4. Choose **Delete** from the **Actions** above (it's to the left of the orange **Create database** button.

   If you see a message that says **This database has deletion protection option enabled**, follow these steps:

   - Choose **Modify**.
   - On the **Deletion protection** card (near the bottom of the page), clear the box next to **Enable deletion protection**. Then choose **Continue**.

- On the **Scheduling of modifications** card, choose **Apply immediately.** Then choose **Modify DB Instance**.
- Try again to delete the instance by choosing **Delete** from the **Actions** menu.

5. Clear the box for **Create final snapshot**. Because this isn't a production database, you don't need to save a copy of it.
6. Verify that you selected the correct database to delete. The name "sample-instance" displays in the title of the screen: **Delete sample-instance instance?**

   If you don't recognize the name of your sample instance in the title, choose **Cancel** and start over.
7. To confirm that you want to permanently delete the database that is displayed in the title of this screen, do the following:

   - Check the box to confirm: **I acknowledge that upon instance deletion, automated backups, including system snapshots and point-in-time recovery, will no longer be available**.
   - Type "`delete me`" into the box **To confirm deletion, type *delete me* into the field**.
   - Choose **Delete**. This action can't be undone.

   The database shows a status of **Deleting** until deletion is complete.

Creating a MySQL DB Instance and Connecting to a Database on a MySQL DB Instance

The easiest way to create a DB instance is to use the AWS Management Console. After you have created the DB instance, you can use standard MySQL utilities such as MySQL Workbench to connect to a database on the DB instance.

> **Important**
> Before you can create or connect to a DB instance, you must complete the tasks in Setting Up for Amazon RDS (p. 58).

Topics

Creating a MySQL DB Instance

The basic building block of Amazon RDS is the DB instance. This environment is where you run your MySQL databases.

Console

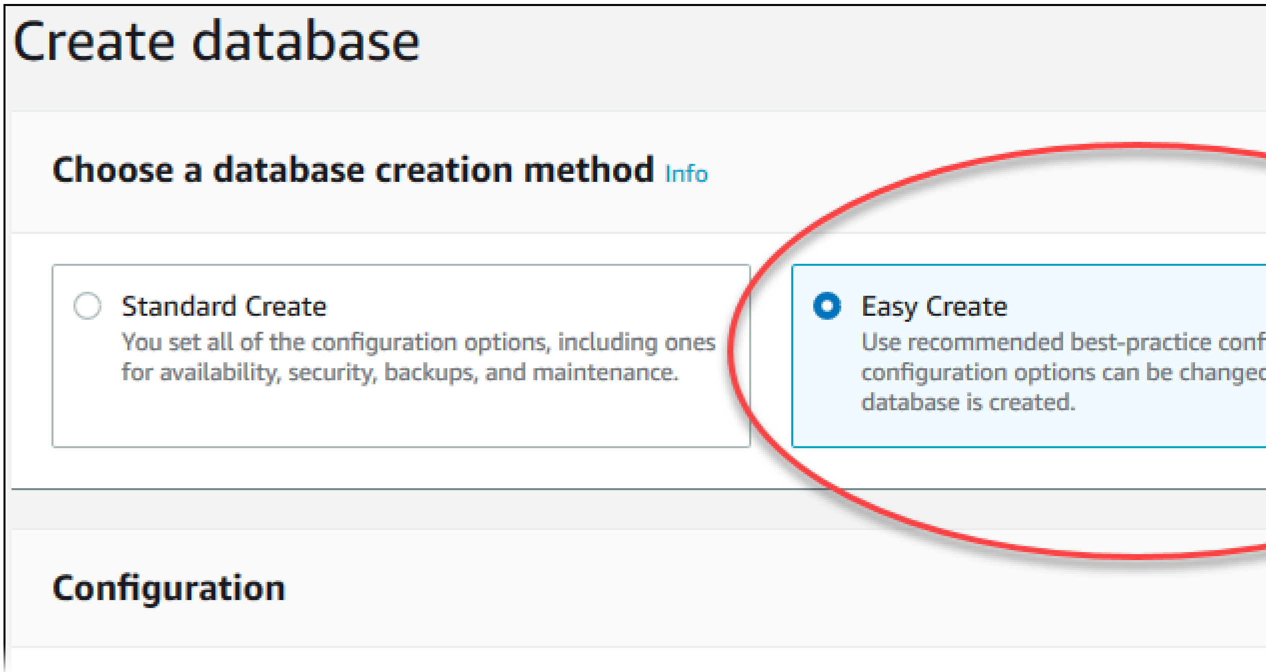
You can create a DB instance running MySQL with the AWS Management Console with **Easy Create** enabled or disabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

In this example, you use **Easy Create** to create a DB instance running the MySQL database engine with a db.t2.micro DB instance class.

Note
For information about creating DB instances with **Easy Create** not enabled, see Creating an Amazon RDS DB Instance (p. 136).

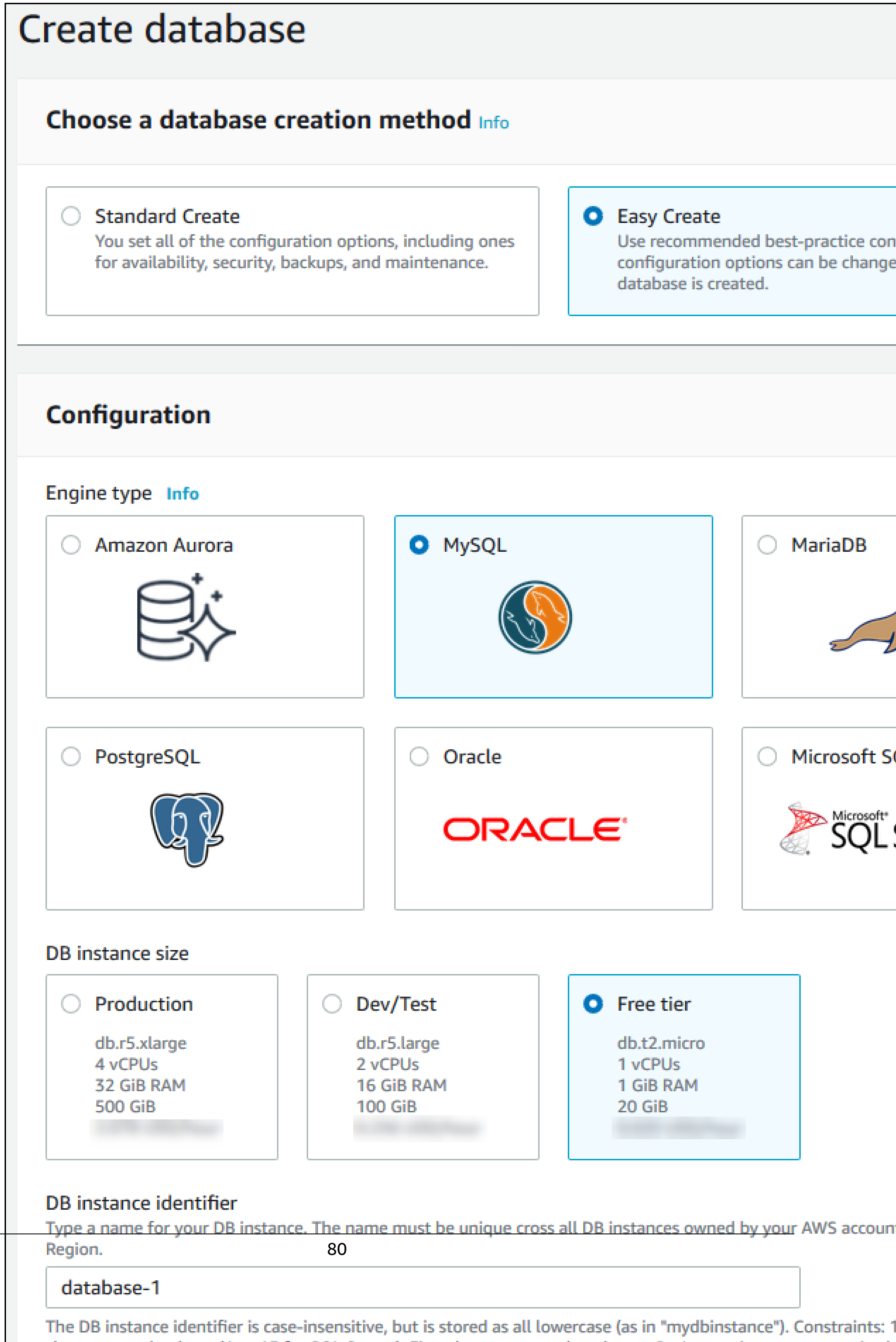
To create a MySQL DB instance with Easy Create enabled

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database** and make sure that **Easy Create** is chosen.



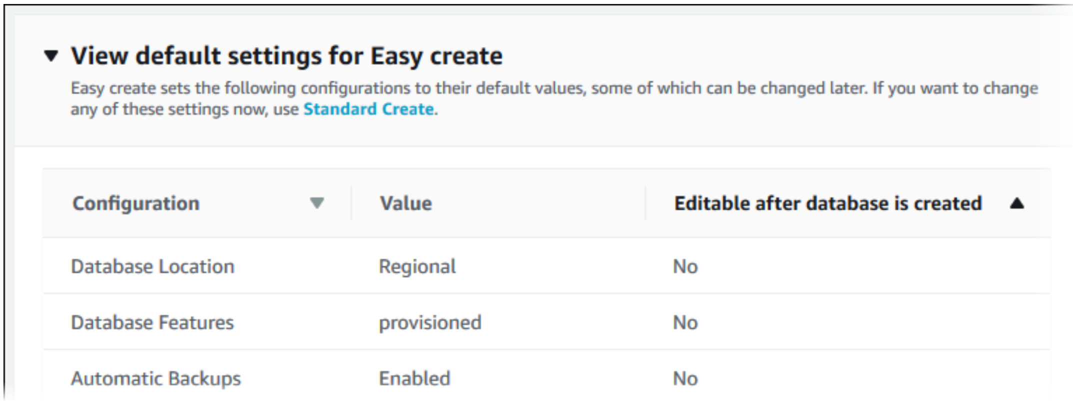
5. In **Configuration**, choose **MySQL**.
6. For **DB instance size**, choose **Free tier**.
7. For **DB instance identifier**, enter a name for the DB instance, or leave the default name.
8. For **Master username**, enter a name for the master user, or leave the default name.

   The **Create database** page should look similar to the following image.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice con
configuration options can be change
database is created.
Configuration
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft S
Microsoft SQL
DB instance size
Production
db.r5.xlarge
4 vCPUs
32 GiB RAM
500 GiB
Dev/Test
db.r5.large
2 vCPUs
16 GiB RAM
100 GiB
Free tier
db.t2.micro
1 vCPUs
1 GiB RAM
20 GiB
DB instance identifier
Type a name for your DB instance. The name must be unique cross all DB instances owned by your AWS accoun
Region.
database-1
The DB instance identifier is case-insensitive, but is stored as all lowercase (as in "mydbinstance"). Constraints: 1

9. To use an automatically generated master password for the DB instance, enable **Auto generate a password**.

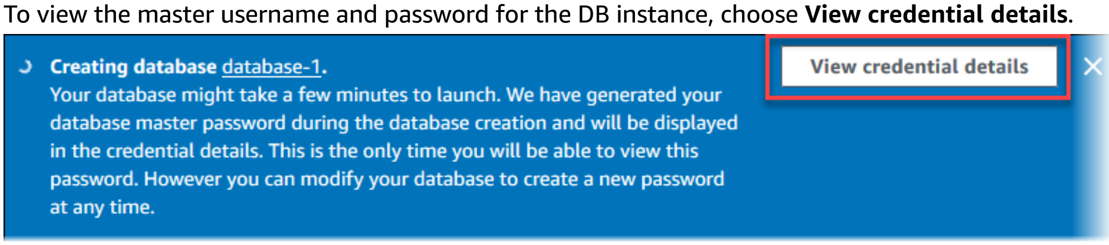
   To enter your master password, disable **Auto generate a password**, and then enter the same password in **Master password** and **Confirm password**.
10. (Optional) Open **View default settings for Easy create**.



   You can examine the default settings used when **Easy Create** is enabled. If you want to change one or more settings during database creation, choose **Standard Create** to set them. The **Editable after database creation** column shows which options you can change after database creation. To change a setting with **No** in that column, use **Standard Create**. For settings with **Yes** in that column, you can either use **Standard Create** or modify the DB instance after it is created to change the setting.
11. Choose **Create database**.

   If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

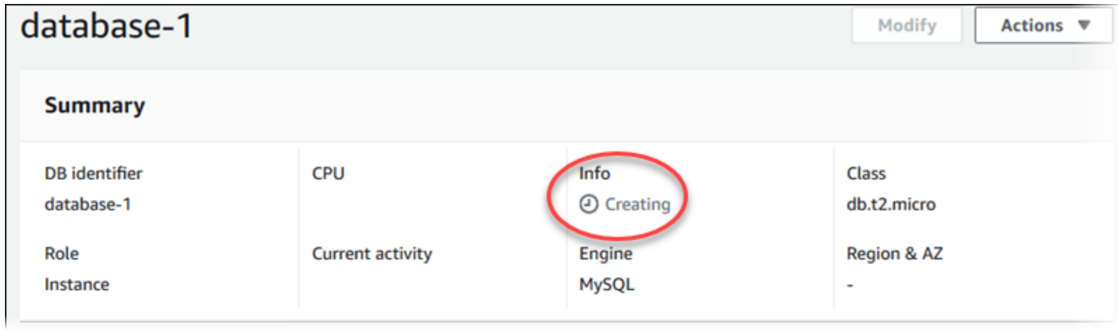
   To view the master username and password for the DB instance, choose **View credential details**.



   You can use the username and password that appears to connect to the DB instance as the master user.

   Important
   You won't be able to view master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, you can modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
12. In the **Databases** list, choose the name of the new MySQL DB instance.

   On the RDS console, the details for new DB instance appear. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.



Connecting to a Database on a DB Instance Running the MySQL Database Engine

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to a database on the DB instance. In this example, you connect to a database on a MySQL DB instance using MySQL monitor commands. One GUI-based application you can use to connect is MySQL Workbench; for more information, go to the Download MySQL Workbench page. For more information on using MySQL, go to the MySQL documentation. For information about installing MySQL (including the MySQL client), see Installing and Upgrading MySQL.

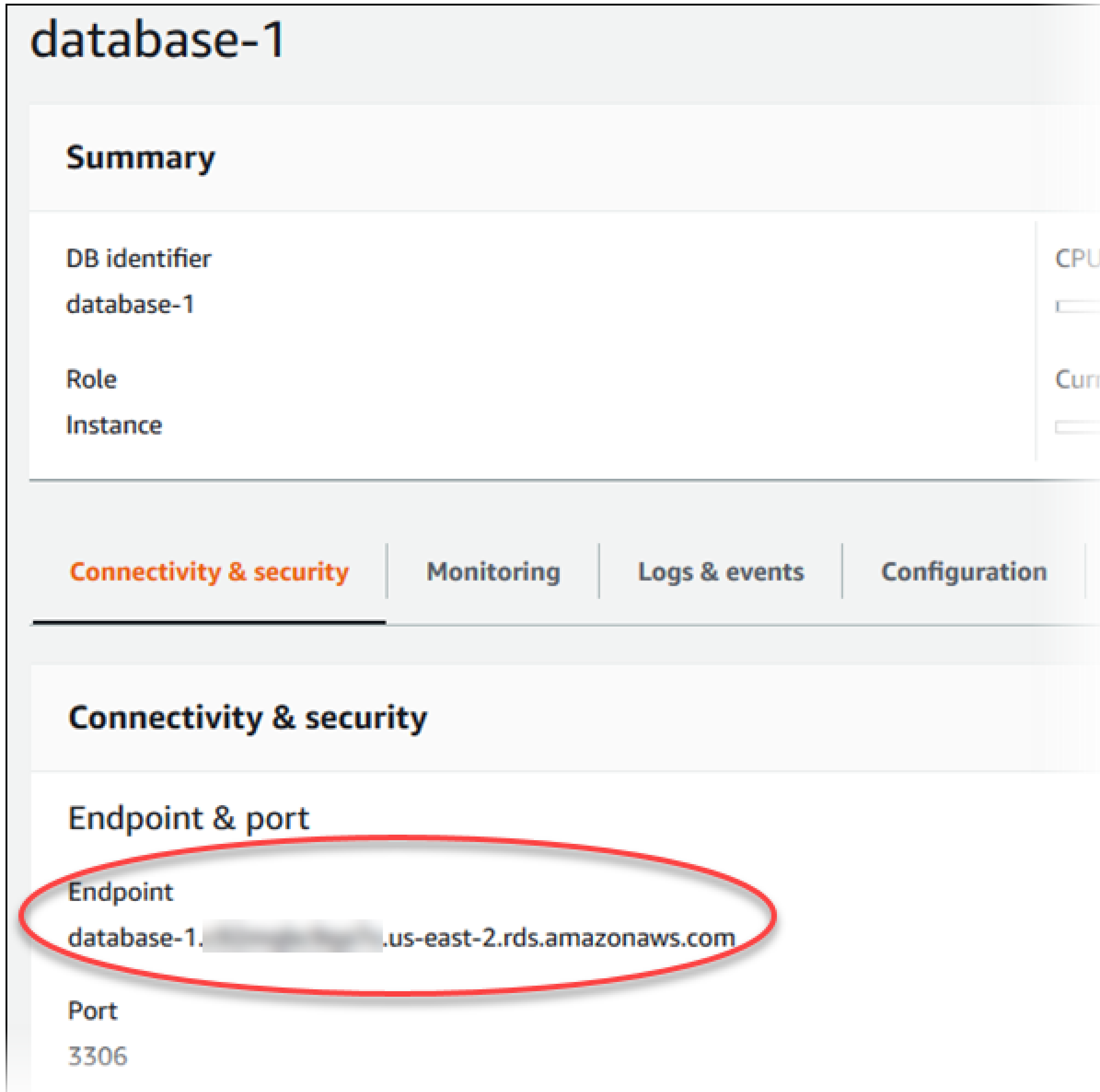
To connect to a database on a DB instance using MySQL monitor

1. Find the endpoint (DNS name) and port number for your DB instance.

   a. Open the RDS console and then choose **Databases** to display a list of your DB instances.

   b. Choose the MySQL DB instance name to display its details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



2. Download a SQL client that you can use to connect to the DB instance.

   You can connect to an Amazon RDS MySQL DB instance by using tools like the MySQL command line utility. For more information on using the MySQL client, go to mysql - The MySQL Command Line Tool in the MySQL documentation. One GUI-based application you can use to connect is MySQL Workbench. For more information, go to the Download MySQL Workbench page.

3. Connect to the a database on a MySQL DB instance. For example, enter the following command at a command prompt on a client computer to connect to a database on a MySQL DB instance using the MySQL client. Substitute the DNS name for your DB instance for *<endpoint>*, the master user name you used for *<mymasteruser>*, and provide the master password you used when prompted for a password.

```
PROMPT> mysql -h <endpoint> -P 3306 -u <mymasteruser> -p
```

   After you enter the password for the user, you should see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 350
Server version: 5.6.40-log MySQL Community Server (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

If you can't connect to your MySQL DB instance, two common causes of connection failures to a new DB instance are:

- The DB instance was created using a security group that does not authorize connections from the device or Amazon EC2 instance where the MySQL application or utility is running. If the DB instance was created in a VPC, it must have a VPC security group that authorizes the connections. If the DB instance was created outside of a VPC, it must have a DB security group that authorizes the connections. For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
- The DB instance was created using the default port of 3306, and your company has firewall rules blocking connections to that port from devices in your company network. To fix this failure, recreate the instance with a different port.

For more information about connecting to a MySQL DB instance, see Connecting to a DB Instance Running the MySQL Database Engine (p. 722). For information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Deleting a DB Instance

After you have connected to the sample DB instance that you created, you should delete the DB instance so you are no longer charged for it.

To delete a DB instance with no final DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to delete.
4. For **Actions**, choose **Delete**.
5. For **Create final snapshot?**, choose **No**, and select the acknowledgment.
6. Choose **Delete**.

Creating an Oracle DB Instance and Connecting to a Database on an Oracle DB Instance

The basic building block of Amazon RDS is the DB instance. Your Amazon RDS DB instance is similar to your on-premises Oracle database.

> **Important**
> You must have an AWS account before you can create a DB instance. If you don't have an AWS account, open https://aws.amazon.com/, and then choose **Create an AWS Account**.

In this topic, you create a sample Oracle DB instance. You then connect to the DB instance and run a simple query. Finally, you delete the sample DB instance.

Creating a Sample Oracle DB Instance

The DB instance is where you run your Oracle databases.

Console

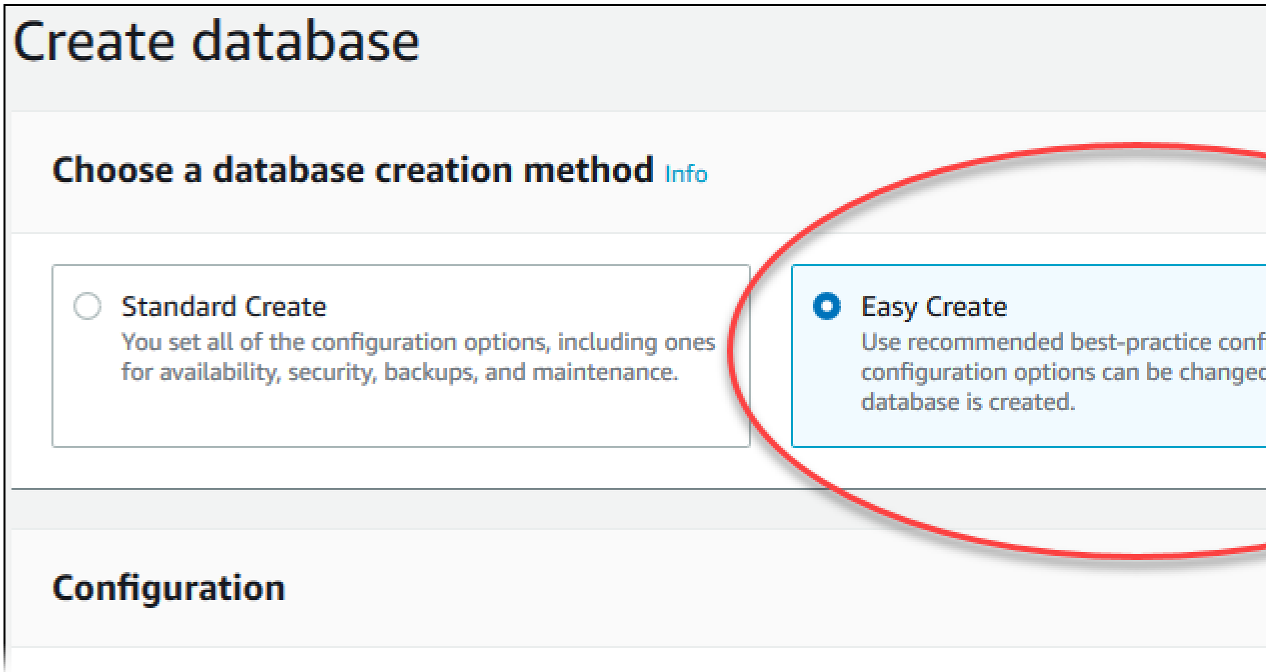
You can create a DB instance running Oracle with the AWS Management Console with **Easy Create** enabled or not enabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

For this example, you use **Easy Create** to create a DB instance running the Oracle database engine with a db.t2.micro DB instance class.

> **Note**
> For information about creating DB instances with **Easy Create** not enabled, see Creating an Amazon RDS DB Instance (p. 136).

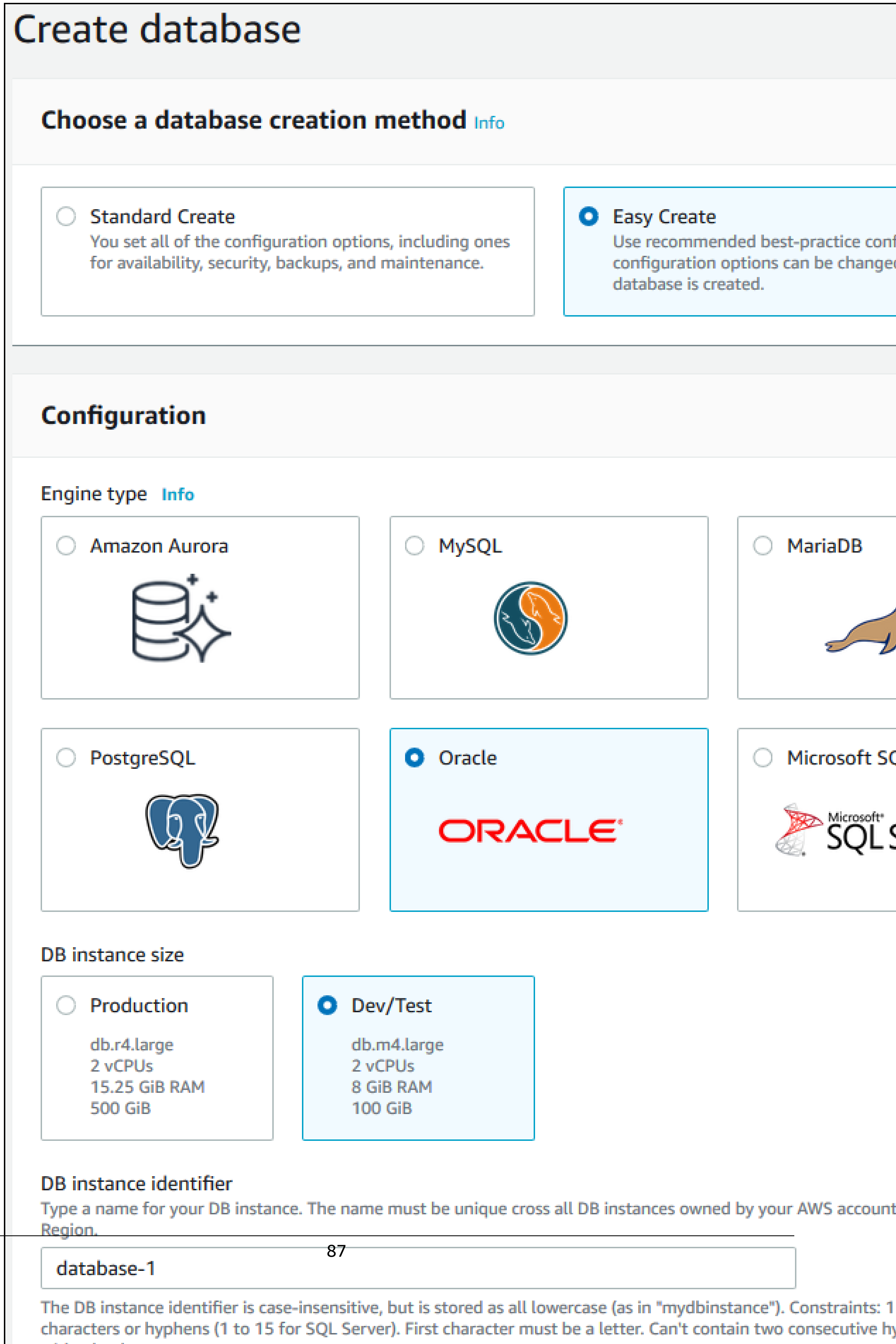
To create an Oracle DB instance with Easy Create enabled

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database** and ensure that **Easy Create** is chosen.



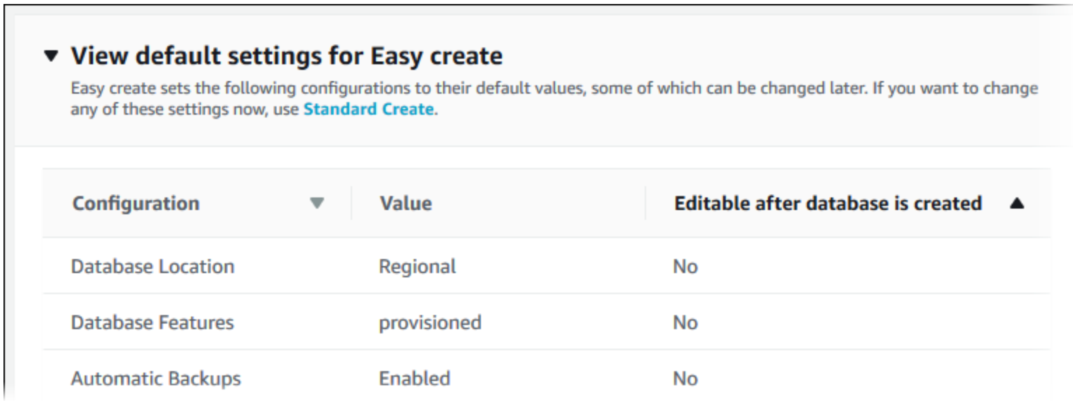
5. In **Configuration**, choose **Oracle**.
6. For **DB instance size**, choose **Free tier**. If **Free tier** isn't available, choose **Dev/Test**.
7. For **DB instance identifier**, enter a name for the DB instance, or leave the default name.
8. For **Master username**, enter a name for the master user, or leave the default name.

   The **Create database** page should look similar to the following image.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice conf
configuration options can be change
database is created.
Configuration
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft SC
Microsoft
SQL S
DB instance size
Production
db.r4.large
2 vCPUs
15.25 GiB RAM
500 GiB
Dev/Test
db.m4.large
2 vCPUs
8 GiB RAM
100 GiB
DB instance identifier
Type a name for your DB instance. The name must be unique cross all DB instances owned by your AWS account
Region.
database-1
The DB instance identifier is case-insensitive, but is stored as all lowercase (as in "mydbinstance"). Constraints: 1
characters or hyphens (1 to 15 for SQL Server). First character must be a letter. Can't contain two consecutive hy

9. To use an automatically generated master password for the DB instance, make sure that the **Auto generate a password** check box is chosen.

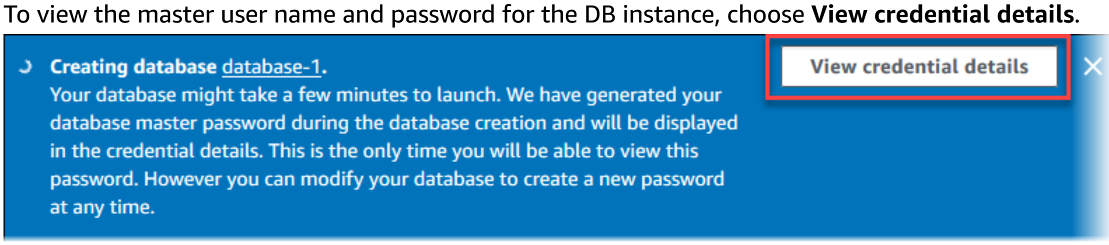
   To enter your master password, clear the **Auto generate a password** check box, and then enter the same password in **Master password** and **Confirm password**.
10. (Optional) Open **View default settings for Easy create**.

    You can examine the default settings that are used when **Easy Create** is enabled. If you want to change one or more settings during database creation, choose **Standard Create** to set them. The **Editable after database creation** column shows which options you can change after database creation. To change a setting with **No** in that column, use **Standard Create**. For settings with **Yes** in that column, you can either use **Standard Create** or modify the DB instance after it's created to change the setting.
11. Choose **Create database**.

    If you used an automatically generated password, the **View credential details** button appears on the **Databases** page.

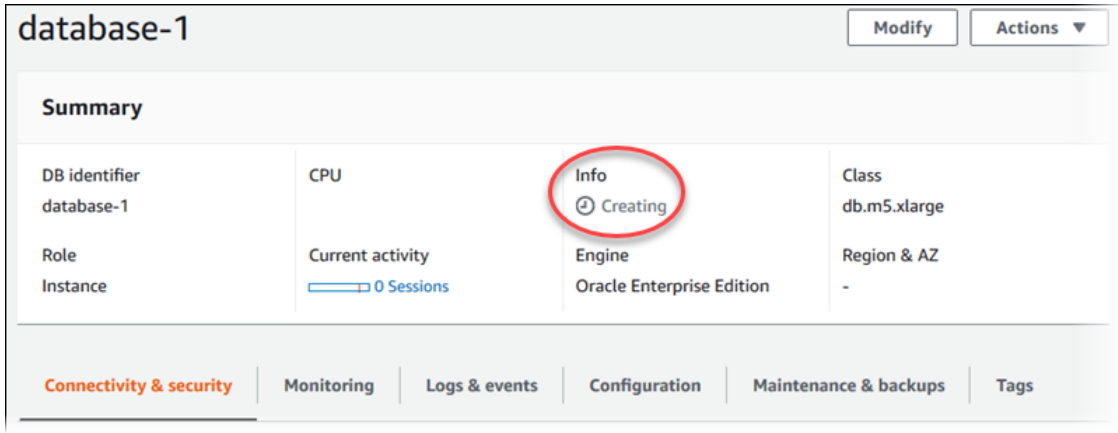
    To view the master user name and password for the DB instance, choose **View credential details**.

    To connect to the DB instance as the master user, use the user name and password that appear.

    Important
    >You can't view the master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, you can modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
12. For **Databases**, choose the name of the new Oracle DB instance.

    On the RDS console, the details for new DB instance appear. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.



Connecting to Your Sample Oracle DB Instance

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to the DB instance. In this procedure, you connect to your sample DB instance by using the Oracle sqlplus command line utility. To download a stand-alone version of this utility, see SQL*Plus User's Guide and Reference.

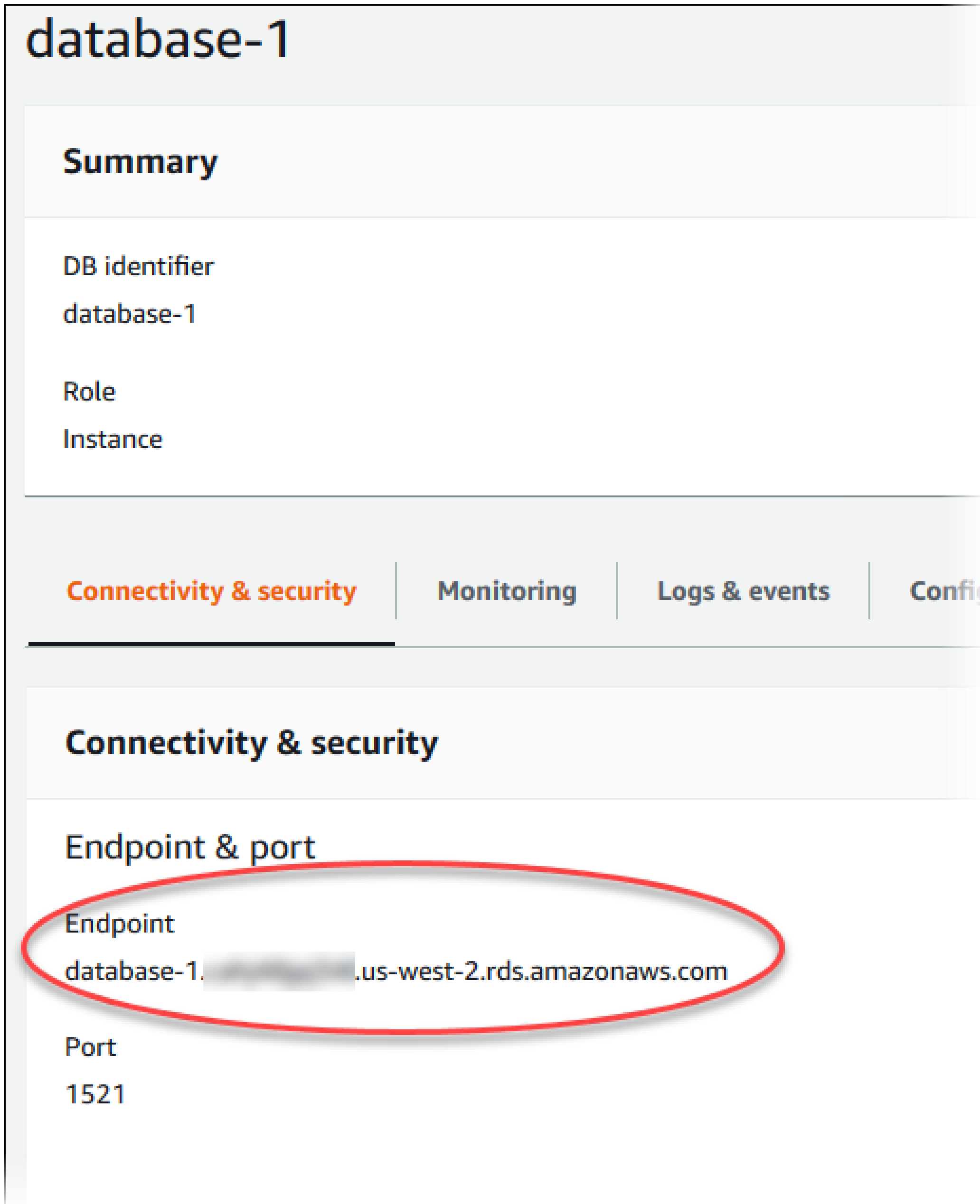
To connect to a DB Instance using SQL*Plus

1. Find the endpoint (DNS name) and port number for your DB Instance.

   a. Open the RDS console and then choose **Databases** to display a list of your DB instances.

   b. Choose the Oracle DB instance name to display its details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



2. Enter the following command on one line at a command prompt to connect to your DB instance by using the sqlplus utility. The value for `Host` is the endpoint for your DB instance, and the value for `Port` is the port you assigned the DB instance. The value for the Oracle `SID` is the name of the DB instance's database that you specified when you created the DB instance, not the name of the DB instance.

```
PROMPT>sqlplus 'mydbusr@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=endpoint)(PORT=1521))
(CONNECT_DATA=(SID=ORCL)))'
```

You should see output similar to the following.

```
SQL*Plus: Release 11.1.0.7.0 - Production on Wed May 25 15:13:59 2011
```

```
SQL>
```

For more information about connecting to an Oracle DB instance, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874). For information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Deleting Your Sample DB Instance

After you are done exploring the sample DB instance that you created, you should delete the DB instance so that you are no longer charged for it.

To delete a DB instance with no final DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to delete.
4. For **Actions**, choose **Delete**.
5. For **Create final snapshot?**, choose **No**, and choose the acknowledgment.
6. Choose **Delete**.

Creating a PostgreSQL DB Instance and Connecting to a Database on a PostgreSQL DB Instance

The easiest way to create a DB instance is to use the RDS console. After you have created the DB instance, you can use standard SQL client utilities to connect to the DB instance, such as the pgAdmin utility. In this example, you create a DB instance running the PostgreSQL database engine called database-1, with a db.t2.micro DB instance class and 20 GiB of storage.

> **Important**
> Before you can create or connect to a DB instance, you must complete the tasks in Setting Up for Amazon RDS (p. 58).

Topics

Creating a PostgreSQL DB Instance

The basic building block of Amazon RDS is the DB instance. This environment is where you run your PostgreSQL databases.

Console

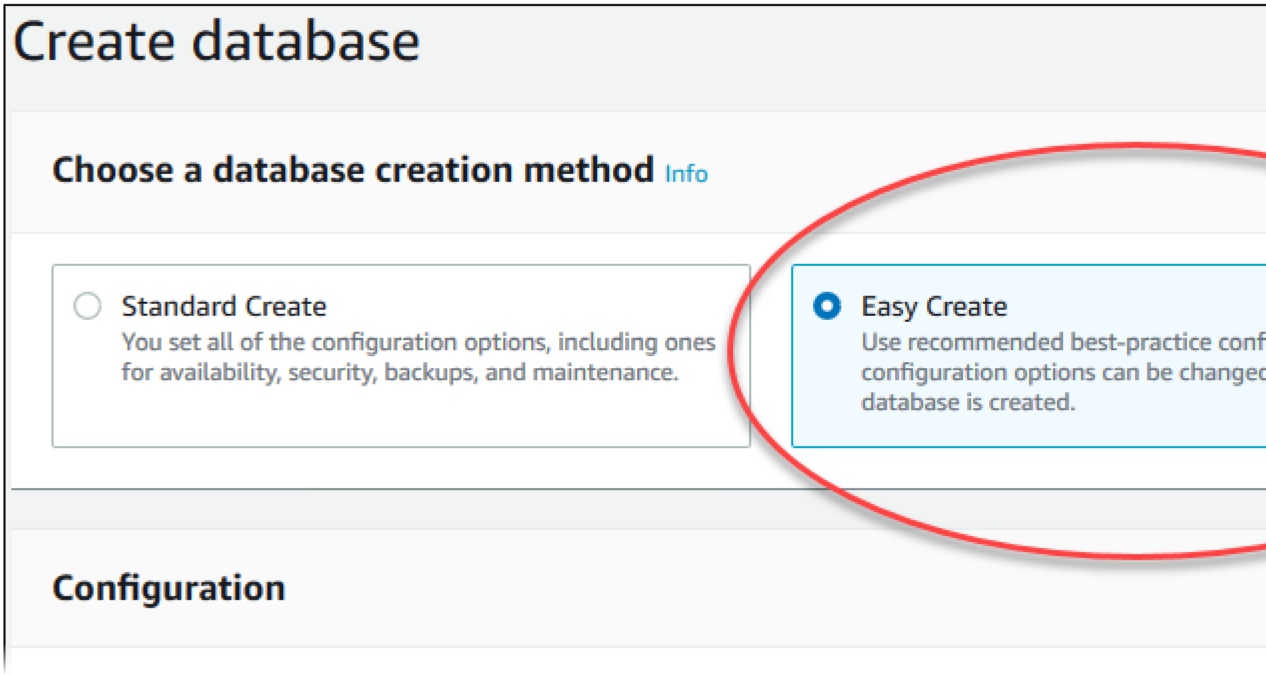
You can create a DB instance running PostgreSQL with the AWS Management Console with **Easy Create** enabled or disabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

In this example, you use **Easy Create** to create a DB instance running the PostgreSQL database engine with a db.t2.micro DB instance class.

> **Note**
> For information about creating DB instances with **Easy Create** not enabled, see Creating an Amazon RDS DB Instance (p. 136).

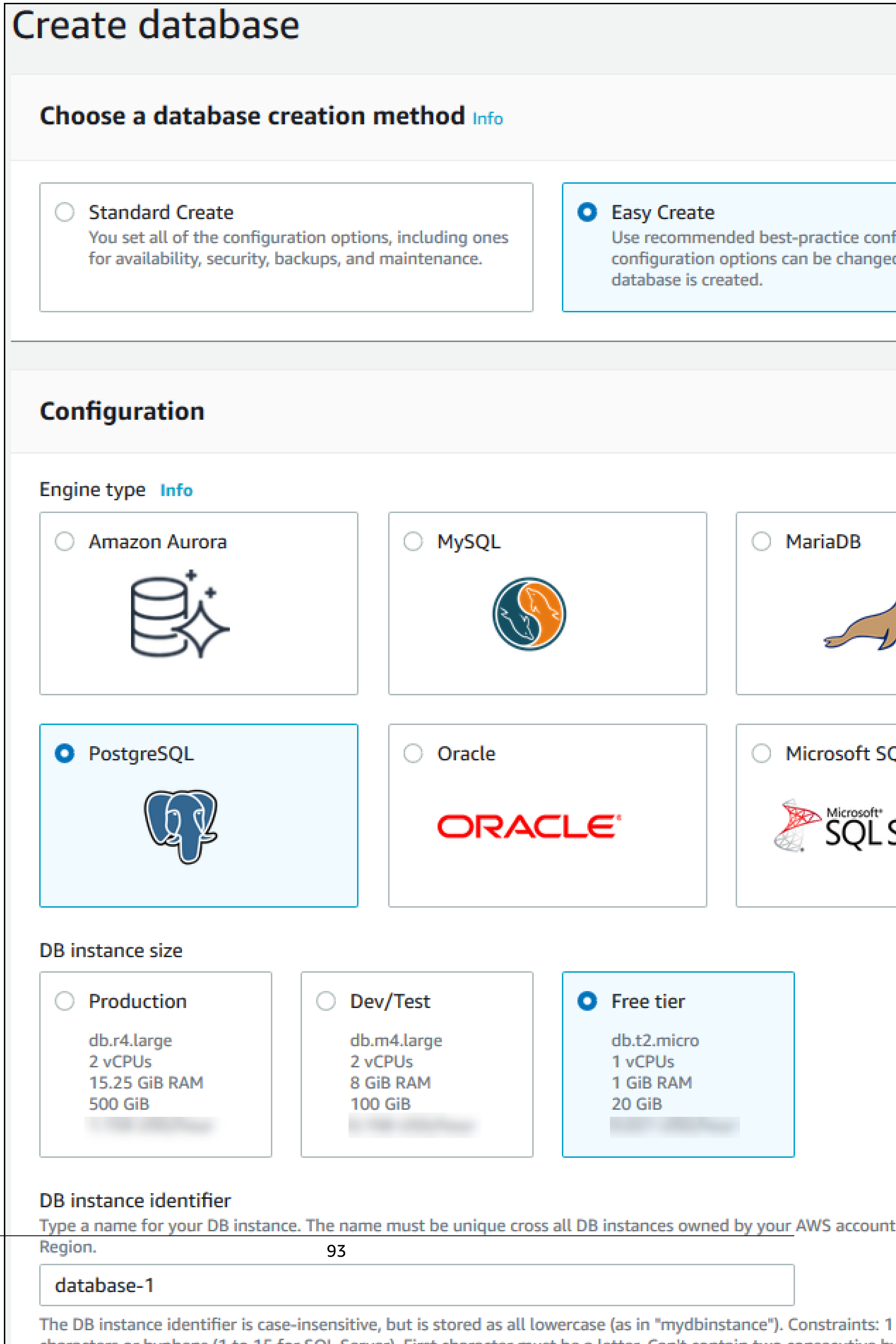
To create a PostgreSQL DB instance with Easy Create enabled

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database** and make sure that **Easy Create** is chosen.



5. In **Configuration**, choose **PostgreSQL**.
6. For **DB instance size**, choose **Free tier**.
7. For **DB instance identifier**, enter a name for the DB instance, or leave the default name.
8. For **Master username**, enter a name for the master user, or leave the default name.

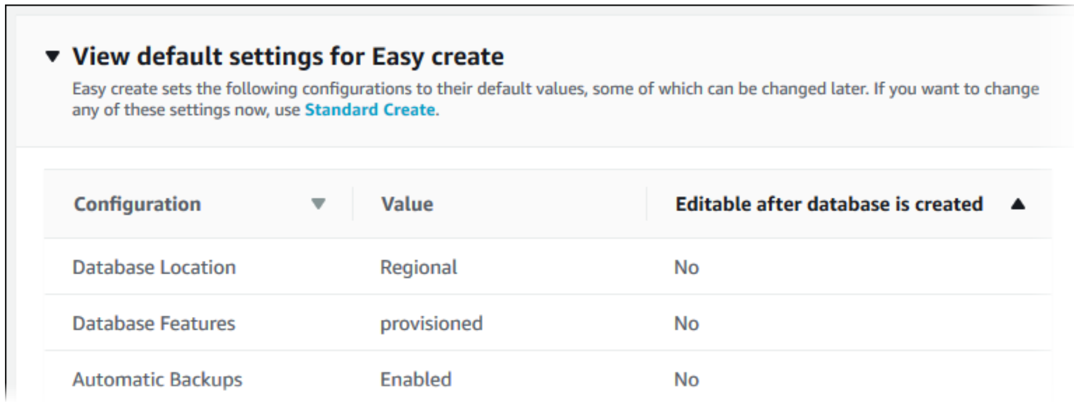
   The **Create database** page should look similar to the following image.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice conf
configuration options can be changed
database is created.
Configuration
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft SQ
Microsoft
SQL S
DB instance size
Production
db.r4.large
2 vCPUs
15.25 GiB RAM
500 GiB
Dev/Test
db.m4.large
2 vCPUs
8 GiB RAM
100 GiB
Free tier
db.t2.micro
1 vCPUs
1 GiB RAM
20 GiB
DB instance identifier
Type a name for your DB instance. The name must be unique cross all DB instances owned by your AWS account
Region.
database-1
The DB instance identifier is case-insensitive, but is stored as all lowercase (as in "mydbinstance"). Constraints: 1

9. To use an automatically generated master password for the DB instance, make sure that the **Auto generate a password** check box is chosen.

   To enter your master password, clear the **Auto generate a password** check box, and then enter the same password in **Master password** and **Confirm password**.

10. (Optional) Open **View default settings for Easy create**.

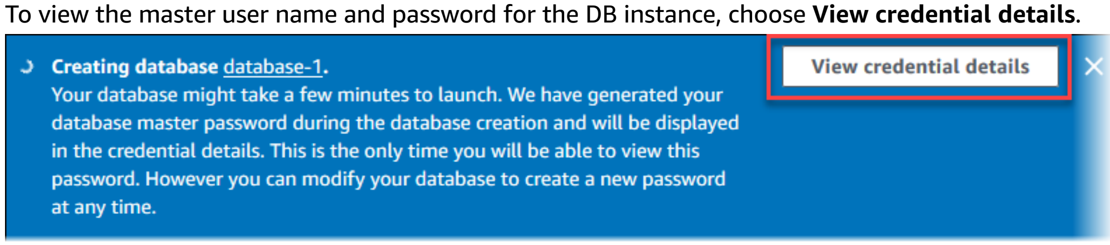


   You can examine the default settings used when **Easy Create** is enabled. If you want to change one or more settings during database creation, choose **Standard Create** to set them. The **Editable after database creation** column shows which options you can change after database creation. To change a setting with **No** in that column, use **Standard Create**. For settings with **Yes** in that column, you can either use **Standard Create** or modify the DB instance after it's created to change the setting.

11. Choose **Create database**.

   If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

   To view the master user name and password for the DB instance, choose **View credential details**.

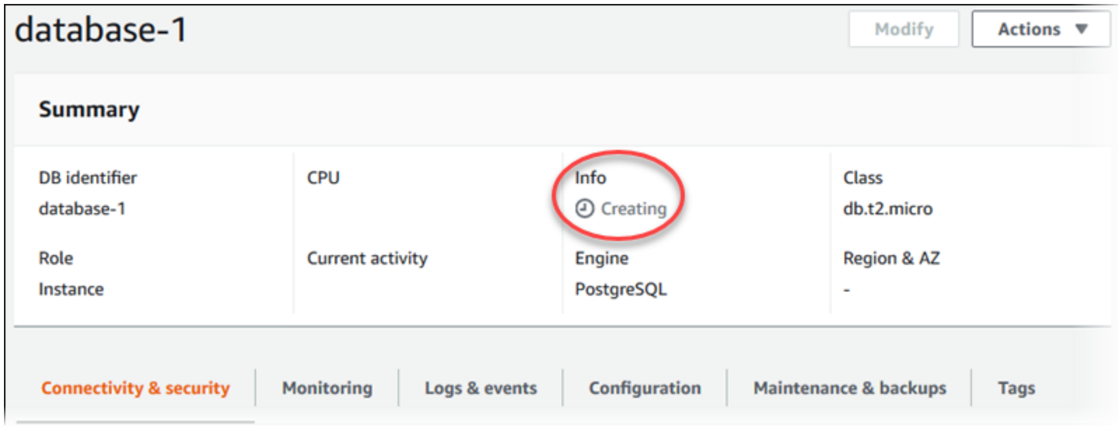


   To connect to the DB instance as the master user, use the user name and password that appear.

   Important
   You can't view the master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, you can modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

12. For **Databases**, choose the name of the new PostgreSQL DB instance.

   On the RDS console, the details for new DB instance appear. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.



Connecting to a PostgreSQL DB Instance

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to the instance. The security group that you assigned to the DB instance when you created it must allow access to the DB instance. If you have difficulty connecting to the DB instance, the problem is most often with the access rules you set up in the security group you assigned to the DB instance.

This section shows two ways to connect to a PostgreSQL DB instance. The first example uses pgAdmin, a popular open-source administration and development tool for PostgreSQL. You can download and use pgAdmin without having a local instance of PostgreSQL on your client computer. The second example uses psql, a command line utility that is part of a PostgreSQL installation. To use psql, you must have a PostgreSQL installed on your client computer or have installed the psql client on your machine.

In this example, you connect to a PostgreSQL DB instance using pgAdmin.

Using pgAdmin to Connect to a PostgreSQL DB Instance

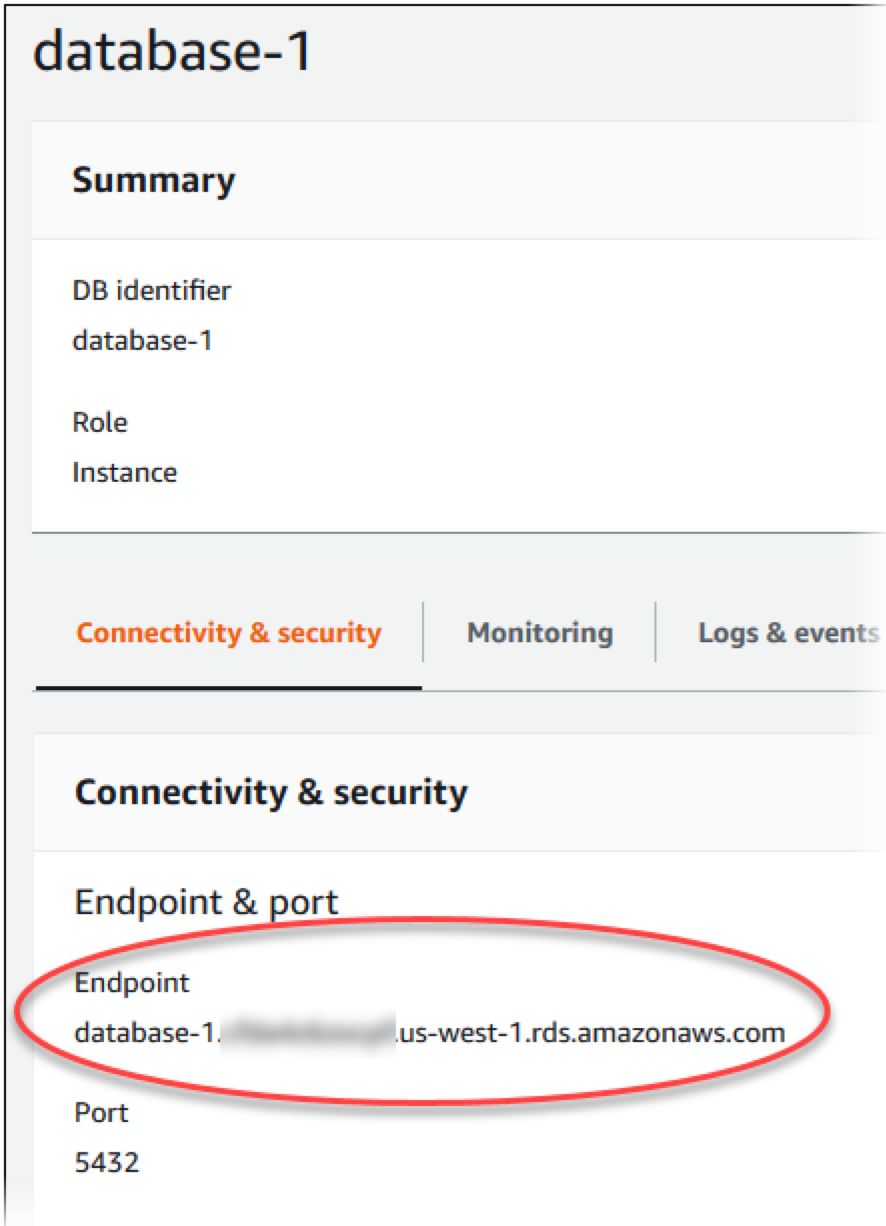
To connect to a PostgreSQL DB instance using pgAdmin

1. Find the endpoint (DNS name) and port number for your DB instance.

   a. Open the RDS console and then choose **Databases** to display a list of your DB instances.

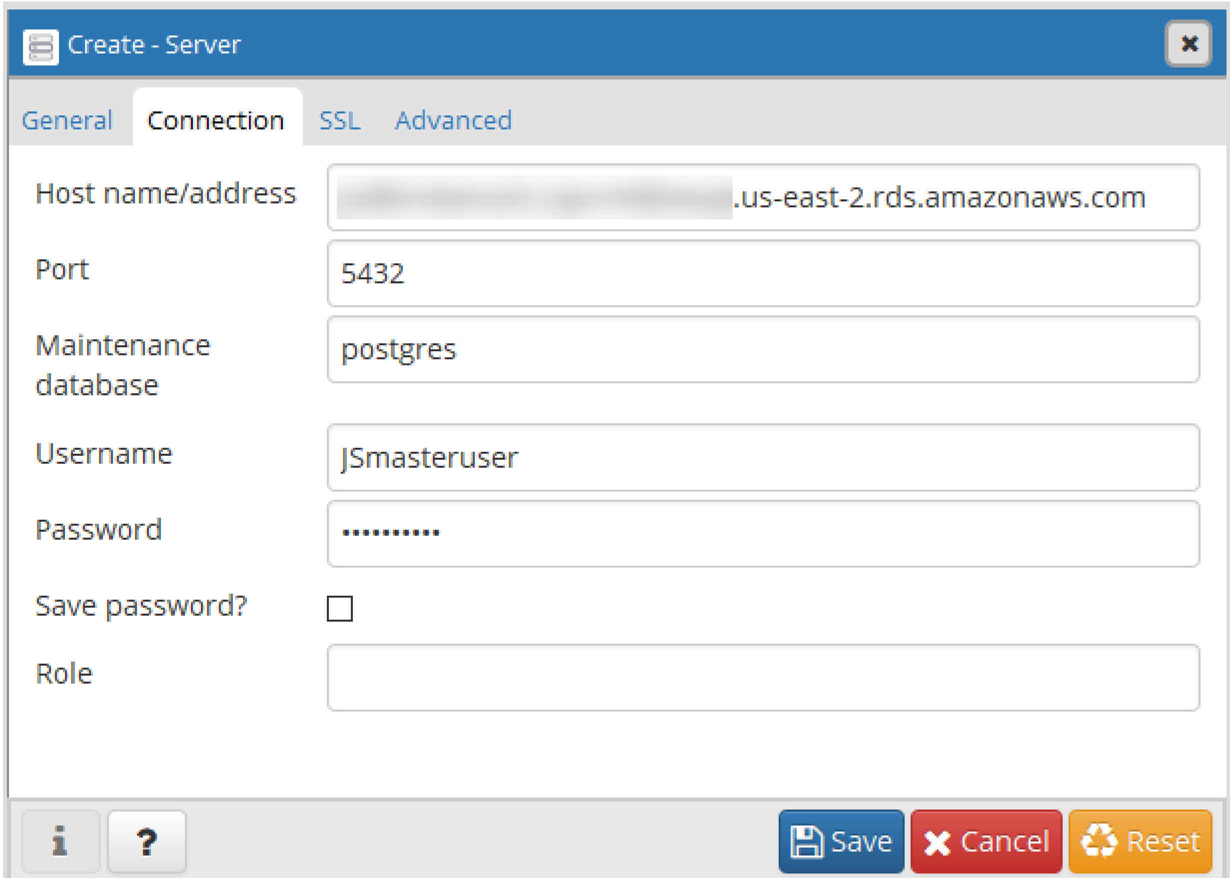
   b. Choose the PostgreSQL DB instance name to display its details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.

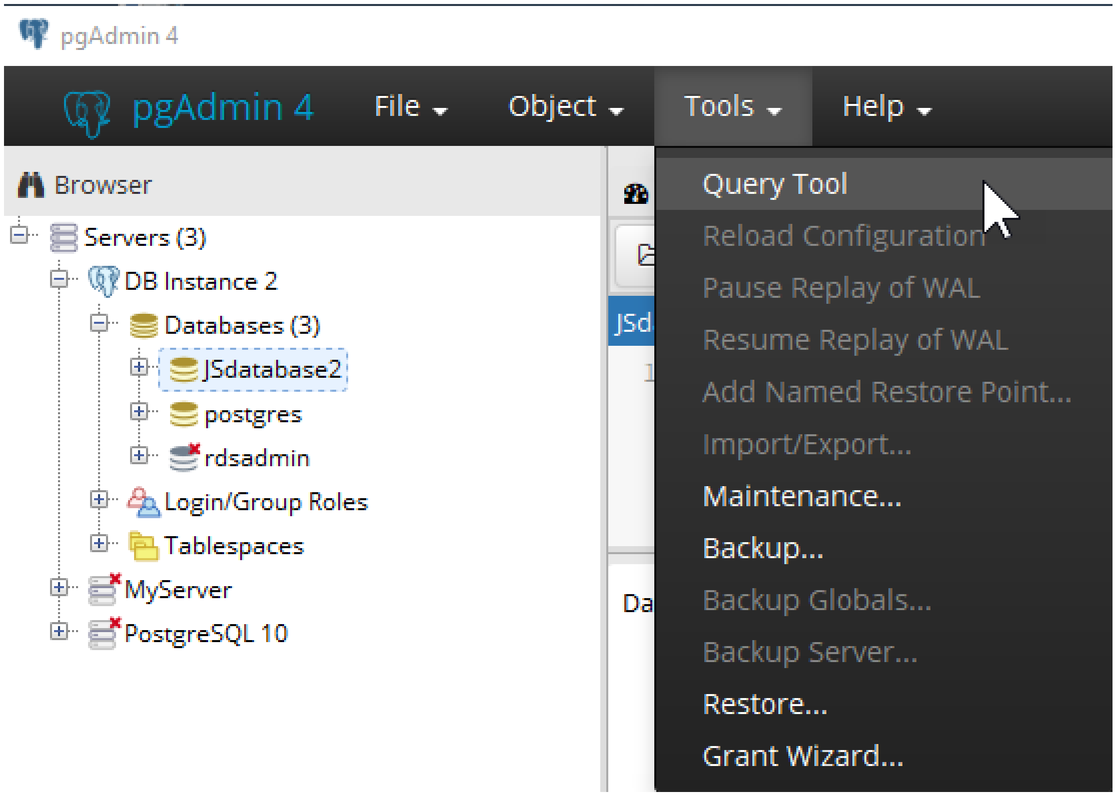


2. Install pgAdmin from http://www.pgadmin.org/. You can download and use pgAdmin without having a local instance of PostgreSQL on your client computer.
3. Launch the pgAdmin application on your client computer.
4. Choose **Add Server** from the **File** menu.
5. In the **New Server Registration** dialog box, enter the DB instance endpoint (for example, `database-1.c6c8dntfzzhgv0.us-west-1.rds.amazonaws.com`) in the **Host** box. Don't include the colon or port number as shown on the Amazon RDS console (`database-1.c6c8dntfzzhgv0.us-west-1.rds.amazonaws.com:5432`).

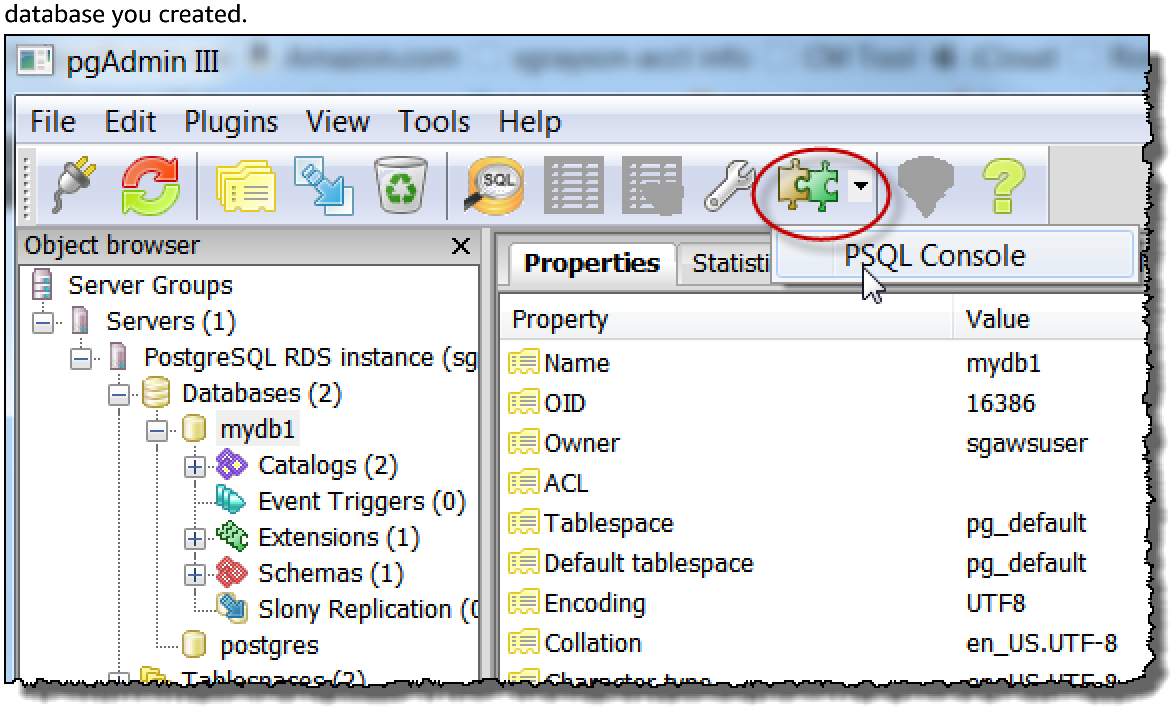
   Enter the port you assigned to the DB instance for **Port**. Enter the user name and user password that you entered when you created the DB instance for **Username** and **Password**.



6. Choose **OK**.
7. In the Object browser, expand **Server Groups**. Choose the server (the DB instance) you created, and then choose the database name.



8. Choose the plugin icon and choose **PSQL Console**. The psql command window opens for the default database you created.



9. Use the command window to enter SQL or psql commands. Enter `\q` to close the window.

Using psql to Connect to a PostgreSQL DB Instance

If your client computer has PostgreSQL installed, you can use a local instance of psql to connect to a PostgreSQL DB instance. To connect to your PostgreSQL DB instance using psql, provide host information and access credentials.

The following format is used to connect to a PostgreSQL DB instance on Amazon RDS.

```
psql --host=DB_instance_endpoint --port=port --username=master_user_name --password --
dbname=database_name
```

For example, the following command connects to a database called `mypgdb` on a PostgreSQL DB instance called `mypostgresql` using fictitious credentials.

```
psql --host=database-1.c6c8dntfzzhgv0.us-west-1.rds.amazonaws.com --port=5432 --
username=awsuser --password --dbname=postgres
```

Troubleshooting Connection Issues

By far the most common problem that occurs when attempting to connect to a database on a DB instance is the access rules in the security group assigned to the DB instance. If you used the default DB security group when you created the DB instance, chances are good that the security group did not have the rules that enable you to access the instance. For more information about Amazon RDS security groups, see Controlling Access with Security Groups (p. 1414)

The most common error is could not connect to server: Connection timed out. If you receive this error, check that the host name is the DB instance endpoint and that the port number is correct. Check that the security group assigned to the DB instance has the necessary rules to allow access through any firewall your connection may be going through.

Deleting a DB Instance

After you have connected to the sample DB instance that you created, you should delete the DB instance so you are no longer charged for it.

To delete a DB instance with no final DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to delete.
4. For **Actions**, choose **Delete**.
5. For **Create final snapshot?**, choose **No**, and select the acknowledgment.
6. Choose **Delete**.

Tutorial: Create a Web Server and an Amazon RDS Database

This tutorial helps you install an Apache web server with PHP, and create a MySQL database. The web server runs on an Amazon EC2 instance using Amazon Linux, and the MySQL database is an Amazon RDS MySQL DB instance. Both the Amazon EC2 instance and the Amazon RDS DB instance run in a virtual private cloud (VPC) based on the Amazon VPC service.

> **Note**
> This tutorial works with Amazon Linux and might not work for other versions of Linux such as Ubuntu.

Before you begin this tutorial, you must have a VPC with both public and private subnets, and corresponding security groups. If you don't have these, complete the following tasks in Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449):

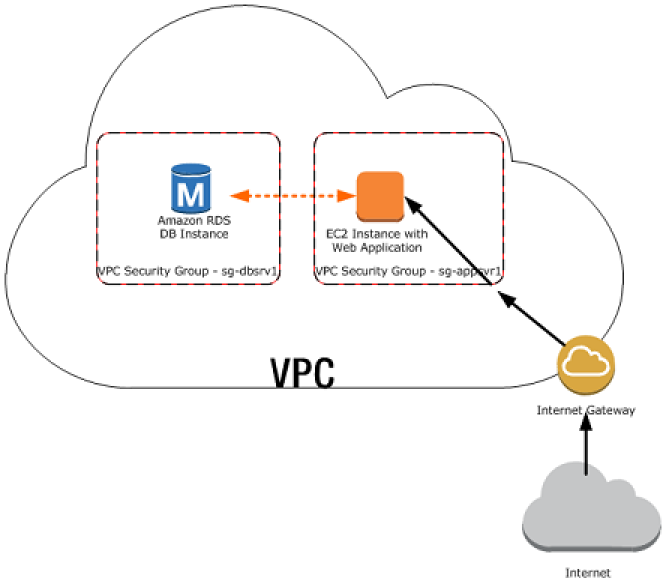
1. Create a VPC with Private and Public Subnets (p. 1449)
2. Create Additional Subnets (p. 1450)
3. Create a VPC Security Group for a Public Web Server (p. 1451)
4. Create a VPC Security Group for a Private DB Instance (p. 1452)
5. Create a DB Subnet Group (p. 1452)

In the tutorial that follows, you specify the VPC, subnets, and security groups when you create the DB instance. You also specify them when you create the EC2 instance that will host your web server. The VPC, subnets, and security groups are required for the DB instance and the web server to communicate. After the VPC is set up, this tutorial shows you how to create the DB instance and install the web server. You connect your web server to your RDS DB instance in the VPC using the DB instance endpoint.

In this tutorial, you perform the following procedures:

- Step 1: Create an RDS DB Instance (p. 101)
- Step 2: Create an EC2 Instance and Install a Web Server (p. 112)

The following diagram shows the configuration when the tutorial is complete.



Step 1: Create an RDS DB Instance

In this step, you create an Amazon RDS MySQL DB instance that maintains the data used by a web application.

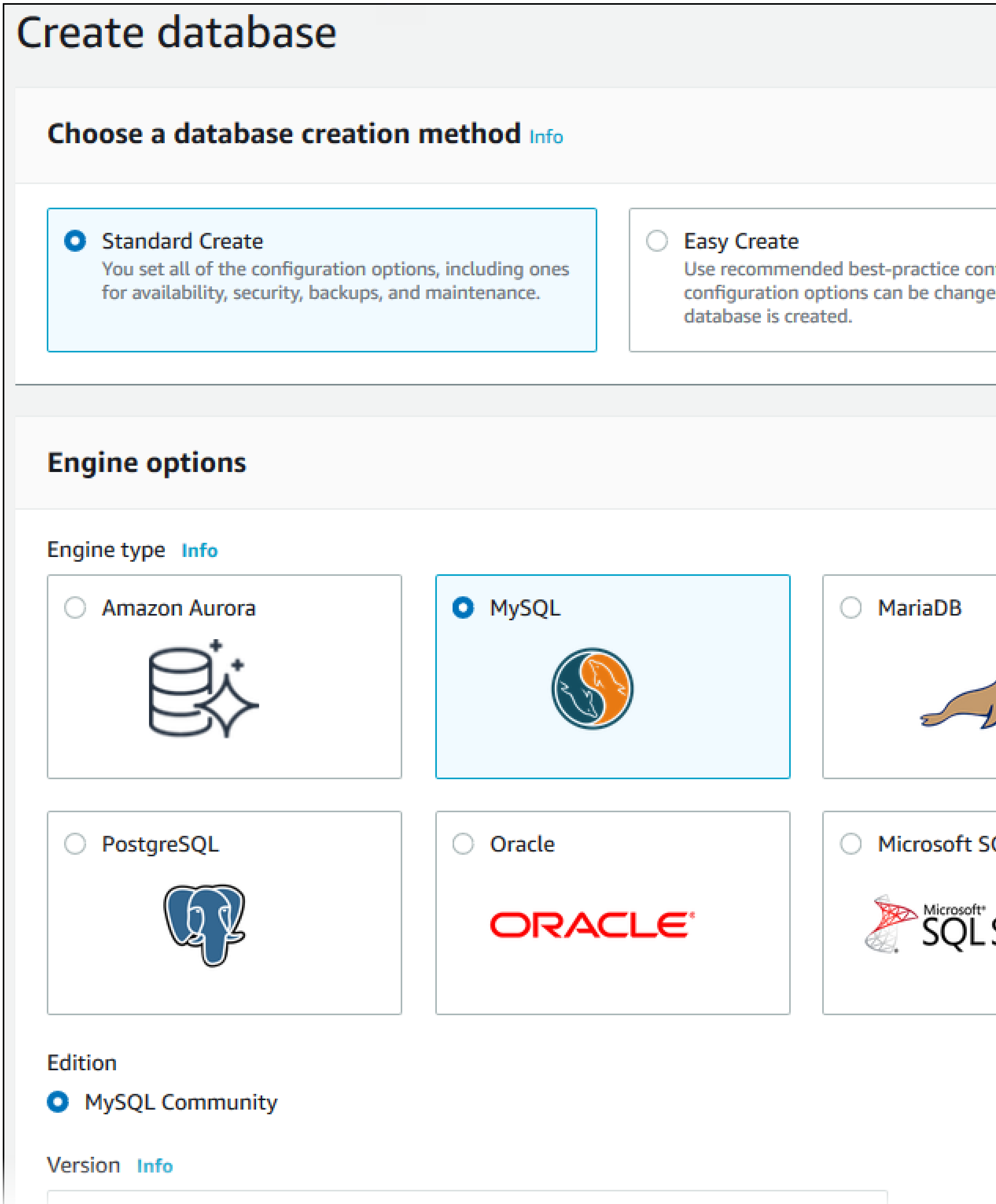
> **Important**
> Before you begin this step, you must have a VPC with both public and private subnets, and corresponding security groups. If you don't have these, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449). Complete the steps in Create a VPC with Private and Public Subnets (p. 1449), Create Additional Subnets (p. 1450), Create a VPC Security Group for a Public Web Server (p. 1451), and Create a VPC Security Group for a Private DB Instance (p. 1452).

> **Note**
> A new console interface is available for database creation. Choose either the **New Console** or the **Original Console** instructions based on the console that you are using. The **New Console** instructions are open by default.

New Console

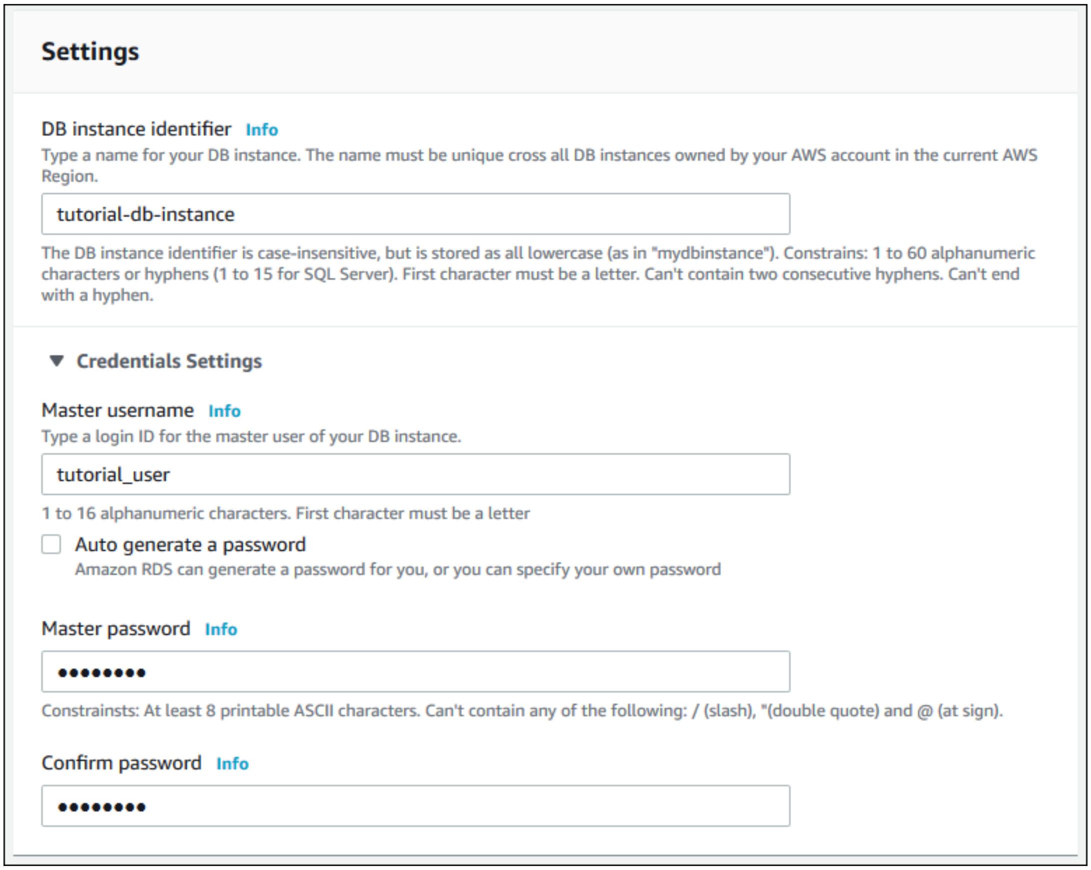
To launch a MySQL DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the AWS Management Console, choose the AWS Region in which you want to create the DB instance. This example uses the US West (Oregon) Region.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database**.
5. On the **Create database** page, shown following, make sure that the **Standard Create** option is chosen, and then choose **MySQL**.



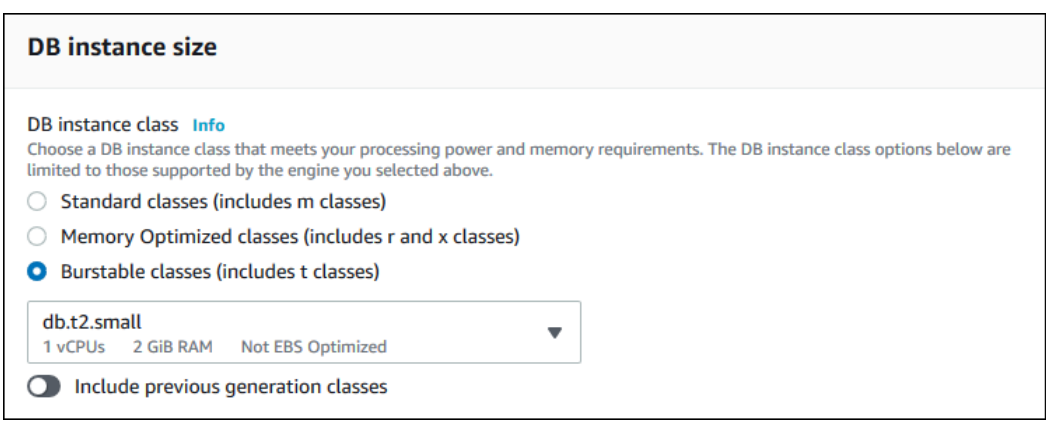
6. In the **Templates** section, choose **Dev/Test**.
7. In the **Settings** section, set these values:
   - **DB instance identifier** – `tutorial-db-instance`

- **Master username** – **`tutorial_user`**
- **Auto generate a password** – Disable the option
- **Master password** – Choose a password.
- **Confirm password** – Retype the password.



8. In the **DB instance size** section, set these values:

   - **Burstable classes (includes t classes)**
   - **db.t2.small**

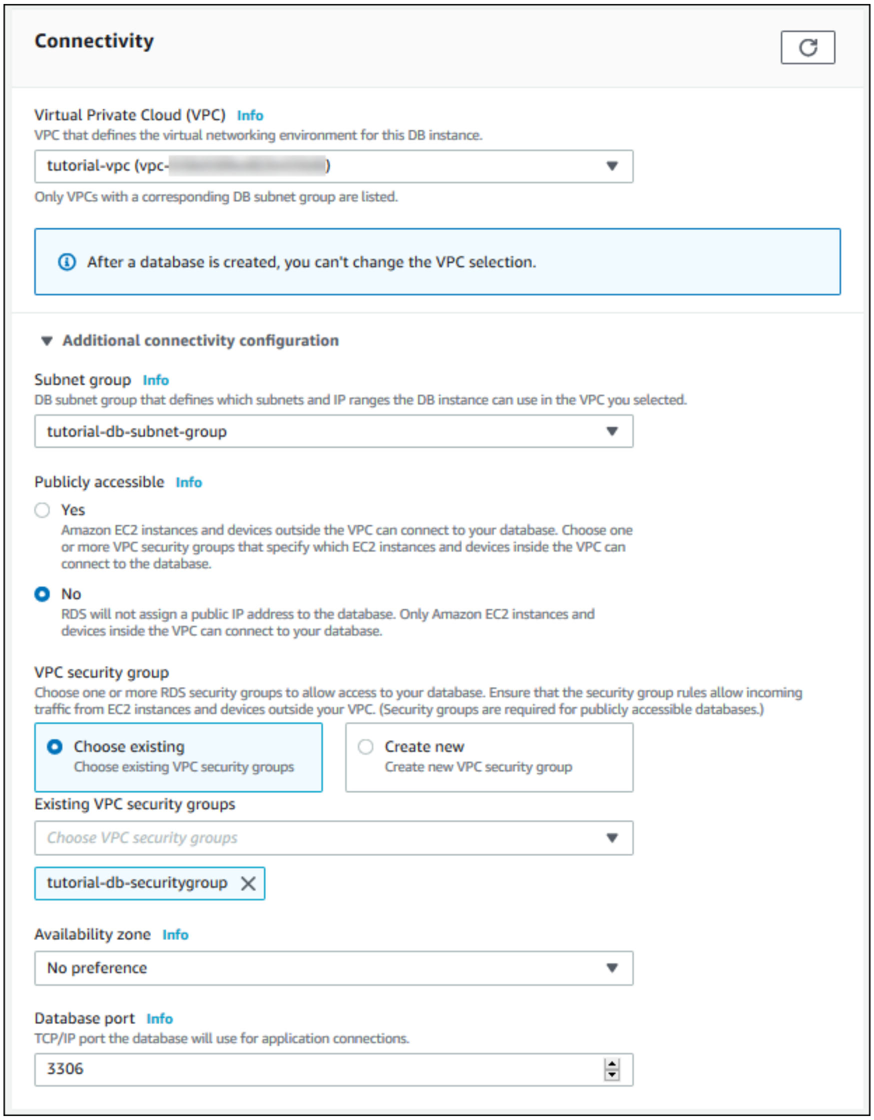


9. In the **Storage** and **Availability & durability** sections, use the default values.
10. In the **Connectivity** section, open **Additional connectivity configuration** and set these values:

    - **Virtual Private Cloud (VPC)** – Choose an existing VPC with both public and private subnets, such as the `tutorial-vpc` (vpc-*identifier*) created in Create a VPC with Private and Public Subnets (p. 1449)

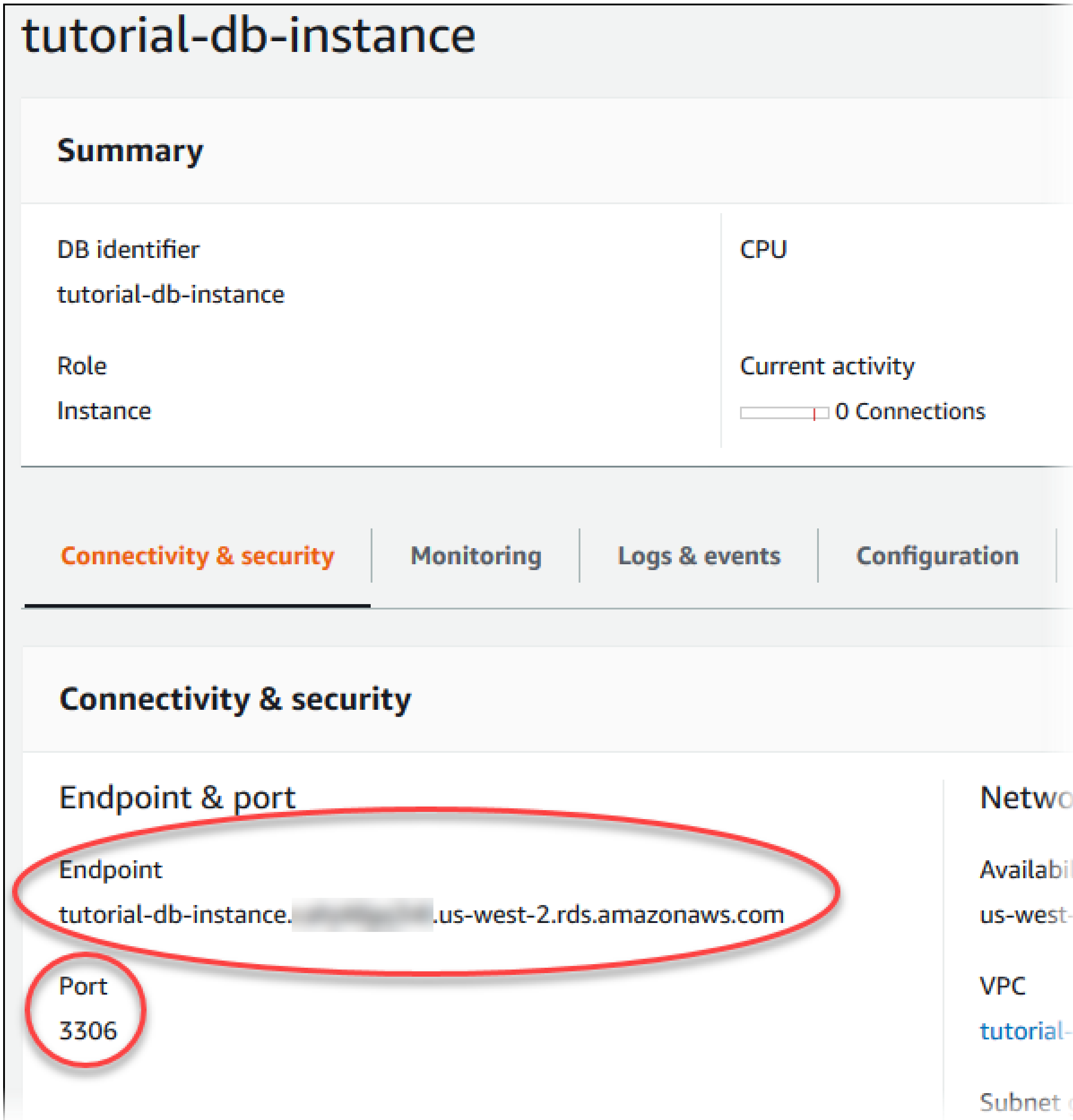
        Note
        The VPC must have subnets in different Availability Zones.
    - **Subnet group** – The DB subnet group for the VPC, such as the `tutorial-db-subnet-group` created in Create a DB Subnet Group (p. 1452)
    - **Publicly accessible** – **No**
    - **VPC security groups** – Choose an existing VPC security group that is configured for private access, such as the `tutorial-db-securitygroup` created in Create a VPC Security Group for a Private DB Instance (p. 1452).

      Remove other security groups, such as the default security group, by choosing the **X** associated with each.
    - **Availability zone** – **No Preference**
    - **Database port** – **3306**



11. Open the **Additional configuration** section, and enter **`sample`** for **Initial database name**. Keep the default settings for the other options.
12. To create your Amazon RDS MySQL DB instance, choose **Create database**.

    Your new DB instance appears in the **Databases** list with the status **Creating**.
13. Wait for the **Status** of your new DB instance to show as **Available**. Then choose the DB instance name to show its details.
14. In the **Connectivity & security** section, view the **Endpoint** and **Port** of the DB instance.



Note the endpoint and port for your DB instance. You use this information to connect your web server to your RDS DB instance.

To make sure your RDS MySQL DB instance is as secure as possible, verify that sources outside of the VPC can't connect to your RDS MySQL DB instance.

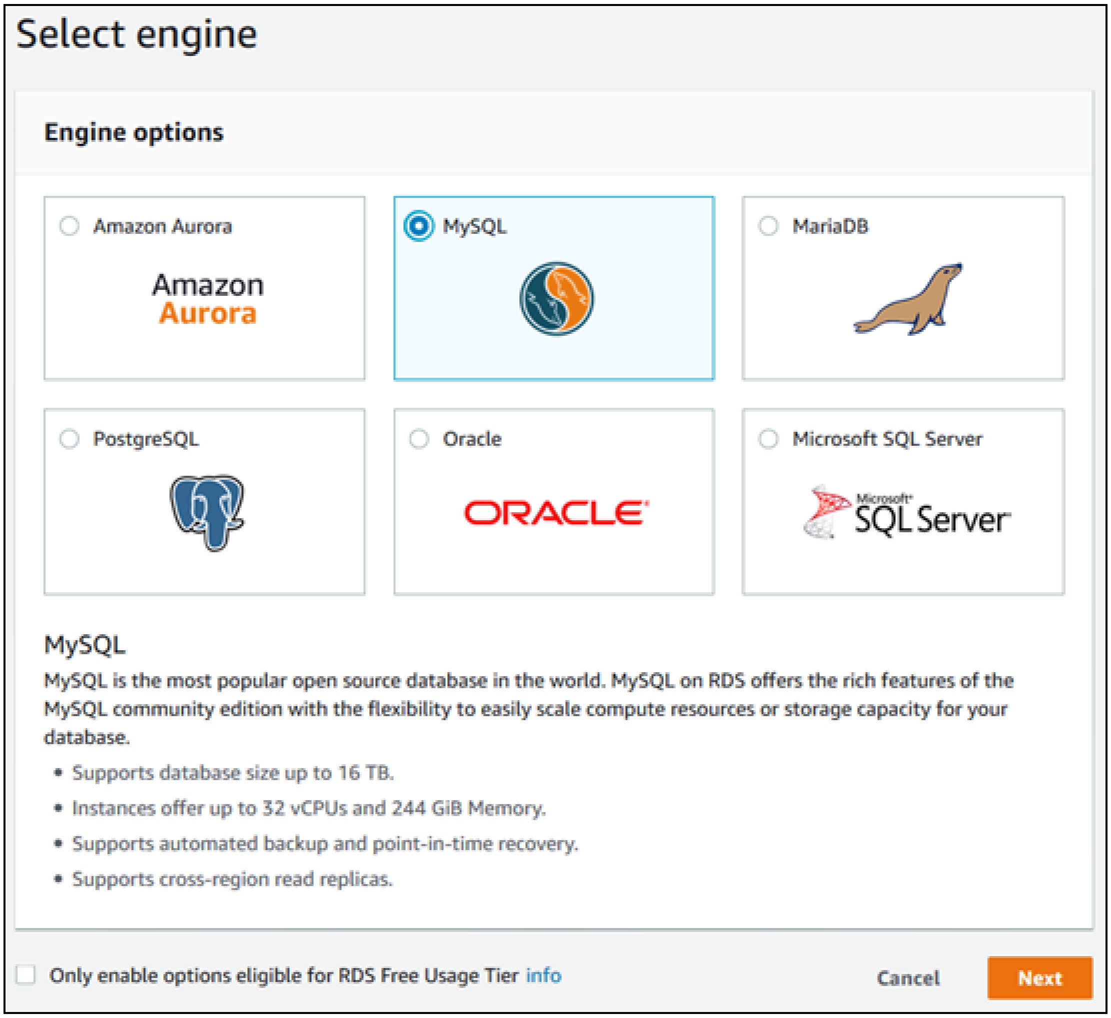
Original Console

To launch a MySQL DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the top-right corner of the AWS Management Console, choose the AWS Region in which you want to create the DB instance. This example uses the US West (Oregon) region.
3. In the navigation pane, choose **Databases**.

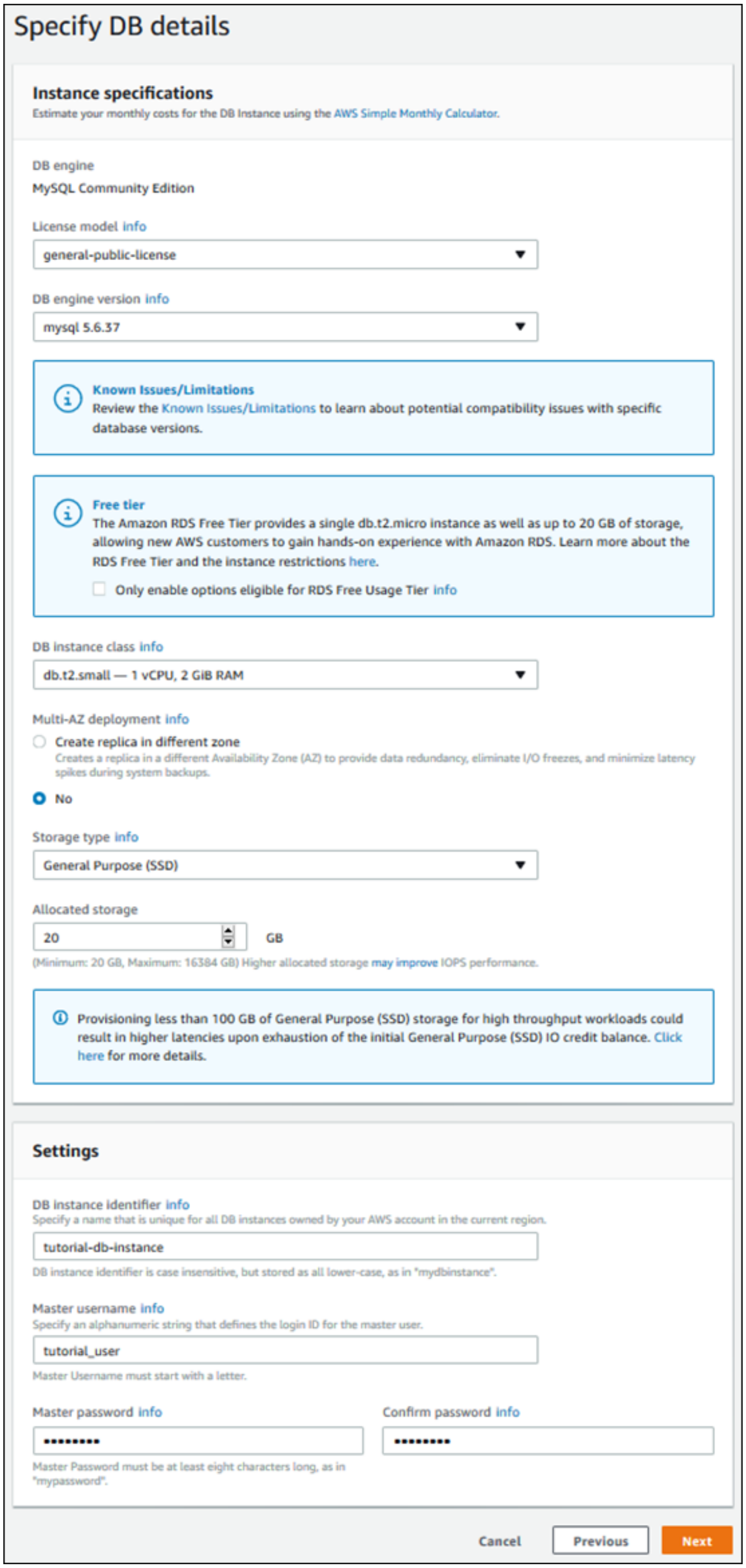
   If the navigation pane is closed, choose the menu icon at the top left to open it.
4. Choose **Create database** to open the **Select engine** page.
5. On the **Select engine** page, shown following, choose **MySQL**, and then choose **Next**.



6. On the **Choose use case** page, choose **Dev/Test – MySQL**, and then choose **Next**.
7. On the **Specify DB details** page, shown following, set these values:

   - **License model:** Use the default value.
   - **DB engine version:** Use the default value.
   - **DB instance class:** `db.t2.small`
   - **Multi-AZ deployment:** `No`
   - **Storage type:** `General Purpose (SSD)`
   - **Allocated storage:** `20 GiB`
   - **DB instance identifier:** `tutorial-db-instance`
   - **Master username:** `tutorial_user`
   - **Master password:** Choose a password.

- **Confirm password:** Retype the password.


Specify DB details
Instance specifications
Estimate your monthly costs for the DB Instance using the AWS Simple Monthly Calculator.
DB engine
MySQL Community Edition
License model info
general-public-license
DB engine version info
mysql 5.6.37
Known Issues/Limitations
Review the Known Issues/Limitations to learn about potential compatibility issues with specific database versions.
Free tier
The Amazon RDS Free Tier provides a single db.t2.micro instance as well as up to 20 GB of storage, allowing new AWS customers to gain hands-on experience with Amazon RDS. Learn more about the RDS Free Tier and the instance restrictions here.
Only enable options eligible for RDS Free Usage Tier info
DB instance class info
db.t2.small — 1 vCPU, 2 GiB RAM
Multi-AZ deployment info
Create replica in different zone
Creates a replica in a different Availability Zone (AZ) to provide data redundancy, eliminate I/O freezes, and minimize latency spikes during system backups.
No
Storage type info
General Purpose (SSD)
Allocated storage
20
GB
(Minimum: 20 GB, Maximum: 16384 GB) Higher allocated storage may improve IOPS performance.
Provisioning less than 100 GB of General Purpose (SSD) storage for high throughput workloads could result in higher latencies upon exhaustion of the initial General Purpose (SSD) IO credit balance. Click here for more details.
Settings
DB instance identifier info
Specify a name that is unique for all DB instances owned by your AWS account in the current region.
tutorial-db-instance
DB instance identifier is case insensitive, but stored as all lower-case, as in "mydbinstance".
Master username info
Specify an alphanumeric string that defines the login ID for the master user.
tutorial_user
Master Username must start with a letter.
Master password info
Confirm password info
Master Password must be at least eight characters long, as in "mypassword".
Cancel
Previous
Next

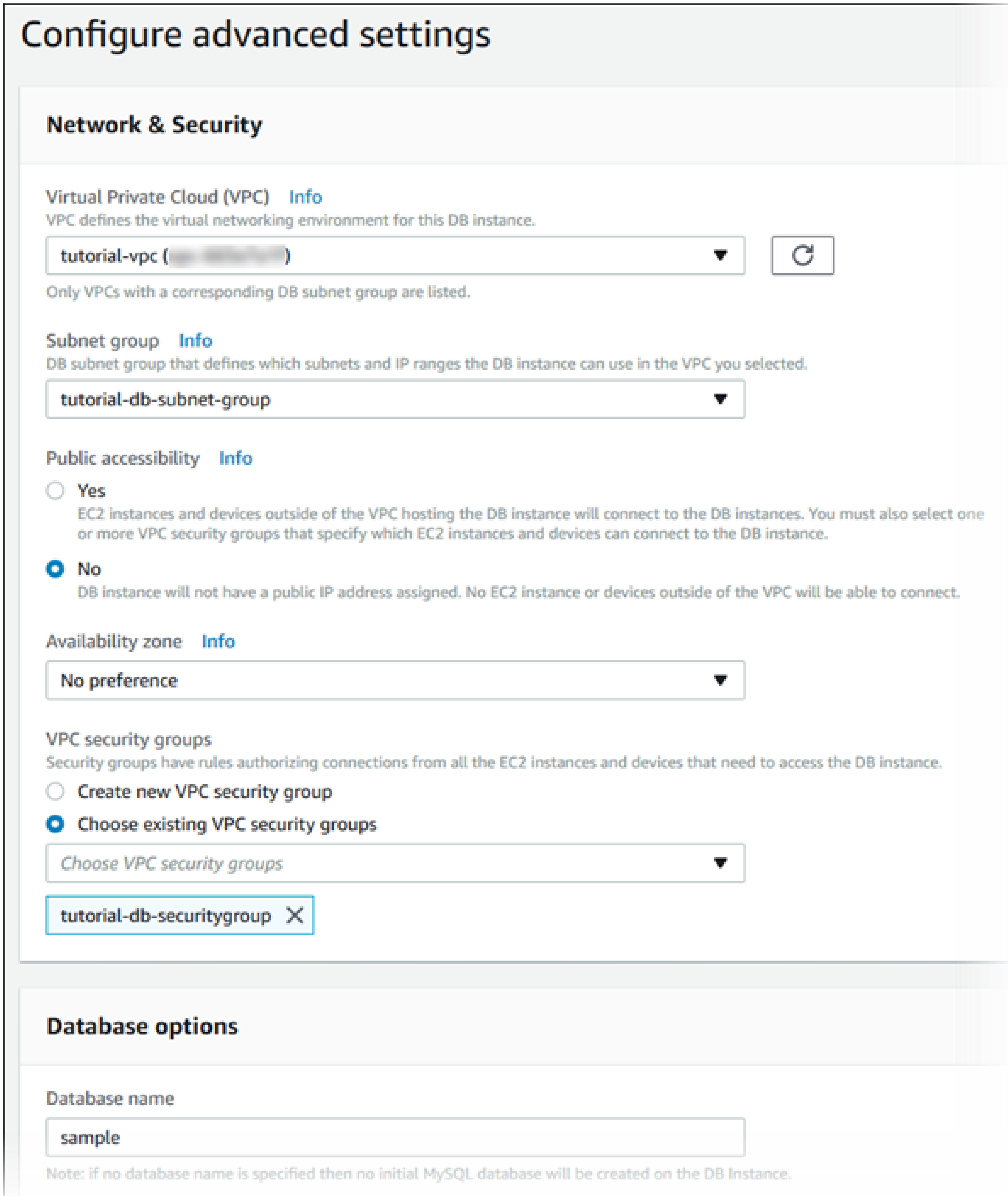
8. Choose **Next** and set the following values in the **Configure advanced settings** page:

   - **Virtual Private Cloud (VPC):** Choose an existing VPC with both public and private subnets, such as the `tutorial-vpc` (vpc-*identifier*) created in Create a VPC with Private and Public Subnets (p. 1449)

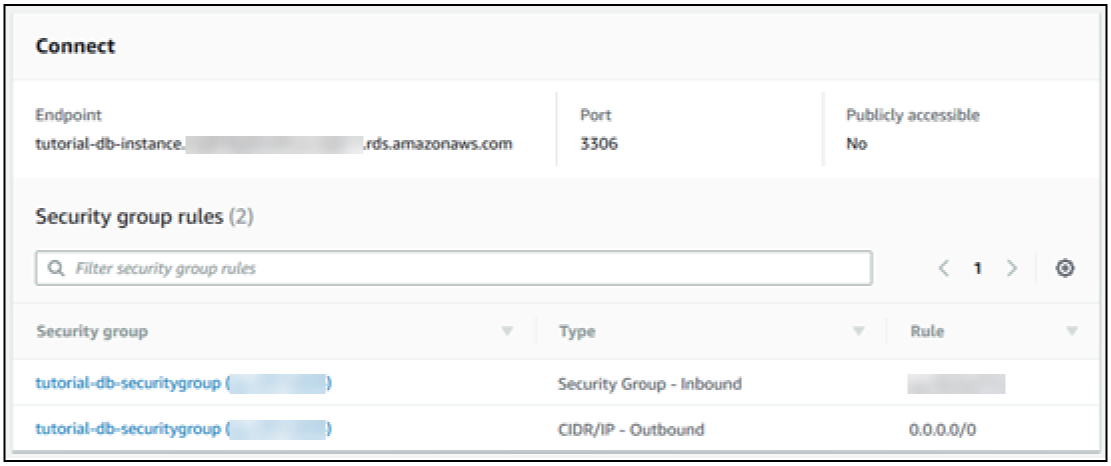
     Note
     The VPC must have subnets in different Availability Zones.
   - **Subnet group:** The DB subnet group for the VPC, such as the `tutorial-db-subnet-group` created in Create a DB Subnet Group (p. 1452)
   - **Public accessibility: No**
   - **Availability zone: No Preference**
   - **VPC security groups:** Choose an existing VPC security group that is configured for private access, such as the `tutorial-db-securitygroup` created in Create a VPC Security Group for a Private DB Instance (p. 1452).

     Remove other security groups, such as the default security group, by choosing the **X** associated with each.
   - **Database name:** `sample`

   Leave the default settings for the other options.



9. To create your Amazon RDS MySQL DB instance, choose **Create database**.
10. On the next page, choose **View DB instances details** to view your RDS MySQL DB instance.
11. Wait for the **DB instance status** of your new DB instance to show as **available**. Then scroll to the **Connect** section, shown following.



Make note of the endpoint and port for your DB instance. You will use this information to connect your web server to your RDS DB instance.

To make sure your RDS MySQL DB instance is as secure as possible, verify that sources outside of the VPC cannot connect to your RDS MySQL DB instance.

Next Step

Step 2: Create an EC2 Instance and Install a Web Server (p. 112)

Step 2: Create an EC2 Instance and Install a Web Server

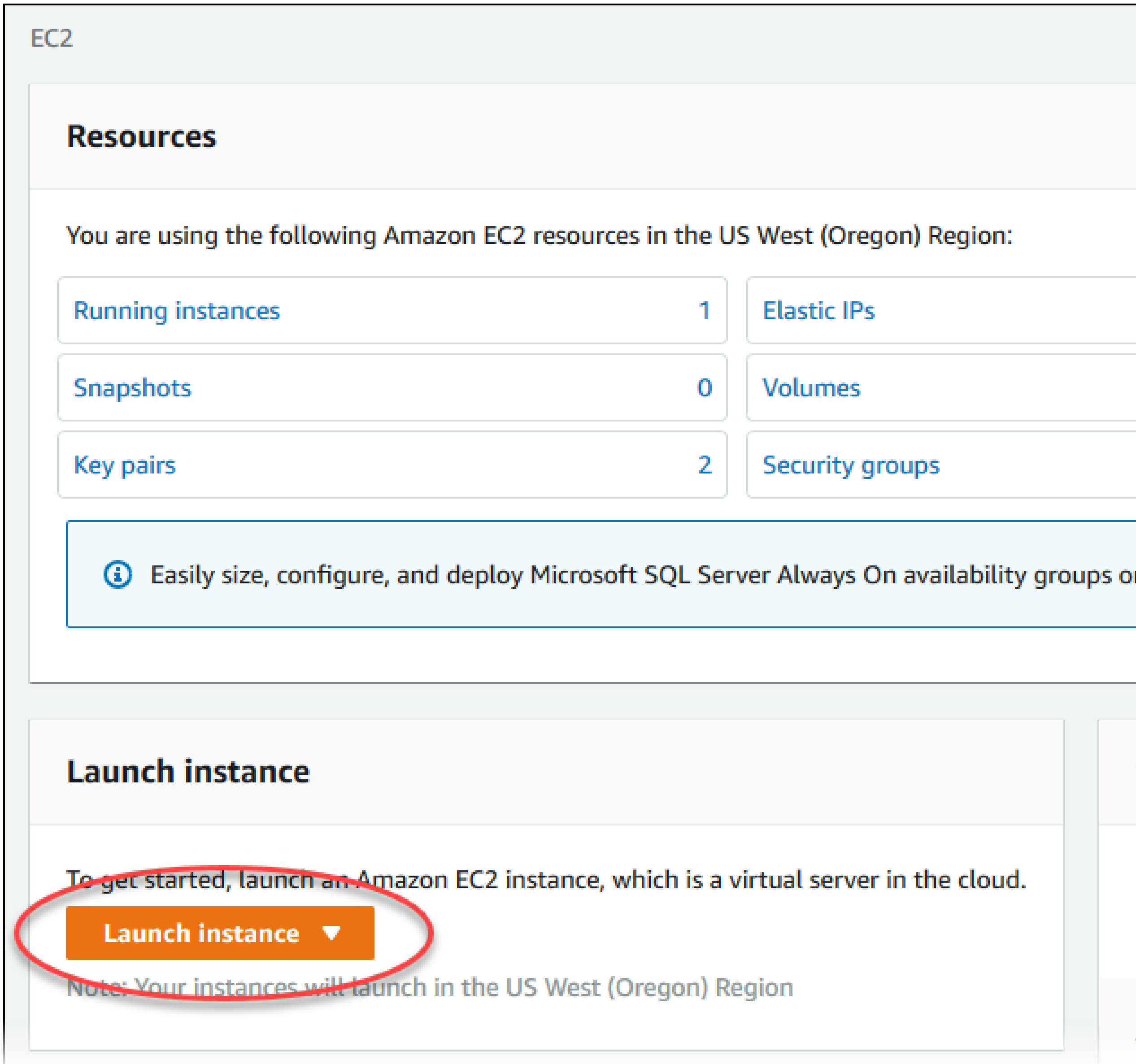
In this step you create a web server to connect to the Amazon RDS DB instance that you created in Step 1: Create an RDS DB Instance (p. 101).

Launch an EC2 Instance

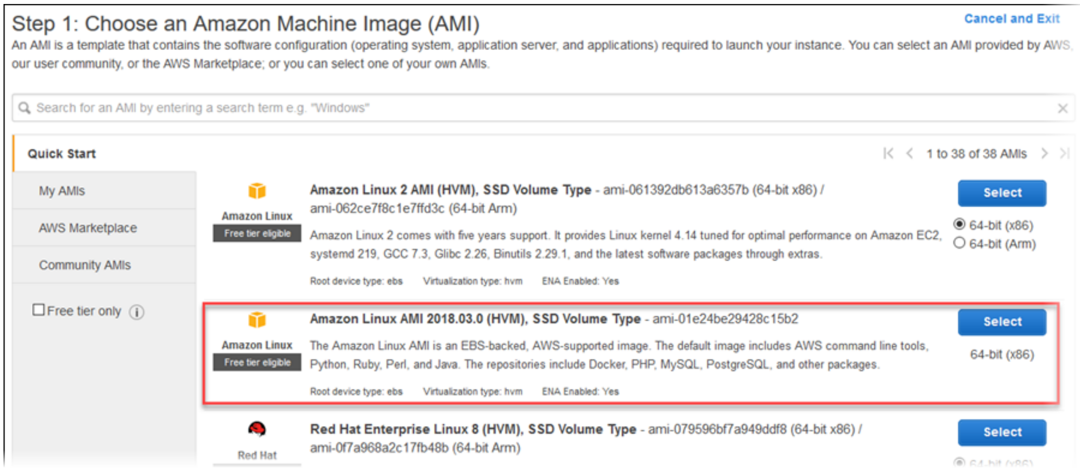
First you create an Amazon EC2 instance in the public subnet of your VPC.

To launch an EC2 instance

1. Sign in to the AWS Management Console and open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.
2. Choose **EC2 Dashboard**, and then choose **Launch instance**, as shown following.

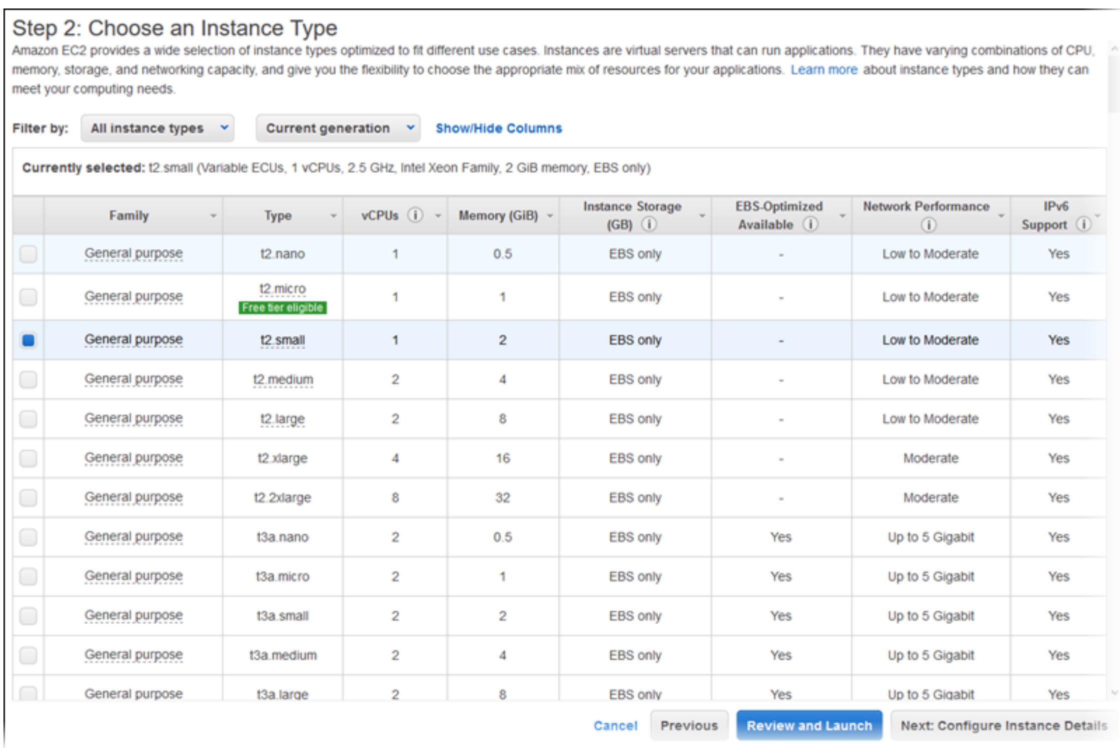


3. Choose the **Amazon Linux AMI**, as shown following.



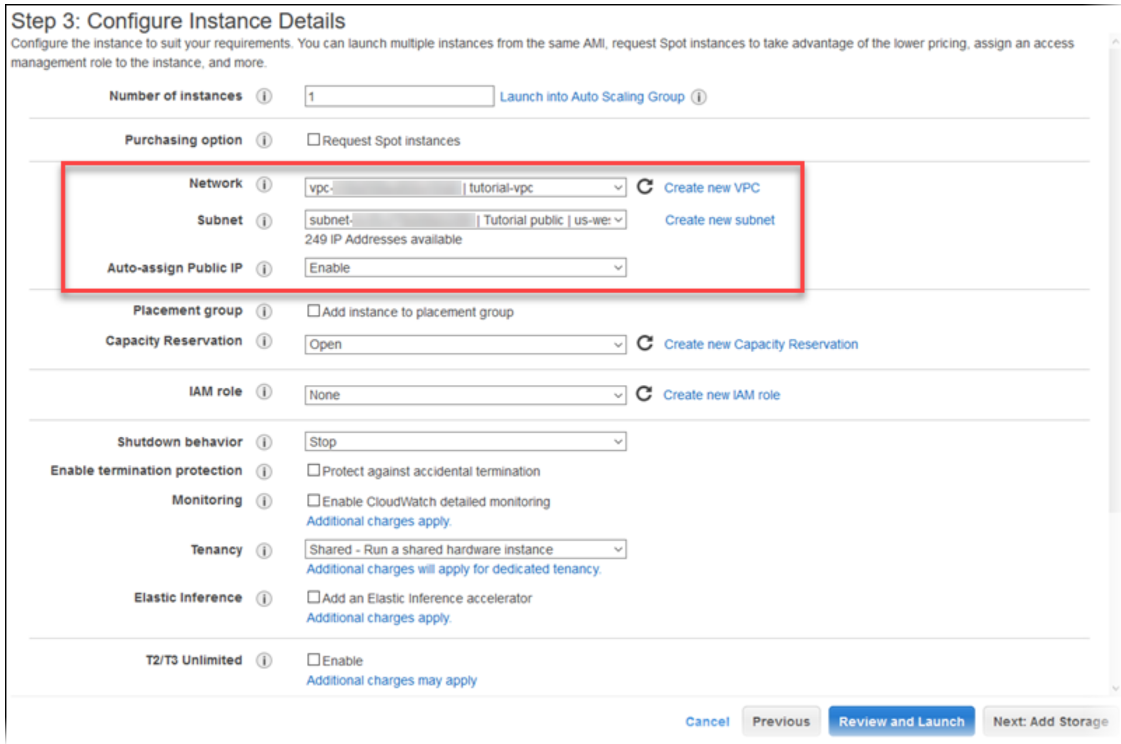
Important
Don't choose **Amazon Linux 2 AMI** because it doesn't have the software packages required for this tutorial.

4. Choose the `t2.small` instance type, as shown following, and then choose **Next: Configure Instance Details**.

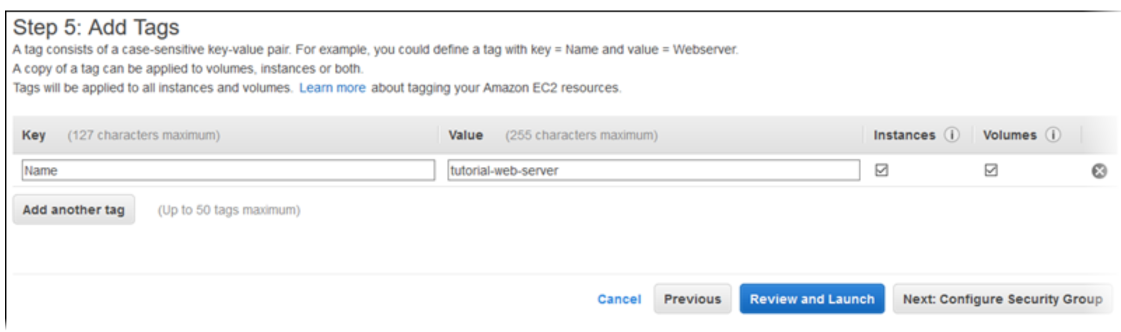


5. On the **Configure Instance Details** page, shown following, set these values and leave the other values as their defaults:

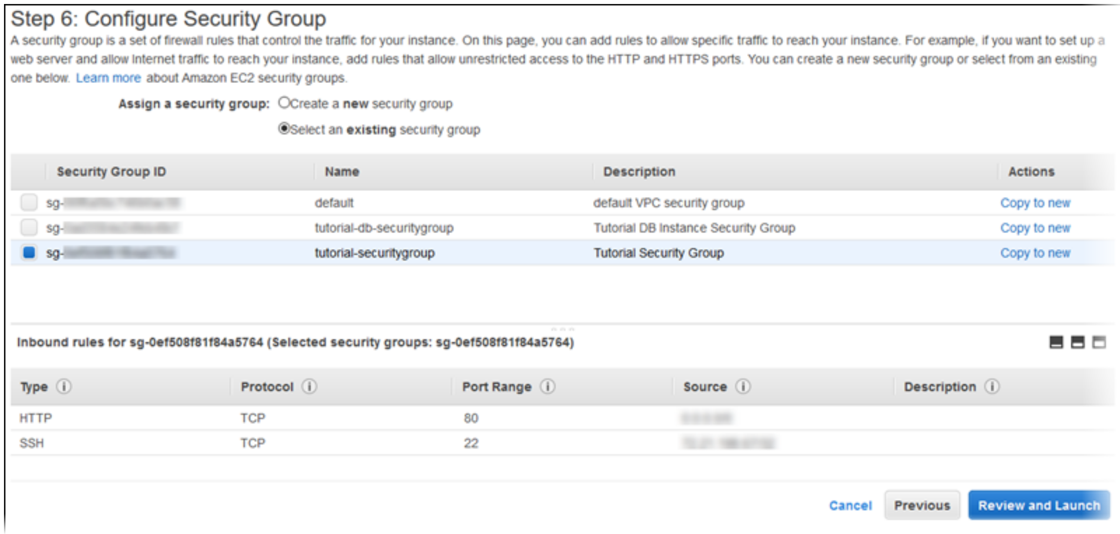
   - **Network:** Choose the VPC with both public and private subnets that you chose for the DB instance, such as the `vpc-identifier | tutorial-vpc` created in Create a VPC with Private and Public Subnets (p. 1449).
   - **Subnet:** Choose an existing public subnet, such as `subnet-identifier | Tutorial public | us-west-2a` created in Create a VPC Security Group for a Public Web Server (p. 1451).
   - **Auto-assign Public IP:** Choose **Enable**.



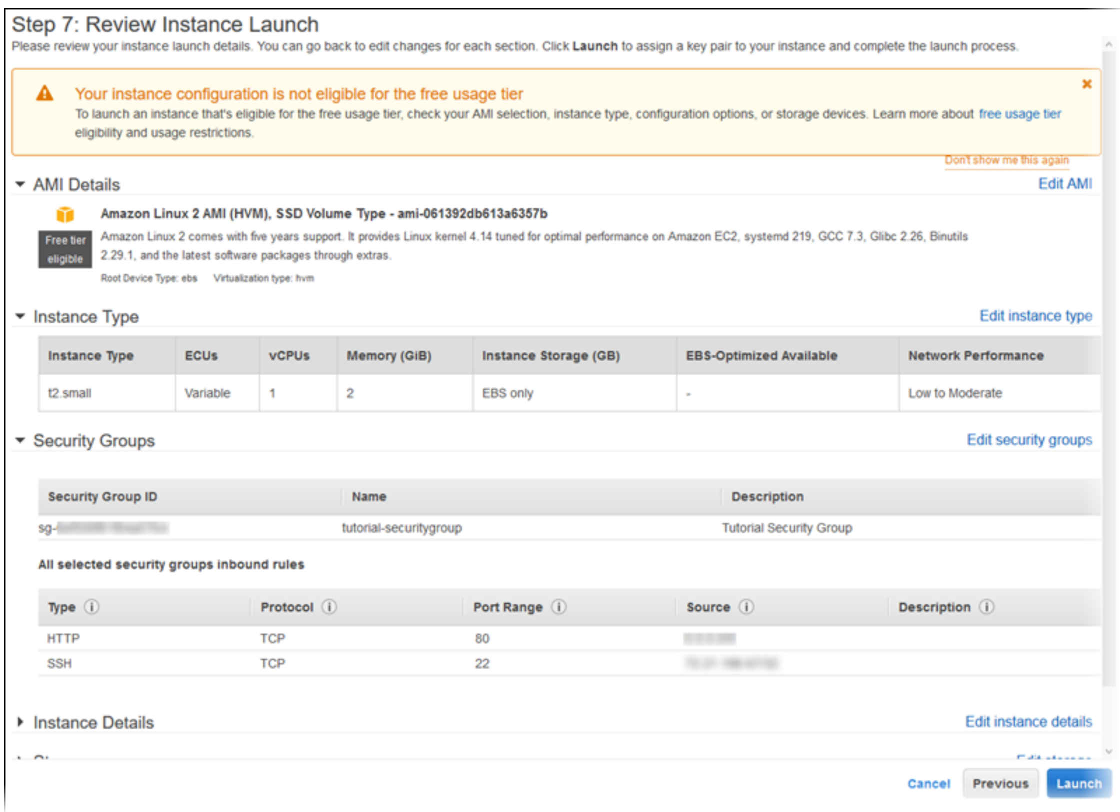
6. Choose **Next: Add Storage**.
7. On the **Add Storage** page, keep the default values and choose **Next: Add Tags**.
8. On the **Add Tags** page, shown following, choose **Add Tag**, then enter **`Name`** for **Key** and enter **`tutorial-web-server`** for **Value**.



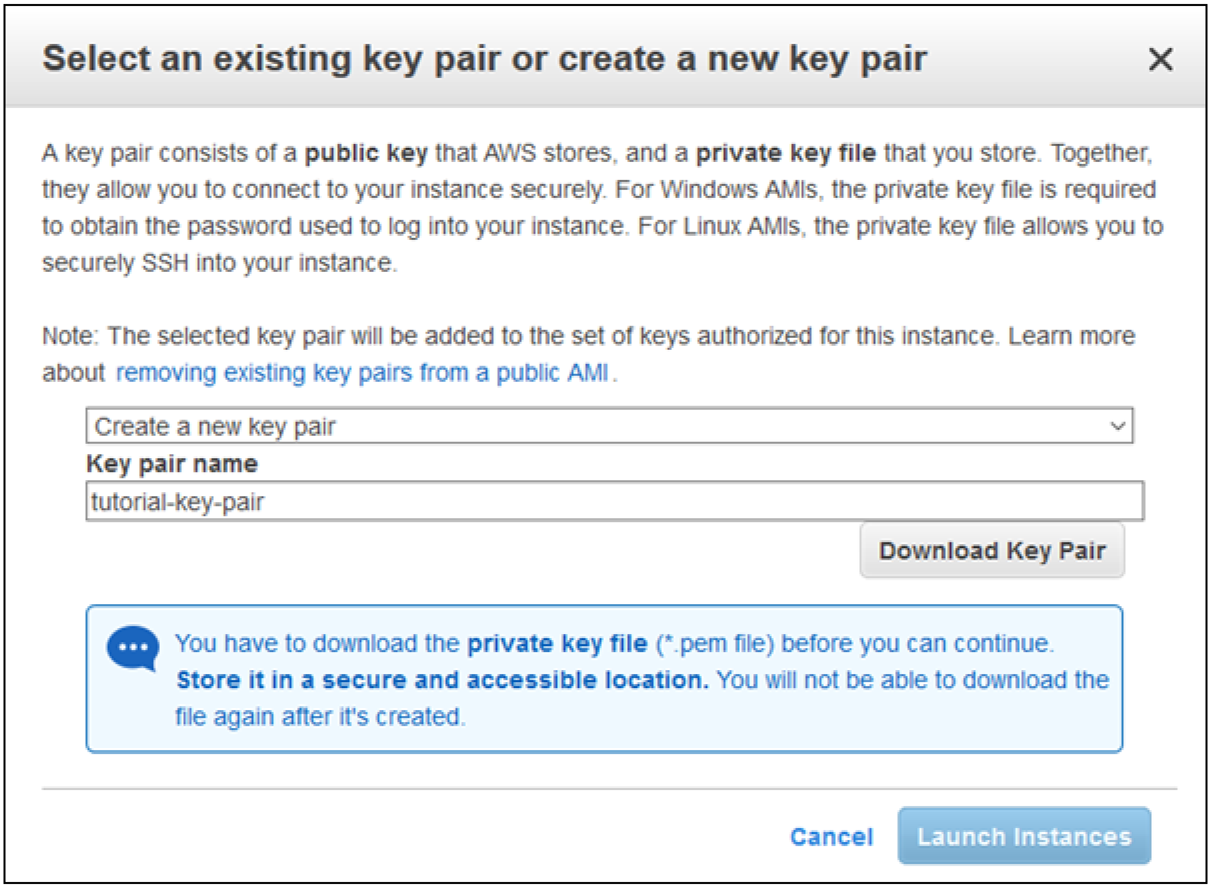
9. Choose **Next: Configure Security Group**.
10. On the **Configure Security Group** page, shown following, choose **Select an existing security group**, and then choose an existing security group, such as the `tutorial-securitygroup` created in Create a VPC Security Group for a Public Web Server (p. 1451). The security group must include inbound rules for SSH and HTTP access.



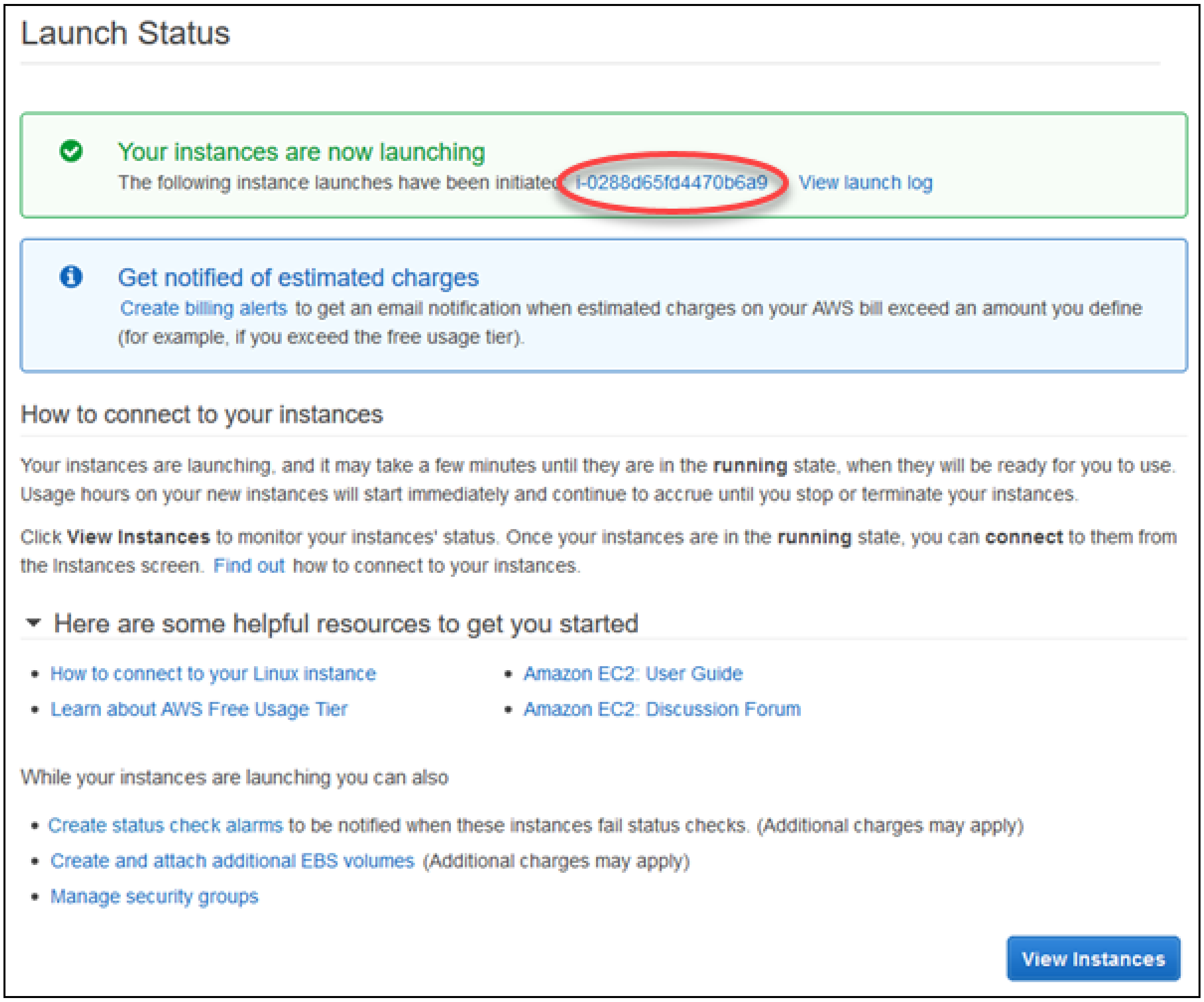
11. Choose **Review and Launch**.
12. On the **Review Instance Launch** page, shown following, verify your settings and then choose **Launch**.



13. On the **Select an existing key pair or create a new key pair** page, shown following, choose **Create a new key pair** and set **Key pair name** to `tutorial-key-pair`. Choose **Download Key Pair**, and then save the key pair file on your local machine. You use this key pair file to connect to your EC2 instance.



14. To launch your EC2 instance, choose **Launch Instances**. On the **Launch Status** page, shown following, note the identifier for your new EC2 instance, for example: `i-0288d65fd4470b6a9`.



15. To find your instance, choose **View Instances**.
16. Wait until **Instance Status** for your instance reads as `running` before continuing.

Install an Apache Web Server with PHP

Next you connect to your EC2 instance and install the web server.

To connect to your EC2 instance and install the Apache web server with PHP

1. To connect to the EC2 instance that you created earlier, follow the steps in Connect to Your Linux Instance.
2. To get the latest bug fixes and security updates, update the software on your EC2 instance by using the following command:

   Note
   The `-y` option installs the updates without asking for confirmation. To examine updates before installing, omit this option.

```
[ec2-user ~]$ sudo yum update -y
```

3. After the updates complete, install the Apache web server with the PHP software package using the **yum install** command, which installs multiple software packages and related dependencies at the same time.

```
[ec2-user ~]$ sudo yum install -y httpd24 php56 php56-mysqlnd
```

   Note
   If you receive the error `No package` *`package-name`* `available`, then your instance was not launched with the Amazon Linux AMI (perhaps you are using the Amazon Linux 2 AMI instead). You can view your version of Amazon Linux with the following command.

```
cat /etc/system-release
```

   For more information, see Updating Instance Software.

4. Start the web server with the command shown following.

```
[ec2-user ~]$ sudo service httpd start
```

   You can test that your web server is properly installed and started by entering the public DNS name of your EC2 instance in the address bar of a web browser, for example: `http://ec2-42-8-168-21.us-west-1.compute.amazonaws.com`. If your web server is running, then you see the Apache test page. If you don't see the Apache test page, then verify that your inbound rules for the VPC security group that you created in Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449) include a rule allowing HTTP (port 80) access for the IP address you use to connect to the web server.

   Note
   The Apache test page appears only when there is no content in the document root directory, `/var/www/html`. After you add content to the document root directory, your content appears at the public DNS address of your EC2 instance instead of the Apache test page.

5. Configure the web server to start with each system boot using the `chkconfig` command.

```
[ec2-user ~]$ sudo chkconfig httpd on
```

To allow `ec2-user` to manage files in the default root directory for your Apache web server, you need to modify the ownership and permissions of the `/var/www` directory. In this tutorial, you add a group named `www` to your EC2 instance, and then you give that group ownership of the `/var/www` directory and add write permissions for the group. Any members of that group can then add, delete, and modify files for the web server.

To set file permissions for the Apache web server

1. Add the `www` group to your EC2 instance with the following command.

```
[ec2-user ~]$ sudo groupadd www
```

2. Add the `ec2-user` user to the `www` group.

```
[ec2-user ~]$ sudo usermod -a -G www ec2-user
```

3. To refresh your permissions and include the new `www` group, log out.

```
[ec2-user ~]$ exit
```

4. Log back in again and verify that the `www` group exists with the `groups` command.

```
[ec2-user ~]$ groups
ec2-user wheel www
```

5. Change the group ownership of the `/var/www` directory and its contents to the `www` group.

```
[ec2-user ~]$ sudo chgrp -R www /var/www
```

6. Change the directory permissions of `/var/www` and its subdirectories to add group write permissions and set the group ID on subdirectories created in the future.

```
[ec2-user ~]$ sudo chmod 2775 /var/www
[ec2-user ~]$ find /var/www -type d -exec sudo chmod 2775 {} +
```

7. Recursively change the permissions for files in the `/var/www` directory and its subdirectories to add group write permissions.

```
[ec2-user ~]$ find /var/www -type f -exec sudo chmod 0664 {} +
```

Connect your Apache web server to your RDS DB instance

Next, you add content to your Apache web server that connects to your Amazon RDS DB instance.

To add content to the Apache web server that connects to your RDS DB instance

1. While still connected to your EC2 instance, change the directory to `/var/www` and create a new subdirectory named `inc`.

```
[ec2-user ~]$ cd /var/www
[ec2-user ~]$ mkdir inc
[ec2-user ~]$ cd inc
```

2. Create a new file in the `inc` directory named `dbinfo.inc`, and then edit the file by calling nano (or the editor of your choice).

```
[ec2-user ~]$ >dbinfo.inc
[ec2-user ~]$ nano dbinfo.inc
```

3. Add the following contents to the `dbinfo.inc` file, where *`db_instance_endpoint`* is the endpoint of your RDS MySQL DB instance, without the port, and *`master password`* is the master password for your RDS MySQL DB instance.

Note
Placing the user name and password information in a folder that is not part of the document root for your web server reduces the possibility of your security information being exposed.

```
<?php

define('DB_SERVER', 'db_instance_endpoint');
define('DB_USERNAME', 'tutorial_user');
define('DB_PASSWORD', 'master password');
define('DB_DATABASE', 'sample');

?>
```

4. Save and close the `dbinfo.inc` file.
5. Change the directory to `/var/www/html`.

```
[ec2-user ~]$ cd /var/www/html
```

6. Create a new file in the `html` directory named `SamplePage.php`, and then edit the file by calling nano (or the editor of your choice).

```
[ec2-user ~]$ >SamplePage.php
[ec2-user ~]$ nano SamplePage.php
```

7. Add the following contents to the `SamplePage.php` file:

Note
Placing the user name and password information in a folder that is not part of the document root for your web server reduces the possibility of your security information being exposed.

```
<?php include "../inc/dbinfo.inc"; ?>
<html>
<body>
<h1>Sample page</h1>
<?php

  /* Connect to MySQL and select the database. */
  $connection = mysqli_connect(DB_SERVER, DB_USERNAME, DB_PASSWORD);

  if (mysqli_connect_errno()) echo "Failed to connect to MySQL: " .
 mysqli_connect_error();

  $database = mysqli_select_db($connection, DB_DATABASE);

  /* Ensure that the EMPLOYEES table exists. */
  VerifyEmployeesTable($connection, DB_DATABASE);

  /* If input fields are populated, add a row to the EMPLOYEES table. */
  $employee_name = htmlentities($_POST['NAME']);
  $employee_address = htmlentities($_POST['ADDRESS']);

  if (strlen($employee_name) || strlen($employee_address)) {
    AddEmployee($connection, $employee_name, $employee_address);
  }
?>
```

```
<!-- Input form -->
<form action="<?PHP echo $_SERVER['SCRIPT_NAME'] ?>" method="POST">
  <table border="0">
    <tr>
      <td>NAME</td>
      <td>ADDRESS</td>
    </tr>
    <tr>
      <td>
        <input type="text" name="NAME" maxlength="45" size="30" />
      </td>
      <td>
        <input type="text" name="ADDRESS" maxlength="90" size="60" />
      </td>
      <td>
        <input type="submit" value="Add Data" />
      </td>
    </tr>
  </table>
</form>

<!-- Display table data. -->
<table border="1" cellpadding="2" cellspacing="2">
  <tr>
    <td>ID</td>
    <td>NAME</td>
    <td>ADDRESS</td>
  </tr>

<?php

$result = mysqli_query($connection, "SELECT * FROM EMPLOYEES");

while($query_data = mysqli_fetch_row($result)) {
  echo "<tr>";
  echo "<td>",$query_data[0], "</td>",
       "<td>",$query_data[1], "</td>",
       "<td>",$query_data[2], "</td>";
  echo "</tr>";
}
?>

</table>

<!-- Clean up. -->
<?php

  mysqli_free_result($result);
  mysqli_close($connection);

?>

</body>
</html>


<?php

/* Add an employee to the table. */
function AddEmployee($connection, $name, $address) {
   $n = mysqli_real_escape_string($connection, $name);
   $a = mysqli_real_escape_string($connection, $address);

   $query = "INSERT INTO EMPLOYEES (NAME, ADDRESS) VALUES ('$n', '$a');";
```

```
   if(!mysqli_query($connection, $query)) echo("<p>Error adding employee data.</p>");
}

/* Check whether the table exists and, if not, create it. */
function VerifyEmployeesTable($connection, $dbName) {
  if(!TableExists("EMPLOYEES", $connection, $dbName))
  {
     $query = "CREATE TABLE EMPLOYEES (
         ID int(11) UNSIGNED AUTO_INCREMENT PRIMARY KEY,
         NAME VARCHAR(45),
         ADDRESS VARCHAR(90)
       )";

     if(!mysqli_query($connection, $query)) echo("<p>Error creating table.</p>");
  }
}

/* Check for the existence of a table. */
function TableExists($tableName, $connection, $dbName) {
  $t = mysqli_real_escape_string($connection, $tableName);
  $d = mysqli_real_escape_string($connection, $dbName);

  $checktable = mysqli_query($connection,
      "SELECT TABLE_NAME FROM information_schema.TABLES WHERE TABLE_NAME = '$t' AND
 TABLE_SCHEMA = '$d'");

  if(mysqli_num_rows($checktable) > 0) return true;

  return false;
}
?>
```

8. Save and close the `SamplePage.php` file.
9. Verify that your web server successfully connects to your RDS MySQL DB instance by opening a web browser and browsing to `http://`*`EC2 instance endpoint`*`/SamplePage.php`, for example: `http://ec2-55-122-41-31.us-west-2.compute.amazonaws.com/SamplePage.php`.

You can use `SamplePage.php` to add data to your RDS MySQL DB instance. The data that you add is then displayed on the page.

To make sure your RDS MySQL DB instance is as secure as possible, verify that sources outside of the VPC cannot connect to your RDS MySQL DB instance.

Tutorials

The following tutorials show you how to perform common tasks that use Amazon RDS:

- Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449)
- Tutorial: Create a Web Server and an Amazon RDS Database (p. 100)
- Tutorial: Restore a DB Instance from a DB Snapshot (p. 340)

For more information about training, see AWS Training and Certification.

Best Practices for Amazon RDS

Learn best practices for working with Amazon RDS. As new best practices are identified, we will keep this section up to date.

Topics

> **Note**
> For common recommendations for Amazon RDS, see Using Amazon RDS Recommendations (p. 424).

Amazon RDS Basic Operational Guidelines

The following are basic operational guidelines that everyone should follow when working with Amazon RDS. Note that the Amazon RDS Service Level Agreement requires that you follow these guidelines:

- Monitor your memory, CPU, and storage usage. Amazon CloudWatch can be set up to notify you when usage patterns change or when you approach the capacity of your deployment, so that you can maintain system performance and availability.
- Scale up your DB instance when you are approaching storage capacity limits. You should have some buffer in storage and memory to accommodate unforeseen increases in demand from your applications.
- Enable automatic backups and set the backup window to occur during the daily low in write IOPS.
- If your database workload requires more I/O than you have provisioned, recovery after a failover or database failure will be slow. To increase the I/O capacity of a DB instance, do any or all of the following:
  - Migrate to a DB instance class with High I/O capacity.
  - Convert from magnetic storage to either General Purpose or Provisioned IOPS storage, depending on how much of an increase you need. For information on available storage types, see Amazon RDS Storage Types (p. 29).

    If you convert to Provisioned IOPS storage, make sure you also use a DB instance class that is optimized for Provisioned IOPS. For information on Provisioned IOPS, see Provisioned IOPS SSD Storage (p. 31).
  - If you are already using Provisioned IOPS storage, provision additional throughput capacity.

- If your client application is caching the Domain Name Service (DNS) data of your DB instances, set a time-to-live (TTL) value of less than 30 seconds. Because the underlying IP address of a DB instance can change after a failover, caching the DNS data for an extended time can lead to connection failures if your application tries to connect to an IP address that no longer is in service.
- Test failover for your DB instance to understand how long the process takes for your use case and to ensure that the application that accesses your DB instance can automatically connect to the new DB instance after failover.

DB Instance RAM Recommendations

An Amazon RDS performance best practice is to allocate enough RAM so that your *working set* resides almost completely in memory. The working set is the data and indexes that are frequently in use on your instance. The more you use the DB instance, the more the working set will grow.

To tell if your working set is almost all in memory, check the ReadIOPS metric (using Amazon CloudWatch) while the DB instance is under load. The value of ReadIOPS should be small and stable. If scaling up the DB instance class—to a class with more RAM—results in a dramatic drop in ReadIOPS, your working set was not almost completely in memory. Continue to scale up until ReadIOPS no longer drops dramatically after a scaling operation, or ReadIOPS is reduced to a very small amount. For information on monitoring a DB instance's metrics, see Viewing DB Instance Metrics (p. 356).

Using Enhanced Monitoring to Identify Operating System Issues

Amazon RDS provides metrics in real time for the operating system (OS) that your DB instance runs on. You can view the metrics for your DB instance using the console, or consume the Enhanced Monitoring JSON output from Amazon CloudWatch Logs in a monitoring system of your choice. For more information about Enhanced Monitoring, see Enhanced Monitoring (p. 362)

Enhanced Monitoring is available for the following database engines:

- MariaDB
- Microsoft SQL Server
- MySQL version 5.5 or later
- Oracle
- PostgreSQL

Enhanced monitoring is available for all DB instance classes except for `db.m1.small`. Enhanced Monitoring is available in all regions except for AWS GovCloud (US-West).

Using Metrics to Identify Performance Issues

To identify performance issues caused by insufficient resources and other common bottlenecks, you can monitor the metrics available for your Amazon RDS DB instance.

Viewing Performance Metrics

You should monitor performance metrics on a regular basis to see the average, maximum, and minimum values for a variety of time ranges. If you do so, you can identify when performance is degraded. You can also set Amazon CloudWatch alarms for particular metric thresholds so you are alerted if they are reached.

To troubleshoot performance issues, it's important to understand the baseline performance of the system. When you set up a new DB instance and get it running with a typical workload, you should capture the average, maximum, and minimum values of all of the performance metrics at a number of different intervals (for example, one hour, 24 hours, one week, two weeks) to get an idea of what is normal. It helps to get comparisons for both peak and off-peak hours of operation. You can then use this information to identify when performance is dropping below standard levels.

To view performance metrics

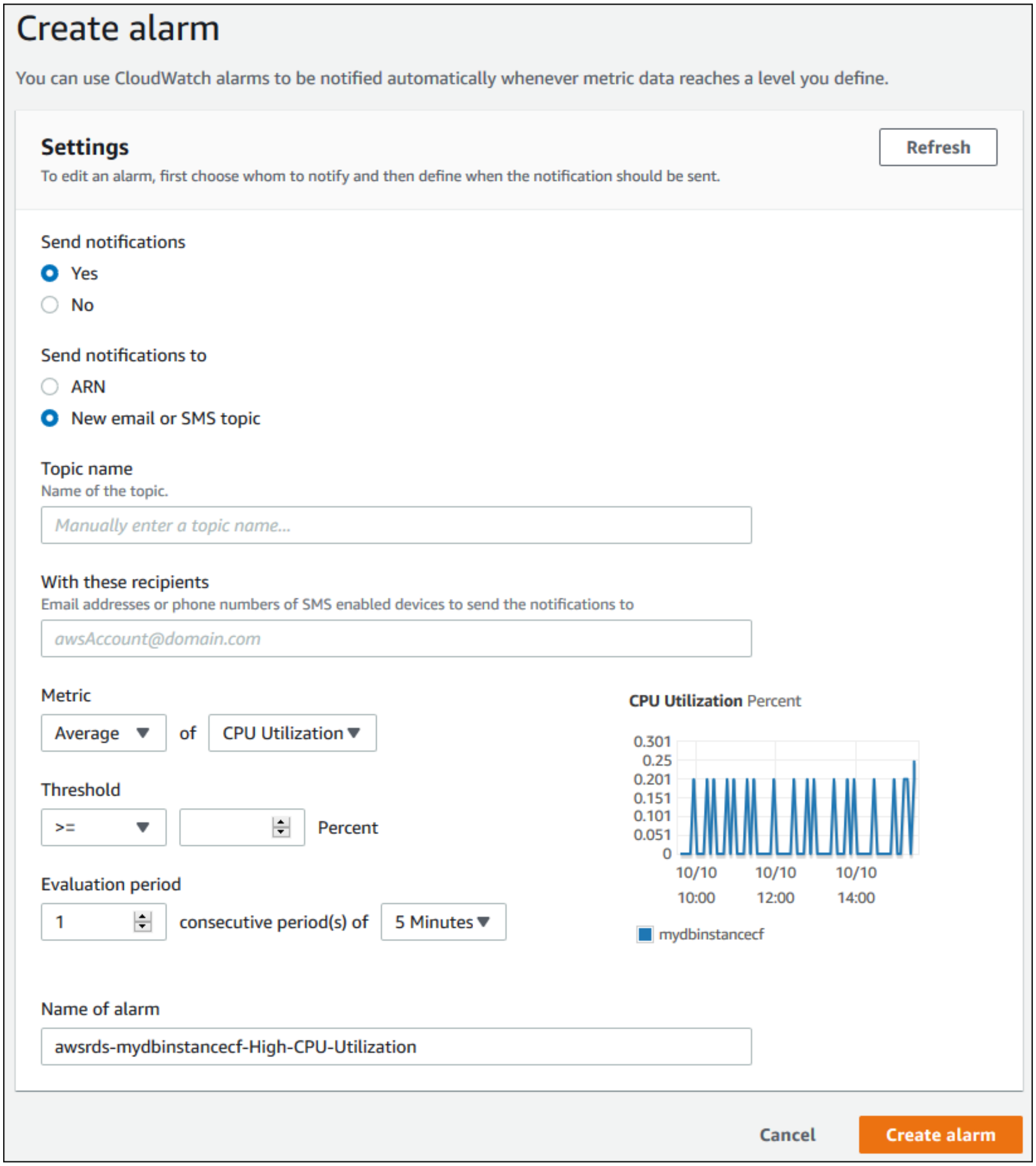
1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose a DB instance.
3. Choose **Monitoring**. The first eight performance metrics display. The metrics default to showing information for the current day.
4. Use the numbered buttons at top right to page through the additional metrics, or choose adjust the settings to see more metrics.
5. Choose a performance metric to adjust the time range in order to see data for other than the current day. You can change the **Statistic**, **Time Range**, and **Period** values to adjust the information displayed. For example, to see the peak values for a metric for each day of the last two weeks, set **Statistic** to **Maximum**, **Time Range** to **Last 2 Weeks**, and **Period** to **Day**.

   Note
   Changing the **Statistic**, **Time Range**, and **Period** values changes them for all metrics. The updated values persist for the remainder of your session or until you change them again.

You can also view performance metrics using the CLI or API. For more information, see Viewing DB Instance Metrics (p. 356).

To set a CloudWatch alarm

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose a DB instance.
3. Choose **Logs & events**.
4. In the **CloudWatch alarms** section, choose **Create alarm**.



5. For **Send notifications**, choose **Yes**, and for **Send notifications to**, choose **New email or SMS topic**.
6. For **Topic name**, enter a name for the notification, and for **With these recipients**, enter a comma-separated list of email addresses and phone numbers.
7. For **Metric**, choose the alarm statistic and metric to set.
8. For **Threshold**, specify whether the metric must be greater than, less than, or equal to the threshold, and specify the threshold value.
9. For **Evaluation period**, choose the evaluation period for the alarm, and for **consecutive period(s) of**, choose the period during which the threshold must have been reached in order to trigger the alarm.
10. For **Name of alarm**, enter a name for the alarm.
11. Choose **Create Alarm**.

The alarm appears in the **CloudWatch alarms** section.

Evaluating Performance Metrics

A DB instance has a number of different categories of metrics, and how to determine acceptable values depends on the metric.

CPU

- CPU Utilization – Percentage of computer processing capacity used.

Memory

- Freeable Memory – How much RAM is available on the DB instance, in megabytes. The red line in the Monitoring tab metrics is marked at 75% for CPU, Memory and Storage Metrics. If instance memory consumption frequently crosses that line, then this indicates that you should check your workload or upgrade your instance.
- Swap Usage – How much swap space is used by the DB instance, in megabytes.

Disk space

- Free Storage Space – How much disk space is not currently being used by the DB instance, in megabytes.

Input/output operations

- Read IOPS, Write IOPS – The average number of disk read or write operations per second.
- Read Latency, Write Latency – The average time for a read or write operation in milliseconds.
- Read Throughput, Write Throughput – The average number of megabytes read from or written to disk per second.
- Queue Depth – The number of I/O operations that are waiting to be written to or read from disk.

Network traffic

- Network Receive Throughput, Network Transmit Throughput – The rate of network traffic to and from the DB instance in megabytes per second.

Database connections

- DB Connections – The number of client sessions that are connected to the DB instance.

For more detailed individual descriptions of the performance metrics available, see Amazon RDS Dimensions and Metrics.

Generally speaking, acceptable values for performance metrics depend on what your baseline looks like and what your application is doing. Investigate consistent or trending variances from your baseline. Advice about specific types of metrics follows:

- **High CPU or RAM consumption –** High values for CPU or RAM consumption might be appropriate, provided that they are in keeping with your goals for your application (like throughput or concurrency) and are expected.

- **Disk space consumption –** Investigate disk space consumption if space used is consistently at or above 85 percent of the total disk space. See if it is possible to delete data from the instance or archive data to a different system to free up space.
- **Network traffic –** For network traffic, talk with your system administrator to understand what expected throughput is for your domain network and Internet connection. Investigate network traffic if throughput is consistently lower than expected.
- **Database connections –** Consider constraining database connections if you see high numbers of user connections in conjunction with decreases in instance performance and response time. The best number of user connections for your DB instance will vary based on your instance class and the complexity of the operations being performed. You can determine the number of database connections by associating your DB instance with a parameter group where the *User Connections* parameter is set to other than 0 (unlimited). You can either use an existing parameter group or create a new one. For more information, see Working with DB Parameter Groups (p. 202).
- **IOPS metrics –** The expected values for IOPS metrics depend on disk specification and server configuration, so use your baseline to know what is typical. Investigate if values are consistently different than your baseline. For best IOPS performance, make sure your typical working set will fit into memory to minimize read and write operations.

For issues with any performance metrics, one of the first things you can do to improve performance is tune the most used and most expensive queries to see if that lowers the pressure on system resources. For more information, see Tuning Queries (p. 130)

If your queries are tuned and an issue persists, consider upgrading your Amazon RDS DB Instance Classes (p. 7) to one with more of the resource (CPU, RAM, disk space, network bandwidth, I/O capacity) that is related to the issue you are experiencing.

Tuning Queries

One of the best ways to improve DB instance performance is to tune your most commonly used and most resource-intensive queries to make them less expensive to run.

MySQL Query Tuning

Go to Optimizing SELECT Statements in the MySQL documentation for more information on writing queries for better performance. You can also go to MySQL Performance Tuning and Optimization Resources for additional query tuning resources.

Oracle Query Tuning

Go to the Database SQL Tuning Guide in the Oracle documentation for more information on writing and analyzing queries for better performance.

SQL Server Query Tuning

Go to Analyzing a Query in the SQL Server documentation to improve queries for SQL Server DB instances. You can also use the execution-, index- and I/O-related data management views (DMVs) described in the Dynamic Management Views and Functions documentation to troubleshoot SQL Server query issues.

A common aspect of query tuning is creating effective indexes. You can use the Database Engine Tuning Advisor to get potential index improvements for your DB instance. For more information, see Analyzing Your Database Workload on an Amazon RDS DB Instance with SQL Server Tuning Advisor (p. 696).

PostgreSQL Query Tuning

Go to Using EXPLAIN in the PostgreSQL documentation to learn how to analyze a query plan. You can use this information to modify a query or underlying tables in order to improve query performance. You can also go to Controlling the Planner with Explicit JOIN Clauses to get tips about how to specify joins in your query for the best performance.

MariaDB Query Tuning

Go to Query Optimizations in the MariaDB documentation for more information on writing queries for better performance.

Best Practices for Working with MySQL Storage Engines

On a MySQL DB instance, observe the following table creation limits:

- You're limited to 10,000 tables if you are either using Provisioned IOPS storage, or using General Purpose storage and the DB instance is 200 GiB or larger in size.
- You're limited to 1000 tables if you are either using magnetic storage, or using General Purpose storage and the DB instance is less than 200 GiB in size.

We recommend these limits because having large numbers of tables significantly increases database recovery time after a failover or database crash. If you need to create more tables than recommended, set the `innodb_file_per_table` parameter to 0. For more information, see Working with InnoDB Tablespaces to Improve Crash Recovery Times (p. 803) and Working with DB Parameter Groups (p. 202).

For MySQL DB instances that use version 5.7 or later, you can exceed these table creation limits due to improvements in InnoDB crash recovery. However, we still recommend that you take caution due to the potential performance impact of creating very large numbers of tables.

On a MySQL DB instance, avoid tables in your database growing too large. Although the general storage limit is 64 TiB, provisioned storage limits restrict the maximum size of a MySQL table file to 16 TiB. Partition your large tables so that file sizes are well under the 16 TiB limit. This approach can also improve performance and recovery time. For more information, see MySQL File Size Limits in Amazon RDS (p. 818).

The Point-In-Time Restore and snapshot restore features of Amazon RDS for MySQL require a crash-recoverable storage engine and are supported for the InnoDB storage engine only. Although MySQL supports multiple storage engines with varying capabilities, not all of them are optimized for crash recovery and data durability. For example, the MyISAM storage engine does not support reliable crash recovery and might prevent a Point-In-Time Restore or snapshot restore from working as intended. This might result in lost or corrupt data when MySQL is restarted after a crash.

InnoDB is the recommended and supported storage engine for MySQL DB instances on Amazon RDS. InnoDB instances can also be migrated to Aurora, while MyISAM instances can't be migrated. However, MyISAM performs better than InnoDB if you require intense, full-text search capability. If you still choose to use MyISAM with Amazon RDS, following the steps outlined in Automated Backups with Unsupported MySQL Storage Engines (p. 299) can be helpful in certain scenarios for snapshot restore functionality.

If you want to convert existing MyISAM tables to InnoDB tables, you can use the process outlined in the MySQL documentation. MyISAM and InnoDB have different strengths and weaknesses, so you should fully evaluate the impact of making this switch on your applications before doing so.

In addition, Federated Storage Engine is currently not supported by Amazon RDS for MySQL.

Best Practices for Working with MariaDB Storage Engines

The point-in-time restore and snapshot restore features of Amazon RDS for MariaDB require a crash-recoverable storage engine. Although MariaDB supports multiple storage engines with varying capabilities, not all of them are optimized for crash recovery and data durability. For example, although Aria is a crash-safe replacement for MyISAM, it might still prevent a point-in-time restore or snapshot restore from working as intended. This might result in lost or corrupt data when MariaDB is restarted after a crash. InnoDB (for version 10.2 and higher) and XtraDB (for version 10.0 and 10.1) are the recommended and supported storage engines for MariaDB DB instances on Amazon RDS. If you still choose to use Aria with Amazon RDS, following the steps outlined in Automated Backups with Unsupported MariaDB Storage Engines (p. 300) can be helpful in certain scenarios for snapshot restore functionality.

Best Practices for Working with Oracle

For information about best practices for working with Amazon RDS for Oracle, see Best Practices for Running Oracle Database on Amazon Web Services and the video Running Oracle Databases on Amazon RDS.

Best Practices for Working with PostgreSQL

Two important areas where you can improve performance with PostgreSQL on Amazon RDS are when loading data into a DB instance and when using the PostgreSQL autovacuum feature. The following sections cover some of the practices we recommend for these areas.

Loading Data into a PostgreSQL DB Instance

When loading data into an Amazon RDS PostgreSQL DB instance, you should modify your DB instance settings and your DB parameter group values to allow for the most efficient importing of data into your DB instance.

Modify your DB instance settings to the following:

- Disable DB instance backups (set backup_retention to 0)
- Disable Multi-AZ

Modify your DB parameter group to include the following settings. You should test the parameter settings to find the most efficient settings for your DB instance:

- Increase the value of the `maintenance_work_mem` parameter. For more information about PostgreSQL resource consumption parameters, see the PostgreSQL documentation.
- Increase the value of the `checkpoint_segments` and `checkpoint_timeout` parameters to reduce the number of writes to the wal log.
- Disable the `synchronous_commit` parameter (do not turn off FSYNC).
- Disable the PostgreSQL autovacuum parameter.
- Make sure none of the tables you are importing are unlogged. Data stored in unlogged tables can be lost during a failover. For more information see, CREATE TABLE UNLOGGED

Use the `pg_dump -Fc` (compressed) or `pg_restore -j` (parallel) commands with these settings.

After the load operation completes, return your DB instance and DB parameters to their normal settings.

Working with the fsync and full_page_writes database parameters

In PostgreSQL 9.4.1 on Amazon RDS, the `fsync` and `full_page_writes` database parameters are not modifiable. Disabling the `fsync` and `full_page_writes` database parameters can lead to data corruption, so we have enabled them for you.

Working with the PostgreSQL Autovacuum Feature

The autovacuum feature for PostgreSQL databases is a feature that we strongly recommend you use to maintain the health of your PostgreSQL DB instance. Autovacuum automates the execution of the VACUUM and ANALYZE command; using autovacuum is required by PostgreSQL, not imposed by Amazon RDS, and its use is critical to good performance. The feature is enabled by default for all new Amazon RDS PostgreSQL DB instances, and the related configuration parameters are appropriately set by default.

Your database administrator needs to know and understand this maintenance operation. For the PostgreSQL documentation on autovacuum, see Routine Vacuuming.

Autovacuum is not a “resource free” operation, but it works in the background and yields to user operations as much as possible. When enabled, autovacuum checks for tables that have had a large number of updated or deleted tuples. It also protects against loss of very old data due to transaction ID wraparound. For more information, see Preventing Transaction ID Wraparound Failures.

Autovacuum should not be thought of as a high-overhead operation that can be reduced to gain better performance. On the contrary, tables that have a high velocity of updates and deletes will quickly deteriorate over time if autovacuum is not run.

> **Important**
> Not running autovacuum can result in an eventual required outage to perform a much more intrusive vacuum operation. When an Amazon RDS PostgreSQL DB instance becomes unavailable because of an over conservative use of autovacuum, the PostgreSQL database will shut down to protect itself. At that point, Amazon RDS must perform a single-user-mode full vacuum directly on the DB instance , which can result in a multi-hour outage. Thus, we strongly recommend that you do not turn off autovacuum, which is enabled by default.

The autovacuum parameters determine when and how hard autovacuum works. The `autovacuum_vacuum_threshold` and `autovacuum_vacuum_scale_factor` parameters determine when autovacuum is run. The `autovacuum_max_workers`, `autovacuum_nap_time`, `autovacuum_cost_limit`, and `autovacuum_cost_delay` parameters determine how hard autovacuum works. For more information about autovacuum, when it runs, and what parameters are required, see the PostgreSQL documentation.

The following query shows the number of "dead" tuples in a table named table1 :

```
PROMPT> select relname, n_dead_tup, last_vacuum, last_autovacuum from
pg_catalog.pg_stat_all_tables
where n_dead_tup > 0 and relname =  'table1';
```

The results of the query will resemble the following:

```
relname | n_dead_tup | last_vacuum | last_autovacuum
---------+------------+-------------+-----------------
 tasks    |   81430522 |             |
(1 row)
```

Best Practices for Working with SQL Server

Best practices for a Multi-AZ deployment with a SQL Server DB instance include the following:

- Use Amazon RDS DB events to monitor failovers. For example, you can be notified by text message or email when a DB instance fails over. For more information about Amazon RDS events, see Using Amazon RDS Event Notification (p. 429).
- If your application caches DNS values, set time to live (TTL) to less than 30 seconds. Setting TTL as so is a good practice in case there is a failover, where the IP address might change and the cached value might no longer be in service.
- We recommend that you *do not* enable the following modes because they turn off transaction logging, which is required for Multi-AZ:
  - Simple recover mode
  - Offline mode
  - Read-only mode
- Test to determine how long it takes for your DB instance to failover. Failover time can vary due to the type of database, the instance class, and the storage type you use. You should also test your application's ability to continue working if a failover occurs.
- To shorten failover time, you should do the following:
  - Ensure that you have sufficient Provisioned IOPS allocated for your workload. Inadequate I/O can lengthen failover times. Database recovery requires I/O.
  - Use smaller transactions. Database recovery relies on transactions, so if you can break up large transactions into multiple smaller transactions, your failover time should be shorter.
- Take into consideration that during a failover, there will be elevated latencies. As part of the failover process, Amazon RDS automatically replicates your data to a new standby instance. This replication means that new data is being committed to two different DB instances, so there might be some latency until the standby DB instance has caught up to the new primary DB instance.
- Deploy your applications in all Availability Zones. If an Availability Zone does go down, your applications in the other Availability Zones will still be available.

When working with a Multi-AZ deployment of SQL Server, remember that Amazon RDS creates replicas for all SQL Server databases on your instance. If you don't want specific databases to have secondary replicas, set up a separate DB instance that doesn't use Multi-AZ for those databases.

Working with DB Parameter Groups

We recommend that you try out DB parameter group changes on a test DB instance before applying parameter group changes to your production DB instances. Improperly setting DB engine parameters in a DB parameter group can have unintended adverse effects, including degraded performance and system instability. Always exercise caution when modifying DB engine parameters and back up your DB instance before modifying a DB parameter group.

For information about backing up your DB instance, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

Amazon RDS Best Practices Presentation Video

The 2016 AWS Summit conference in Chicago included a presentation on best practices for creating and configuring a secure, highly available database instance using Amazon RDS. A video of the presentation is available here.

Configuring an Amazon RDS DB Instance

This section shows how to set up your Amazon RDS DB instance. Before creating a DB instance, decide on the DB instance class that will run the DB instance. Also, decide where the DB instance will run by choosing an AWS Region. Next, create the DB instance.

Topics

Creating an Amazon RDS DB Instance

The basic building block of Amazon RDS is the DB instance, where you create your databases. You choose the engine-specific characteristics of the DB instance when you create it. You also choose the storage capacity, CPU, memory, and so on, of the AWS instance on which the database server runs.

Important
Before you can create or connect to a DB instance, you must complete the tasks in Setting Up for Amazon RDS (p. 58).

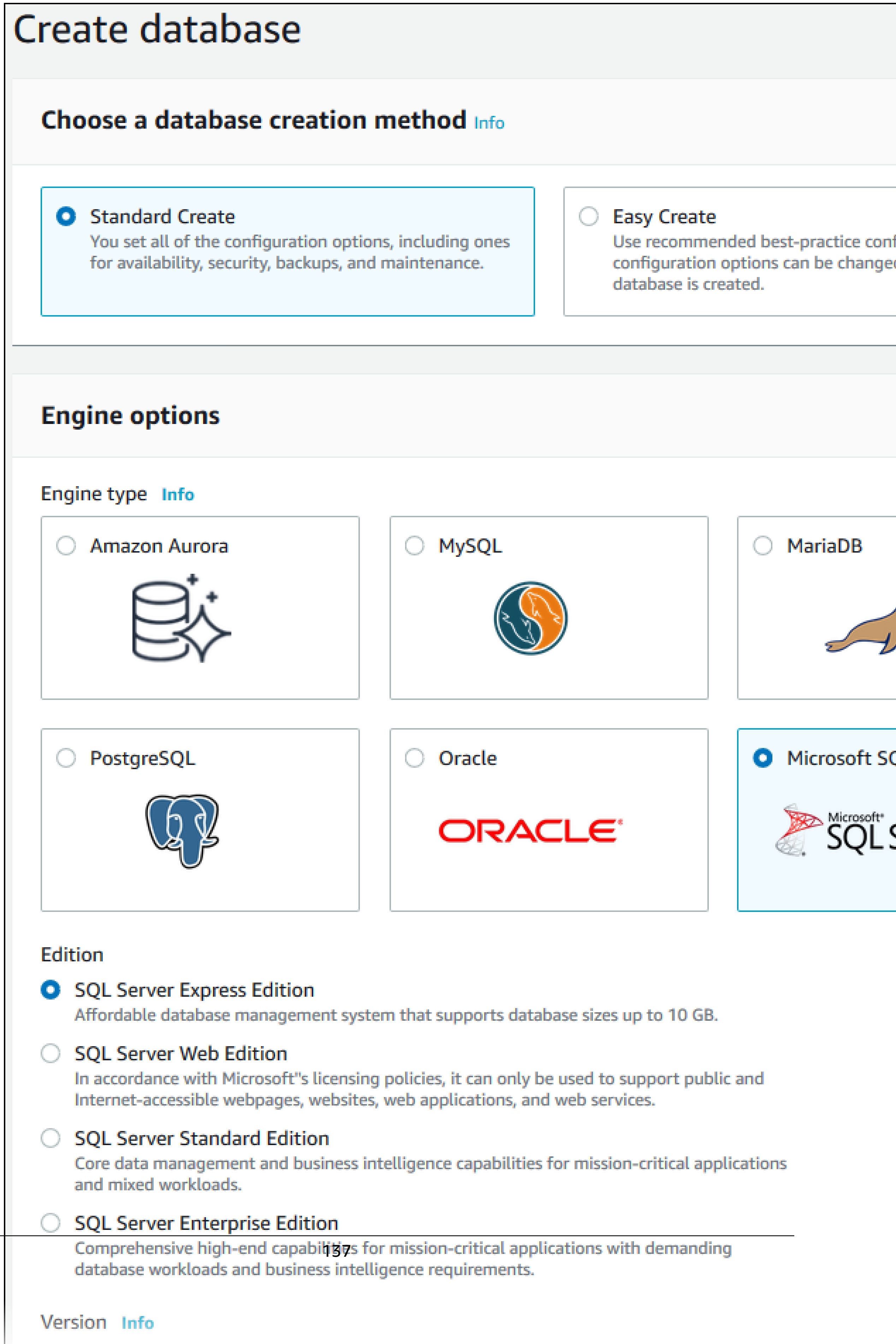
Console

You can create a DB instance by using the AWS Management Console with **Easy Create** enabled or not enabled. With **Easy Create** enabled, you specify only the DB engine type, DB instance size, and DB instance identifier. **Easy Create** uses the default setting for other configuration options. With **Easy Create** not enabled, you specify more configuration options when you create a database, including ones for availability, security, backups, and maintenance.

Note
In the following procedure, **Standard Create** is enabled, and **Easy Create** isn't enabled. This procedure uses Microsoft SQL Server as an example.
For examples that use **Easy Create** to walk you through creating and connecting to sample DB instances for each engine, see Getting Started with Amazon RDS (p. 64). For an example that uses the original console to create a DB instance, see Original Console Example (p. 150).

To create a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database**.
5. In **Choose a database creation method**, select **Standard Create**.
6. In **Engine options**, choose the engine type: MariaDB, Microsoft SQL Server, MySQL, Oracle, or PostgreSQL. **Microsoft SQL Server** is shown here.


Create database
Choose a database creation method Info
Standard Create
You set all of the configuration options, including ones for availability, security, backups, and maintenance.
Easy Create
Use recommended best-practice conf
configuration options can be change
database is created.
Engine options
Engine type Info
Amazon Aurora
MySQL
MariaDB
PostgreSQL
Oracle
ORACLE
Microsoft SQ
Microsoft
SQL S
Edition
SQL Server Express Edition
Affordable database management system that supports database sizes up to 10 GB.
SQL Server Web Edition
In accordance with Microsoft''s licensing policies, it can only be used to support public and Internet-accessible webpages, websites, web applications, and web services.
SQL Server Standard Edition
Core data management and business intelligence capabilities for mission-critical applications and mixed workloads.
SQL Server Enterprise Edition
Comprehensive high-end capabilities for mission-critical applications with demanding database workloads and business intelligence requirements.
Version Info

7. For **Edition**, if you're using Oracle or SQL Server choose the DB engine edition that you want to use.

   MySQL has only one option for the edition, and MariaDB and PostgreSQL have none.
8. For **Version**, choose the engine version.
9. In **Templates**, choose the template that matches your use case. If you choose **Production**, the following are preselected in a later step:

   - **Multi-AZ** failover option
   - **Provisioned IOPS** storage option
   - **Enable deletion protection** option

   We recommend these features for any production environment.

   Note
   Template choices vary by edition.
10. To enter your master password, do the following:

    a. In the **Settings** section, open **Credential Settings**.

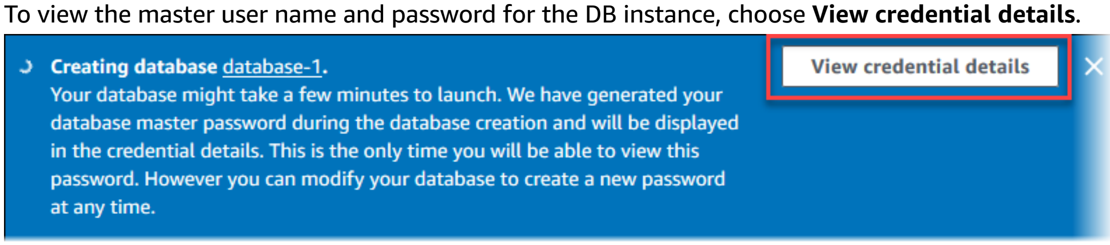
    b. Clear the **Auto generate a password** check box.

    c. (Optional) Change the **Master username** value and enter the same password in **Master password** and **Confirm password**.

    By default, the new DB instance uses an automatically generated password for the master user.
11. For the remaining sections, specify your DB instance settings. For information about each setting, see Settings for DB Instances (p. 141).
12. Choose **Create database**.

    If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

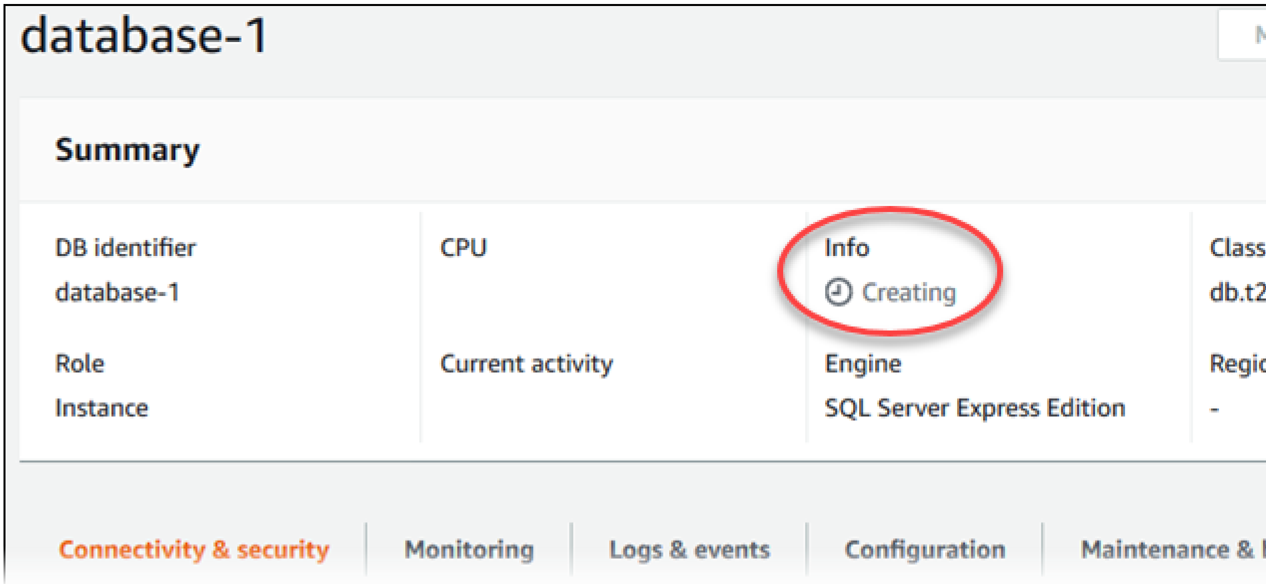
    To view the master user name and password for the DB instance, choose **View credential details**.



    To connect to the DB instance as the master user, use the user name and password that appear.

    Important
    You can't view the master user password again. If you don't record it, you might have to change it. If you need to change the master user password after the DB instance is available, modify the DB instance to do so. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
13. For **Databases**, choose the name of the new DB instance.

    On the RDS console, the details for the new DB instance appear. The DB instance has a status of **creating** until the DB instance is created and ready for use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and storage allocated, it can take several minutes for the new instance to be available.



AWS CLI

To create a DB instance by using the AWS CLI, call the create-db-instance command with the following parameters. This example uses Microsoft SQL Server.

For information about each setting, see Settings for DB Instances (p. 141).

- `--db-instance-identifier`
- `--db-instance-class`
- `--db-security-groups`
- `--db-subnet-group`
- `--engine`
- `--master-user-name`
- `--master-user-password`
- `--allocated-storage`
- `--backup-retention-period`

Example

For Linux, macOS, or Unix:

```
aws rds create-db-instance
    --engine sqlserver-se \
    --db-instance-identifier mymsftsqlserver \
    --allocated-storage 250 \
    --db-instance-class db.m1.large \
    --db-security-groups mydbsecuritygroup \
    --db-subnet-group mydbsubnetgroup \
    --master-user-name masterawsuser \
    --master-user-password masteruserpassword \
    --backup-retention-period 3
```

For Windows:

```
aws rds create-db-instance ^
    --engine sqlserver-se ^
    --db-instance-identifier mydbinstance ^
    --allocated-storage 250 ^
    --db-instance-class db.m1.large ^
    --db-security-groups mydbsecuritygroup ^
    --db-subnet-group mydbsubnetgroup ^
    --master-user-name masterawsuser ^
    --master-user-password masteruserpassword ^
    --backup-retention-period 3
```

This command produces output similar to the following.

```
DBINSTANCE  mydbinstance  db.m1.large  sqlserver-se  250  sa  creating  3  ****  n
 10.50.2789
SECGROUP  default  active
PARAMGRP  default.sqlserver-se-10.5  in-sync
```

RDS API

To create a DB instance by using the Amazon RDS API, call the CreateDBInstance operation with the following parameters. This example uses Microsoft SQL Server.

For information about each setting, see Settings for DB Instances (p. 141).

- AllocatedStorage
- BackupRetentionPeriod
- DBInstanceClass
- DBInstanceIdentifier
- DBSecurityGroups
- DBSubnetGroup
- Engine
- MasterUsername
- MasterUserPassword

Example

```
https://rds.amazonaws.com/
    ?Action=CreateDBInstance
    &AllocatedStorage=250
    &BackupRetentionPeriod=3
    &DBInstanceClass=db.m1.large
    &DBInstanceIdentifier=mydbinstance
    &DBSecurityGroups.member.1=mysecuritygroup
    &DBSubnetGroup=mydbsubnetgroup
    &Engine=sqlserver-se
    &MasterUserPassword=masteruserpassword
    &MasterUsername=masterawsuser
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20140305/us-west-1/rds/aws4_request
    &X-Amz-Date=20140305T185838Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=b441901545441d3c7a48f63b5b1522c5b2b37c137500c93c45e209d4b3a064a3
```

Settings for DB Instances

In the following table, you can find details about settings that you choose when you create a DB instance. The table also shows the DB engines for which each setting is supported.

You can create a DB instance using the console, the `create-db-instance` CLI command, or the `CreateDBInstance` RDS API operation.

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Allocated storage	The amount of storage to allocate for your DB instance (in gigabytes). In some cases, allocating a higher amount of storage for your DB instance than the size of your database can improve I/O performance.
	
	For more information, see Amazon RDS DB Instance Storage (p. 29).
		CLI option:
		
		`--allocated-storage`
		
		API parameter:
		
		`AllocatedStorage`
			All

Auto minor version upgrade	**Enable auto minor version upgrade** to enable your DB instance to receive preferred minor DB engine version upgrades automatically when they become available. Amazon RDS performs automatic minor version upgrades in the maintenance window.	**CLI option:**
		
		`--auto-minor-version-upgrade`
		
		`--no-auto-minor-version-upgrade`
		
		API parameter:
		
		`AutoMinorVersionUpgrade`
			All except SQL Server

Availability zone	The Availability Zone for your DB instance. Use the default value of **No Preference** unless you want to specify an Availability Zone.
	
	For more information, see Regions, Availability Zones, and Local Zones (p. 37).
		CLI option:
		
		`--availability-zone`
		
		API parameter:
		
		`AvailabilityZone`
			All

Backup retention period	The number of days that you want automatic backups of your DB instance to be retained. For any nontrivial DB instance, set this value to `1` or greater. For more information, see Working With Backups (p. 291).	**CLI option:** `--backup-retention-period`	All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines
		API parameter: `BackupRetentionPeriod`	

Backup window	The time period during which Amazon RDS automatically takes a backup of your DB instance. Unless you have a specific time that you want to have your database backed up, use the default of **No Preference**.
	
	For more information, see Working With Backups (p. 291).
		CLI option:
		
		`--preferred-backup-window`
		
		API parameter:
		
		`PreferredBackupWindow`
			All

Character set	The character set for your DB instance. The default value of **AL32UTF8** is for the Unicode 5.0 UTF-8 Universal character set. You can't change the character set after the DB instance is created.
	
	For more information, see Oracle Character Sets Supported in Amazon RDS (p. 911).
		CLI option:
		
		`--character-set-name`
		
		API parameter:
		
		`CharacterSetName`
			Oracle

Collation	A server-level collation for your DB instance.
	
	For more information, see Server-Level Collation for Microsoft SQL Server (p. 698).
		CLI option:
		
		`--character-set-name`
		
		API parameter:
		
		`CharacterSetName`
			SQL Server

Copy tags to snapshots	This option copies any DB instance tags to a DB snapshot when you create a snapshot.
	
	For more information, see Tagging Amazon RDS Resources (p. 266).
		CLI option:
		
		`--copy-tags-to-snapshot`
		
		`--no-copy-tags-to-snapshot`
		
		RDS API parameter:
		
		`CopyTagsToSnapshot`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Database port	The port that you want to access the DB instance through. The default port is shown. If you use a DB security group with your DB instance, this port value must be the same one that you provided when creating the DB security group.
	
	Note
	The firewalls at some companies block connections to the default MariaDB, MySQL, and PostgreSQL ports. If your company firewall blocks the default port, enter another port for your DB instance.
		CLI option:
		
		`--port`
		
		RDS API parameter:
		
		`Port`
			All

Database authentication	The database authentication option that you want to use.
	
	Choose **Password authentication** to authenticate database users with database passwords only.
	
	Choose **Password and IAM DB authentication** to authenticate database users with database passwords and user credentials through IAM users and roles. For more information, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387). This option is only supported for MySQL and PostgreSQL.
	
	Choose **Password and Kerberos authentication** to authenticate database users with database passwords and Kerberos authentication through an AWS Managed Microsoft AD created with AWS Directory Service. Next, choose the directory or choose **Create a new Directory**.
	
	For more information, see one of the following:
	
	• Using Kerberos Authentication for MySQL (p. 806)
	• Using Kerberos Authentication with Amazon RDS for Oracle (p. 1053)
	• Using Kerberos Authentication with Amazon RDS for PostgreSQL (p. 1296)
		IAM:
		
		CLI option:
		
		`--enable-iam-database-authentication`
		
		`--no-enable-iam-database-authentication`
		
		RDS API parameter:
		
		`EnableIAMDatabaseAuthentication`
		
		Kerberos:
		
		CLI option:
		
		`--domain`
		
		`--domain-iam-role-name`
		
		RDS API parameter:
		
		`Domain`
		
		`DomainIAMRoleName`
			MySQL
			
			Oracle
			
			PostgreSQL

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

DB engine version	The version of database engine that you want to use.	**CLI option:**
		`--engine-version`
		RDS API parameter:
		`EngineVersion`
			All

DB instance class	The configuration for your DB instance. For example, a **db.m1.small** instance class has 1.7 GiB memory, 1 ECU (1 virtual core with 1 ECU), 64-bit platform, and moderate I/O capacity.
	If possible, choose an instance class large enough that a typical query working set can be held in memory. When working sets are held in memory the system can avoid writing to disk, which improves performance.
	For more information, see DB Instance Classes (p. 7).
		CLI option:
		`--db-instance-class`
		RDS API parameter:
		`DBInstanceClass`
			All

DB instance identifier	The name for your DB instance. Name your DB instances in the same way that you name your on-premises servers. Your DB instance identifier can contain up to 63 alphanumeric characters, and must be unique for your account in the AWS Region you chose. You can add some intelligence to the name, such as including the AWS Region and DB engine you chose, for example **`sqlsrvr-instance1`**.	**CLI option:**
		`--db-instance-identifier`
		RDS API parameter:
		`DBInstanceIdentifier`
			All

DB parameter group	A parameter group for your DB instance. You can choose the default parameter group or you can create a custom parameter group.
	For more information, see Working with DB Parameter Groups (p. 202).
		CLI option:
		`--db-parameter-group-name`
		RDS API parameter:
		`DBParameterGroupName`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Deletion protection	**Enable deletion protection** to prevent your DB instance from being deleted. If you create a production DB instance with the AWS Management Console, deletion protection is enabled by default.
	
	For more information, see Deleting a DB Instance (p. 286).
		CLI option:
		
		`--deletion-protection`
		
		`--no-deletion-protection`
		
		RDS API parameter:
		
		`DeletionProtection`
			All

Encryption	**Enable Encryption** to enable encryption at rest for this DB instance.
	
	For more information, see Encrypting Amazon RDS Resources (p. 1358).
		CLI option:
		
		`--storage-encrypted`
		
		`--no-storage-encrypted`
		
		RDS API parameter:
		
		`DeletionProtection`
			All

Enhanced Monitoring	**Enable enhanced monitoring** to enable gathering metrics in real time for the operating system that your DB instance runs on.
	
	For more information, see Enhanced Monitoring (p. 362).
		CLI options:
		
		`--monitoring-interval`
		
		`--monitoring-role-arn`
		
		RDS API parameters:
		
		`MonitoringInterval`
		
		`MonitoringRoleArn`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Initial database name	The name for the database on your DB instance. If you don't provide a name, Amazon RDS doesn't create a database on the DB instance (except Oracle). The name can't be a word reserved by the database engine, and has other constraints depending on the DB engine.
	
	MariaDB and MySQL:
	• It must contain 1–64 alphanumeric characters.
	
	Oracle:
	• It must contain 1–8 alphanumeric characters.
	• It can't be `NULL`. The default value is ORCL.
	• It must begin with a letter.
	
	PostgreSQL:
	• It must contain 1–63 alphanumeric characters.
	• It must begin with a letter or an underscore. Subsequent characters can be letters, underscores, or digits (0-9).
		CLI option:
		
		`--db-name`
		
		RDS API parameter:
		
		`DBName`
			All except SQL Server

License	The license model:
	• Choose **license-included** for Microsoft SQL Server.
	• Choose **license-included** or **bring-your-own-license** for Oracle.
		CLI option:
		
		`--license-model`
		
		RDS API parameter:
		
		`LicenseModel`
			SQL Server
			
			Oracle

Maintenance window	The 30-minute window in which pending modifications to your DB instance are applied. If the time period doesn't matter, choose **No Preference**.
	
	For more information, see The Amazon RDS Maintenance Window (p. 238).
		CLI option:
		
		`--preferred-maintenance-window`
		
		RDS API parameter:
		
		`PreferredMaintenanceWindow`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Master password	The password for your master user account. The password has the following number of printable ASCII characters (excluding `/`, `"`, a space, and `@`) depending on the DB engine:
	• Oracle: 8–30
	• MariaDB and MySQL: 8–41
	• SQL Server and PostgreSQL: 8–128
		CLI option:
		`--master-user-password`
		RDS API parameter:
		`MasterUserPassword`
			All

Master username	The name that you use as the master user name to log on to your DB instance with all database privileges.
	• It can contain 1–16 alphanumeric characters and underscores.
	• Its first character must be a letter.
	• It can't be a word reserved by the database engine.
	For more information on privileges granted to the master user, see the following topics:
	• MariaDB Security on Amazon RDS (p. 503)
	• Microsoft SQL Server Security (p. 547)
	• MySQL Security on Amazon RDS (p. 715)
	• Oracle Security (p. 853)
	• Amazon RDS for PostgreSQL Versions and Extensions (p. 1310)
		CLI option:
		`--master-username`
		RDS API parameter:
		`MasterUsername`
			All

Microsoft SQL Server Windows Authentication	**Enable Microsoft SQL Server Windows authentication**, then **Browse Directory** to choose the directory where you want to allow authorized domain users to authenticate with this SQL Server instance using Windows Authentication.	**CLI options:**
		`--domain`
		`--domain-iam-role-name`
		RDS API parameters:
		`Domain`
		`DomainIAMRoleName`
			SQL Server

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Multi-AZ deployment	**Create a standby instance** to create a passive secondary replica of your DB instance in another Availability Zone for failover support. We recommend Multi-AZ for production workloads to maintain high availability.
	
	For development and testing, you can choose **Do not create a standby instance**.
	
	For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).
		CLI option:
		
		`--multi-az`
		
		`--no-multi-az`
		
		RDS API parameter:
		
		`MultiAZ`
			All

Option group	An option group for your DB instance. You can choose the default option group or you can create a custom option group.
	
	For more information, see Working with Option Groups (p. 186).
		CLI option:
		
		`--option-group-name`
		
		RDS API parameter:
		
		`OptionGroupName`
			All

Performance Insights	**Enable Performance Insights** to monitor your DB instance load so that you can analyze and troubleshoot your database performance.
	
	Choose a retention period to determine how much rolling data history to keep. The default of seven days is in the free tier. Long-term retention (two years) is priced per vCPU per month.
	
	Choose a master key to use to protect the key used to encrypt this database volume. Choose from the master keys in your account, or enter the key from a different account.
	
	For more information, see Using Amazon RDS Performance Insights (p. 376).
		CLI options:
		
		`--enable-performance-insights`
		
		`--no-enable-performance-insights`
		
		`--performance-insights-retention-period`
		
		`--performance-insights-kms-key-id`
		
		RDS API parameters:
		
		`EnablePerformanceInsights`
		
		`PerformanceInsightsRetentionPeri`
		
		`PerformanceInsightsKMSKeyId`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Publicly accessible	**Yes** to give the DB instance a public IP address, meaning that it's accessible outside the VPC. To be publicly accessible, the DB instance also has to be in a public subnet in the VPC.
	
	No to make the DB instance accessible only from inside the VPC.
	
	For more information, see Hiding a DB Instance in a VPC from the Internet (p. 1443).
		CLI option:
		
		`--publicly-accessible`
		
		`--no-publicly-accessible`
		
		RDS API parameter:
		
		`PubliclyAccessible`
			All

Storage autoscaling	**Enable storage autoscaling** to enable Amazon RDS to automatically increase storage when needed to avoid having your DB instance run out of storage space.
	
	Use **Maximum storage threshold** to set the upper limit for Amazon RDS to automatically increase storage for your DB instance. The default is 1,000 GiB.
	
	For more information, see Managing Capacity Automatically with Amazon RDS Storage Autoscaling (p. 279).
		CLI option:
		
		`--max-allocated-storage`
		
		RDS API parameter:
		
		`MaxAllocatedStorage`
			All

Storage type	The storage type for your DB instance.
	
	For more information, see Amazon RDS Storage Types (p. 29).
		CLI option:
		
		`--storage-type`
		
		RDS API parameter:
		
		`StorageType`
			All

Subnet group	This setting depends on the platform that you are on. If you are a new customer to AWS, choose **default**, which is the default DB subnet group that was created for your account.
	
	If you are creating a DB instance on the earlier E2-Classic platform, you might want your DB instance in a specific VPC. In this case, choose the DB subnet group that you created for that VPC.
		CLI option:
		
		`--db-subnet-group-name`
		
		RDS API parameter:
		
		`DBSubnetGroupName`
			All

Console Setting	Setting Description	CLI Option and RDS API Parameter	Supported DB Engines

Time zone	The time zone for your DB instance. If you don't choose a time zone, your DB instance uses the default time zone. You can't change the time zone after the DB instance is created.
	
	For more information, see Local Time Zone for Microsoft SQL Server DB Instances (p. 555).
		CLI option:
		
		`--timezone`
		
		RDS API parameter:
		
		`Timezone`
			SQL Server

Virtual Private Cloud (VPC)	This setting depends on the platform that you are on. If you are a new customer to AWS, choose the default VPC shown. If you are creating a DB instance on the earlier E2-Classic platform that doesn't use a VPC, choose **Not in VPC**. For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).	For the CLI and API, you specify the VPC security group IDs.	All

VPC security group	If you are a new customer to AWS, **Create new** to create a new VPC security group. Otherwise, **Choose existing**, then choose from security groups that you previously created.
	
	When you choose **Create new** in the RDS console, a new security group is created. This new security group has an inbound rule that allows access to the DB instance from the IP address detected in your browser.
	
	For more information, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).
		CLI option:
		
		`--vpc-security-group-ids`
		
		RDS API parameter:
		
		`VpcSecurityGroupIds.VpcSecurityG`
			All

Original Console Example

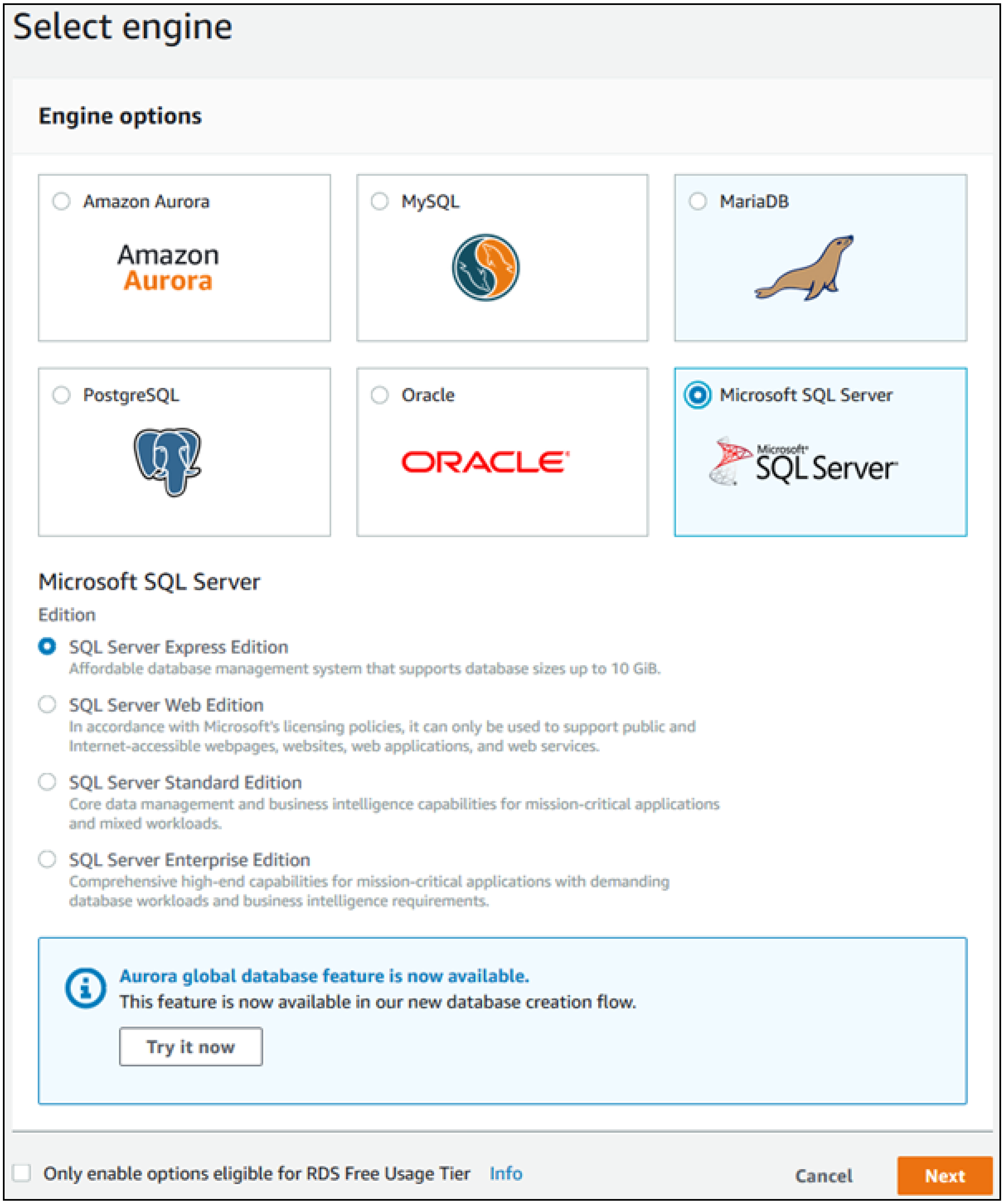
You can create a DB instance with the original AWS Management Console. This example uses Microsoft SQL Server.

To launch a SQL Server DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region in which you want to create the DB instance.
3. In the navigation pane, choose **Databases**.

   If the navigation pane is closed, choose the menu icon at the top left to open it.

4. Choose **Create database** to open the **Select engine** page.
5. Choose the **Microsoft SQL Server** icon.



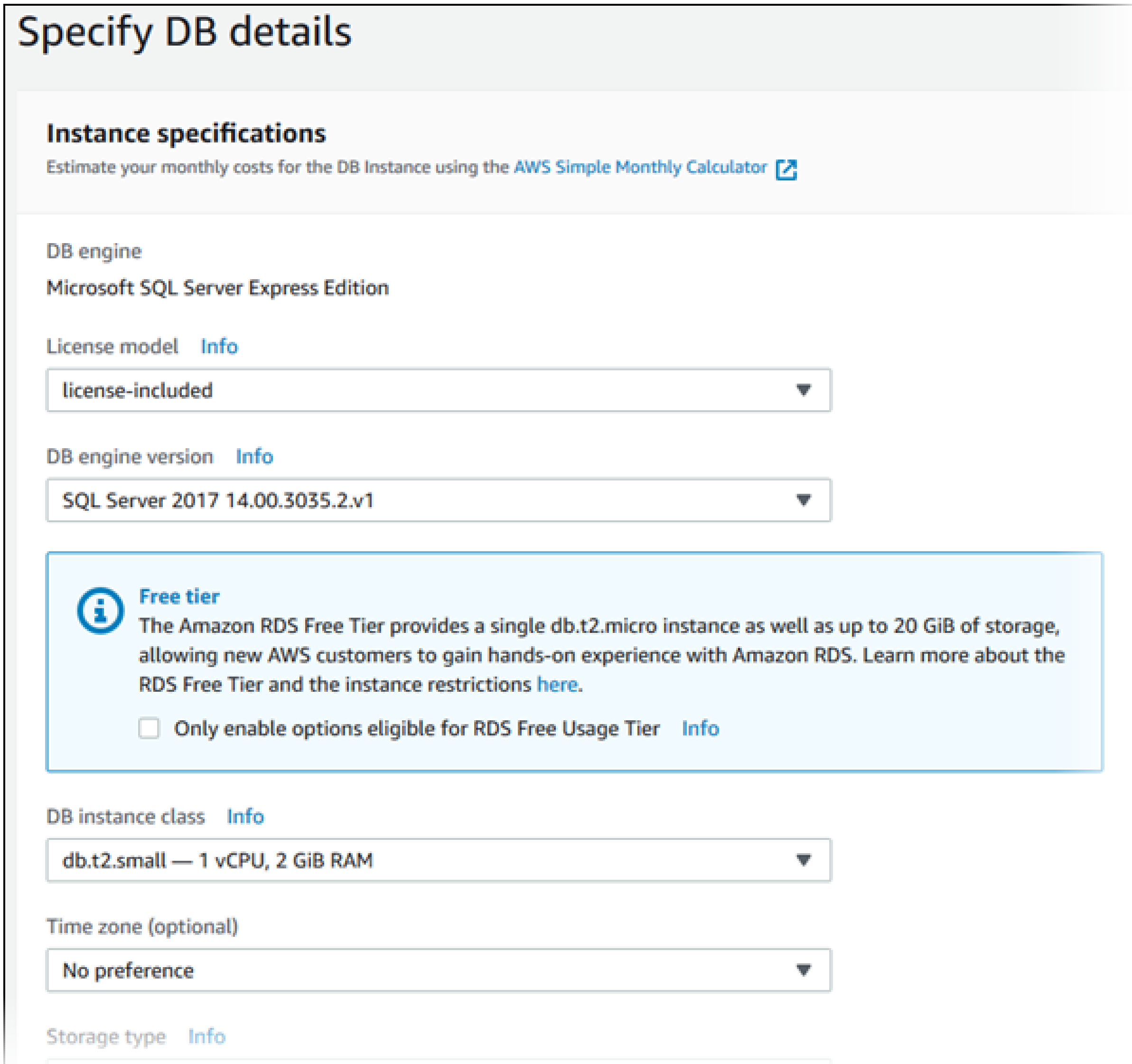
6. Choose the SQL Server DB engine edition that you want to use. The SQL Server editions that are available vary by AWS Region.
7. For some editions, the **Use Case** step asks if you are planning to use the DB instance you are creating for production. If you are, choose **Production**. If you choose **Production**, the following are all preselected in a later step:

- **Multi-AZ** failover option
- **Provisioned IOPS** storage option
- **Enable deletion protection** option

We recommend these features for any production environment.

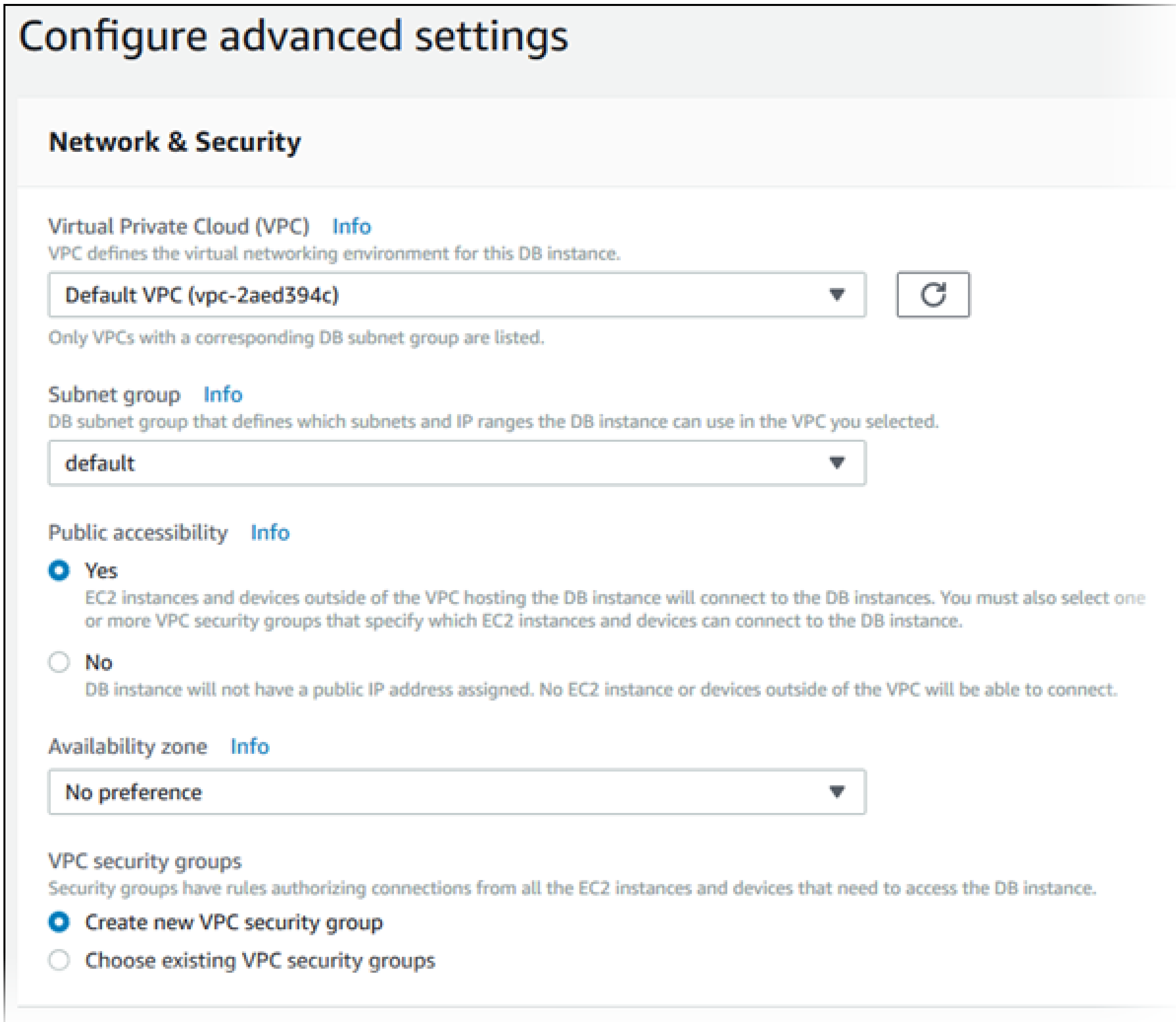
8. Choose **Next** to continue. The **Specify DB Details** page appears.

On the **Specify DB Details** page, specify your DB instance information. For information about each setting, see Settings for DB Instances (p. 141).



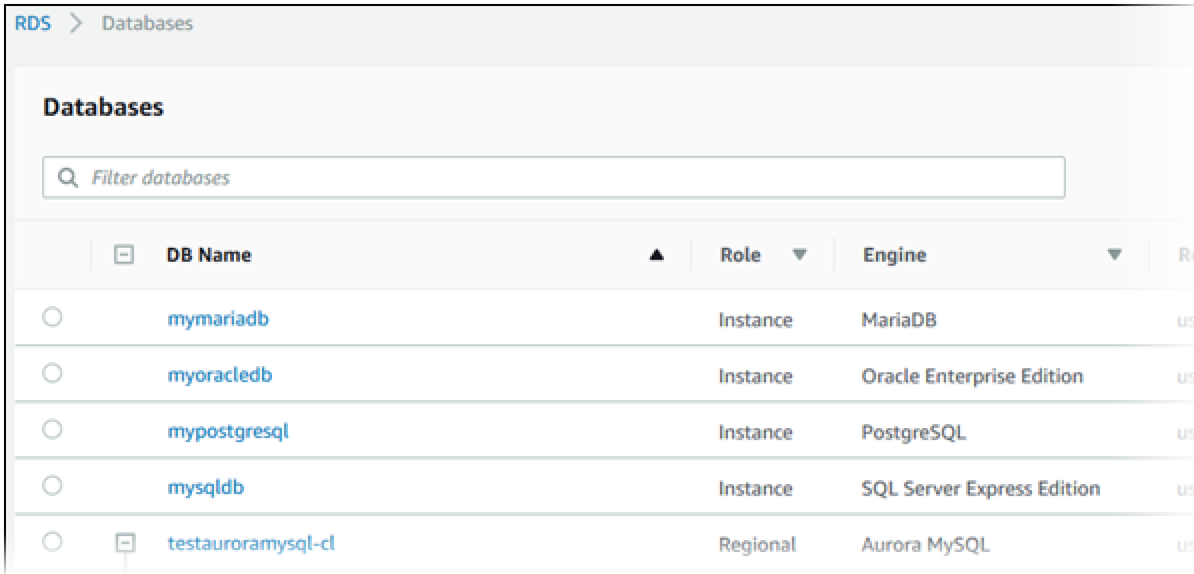
9. Choose **Next** to continue. The **Configure Advanced Settings** page appears.

On the **Configure Advanced Settings** page, provide additional information that Amazon RDS needs to launch the DB instance. For information about each setting, see Settings for DB Instances (p. 141).



10. Choose **Launch DB Instance**.
11. On the final page of the wizard, choose **Close**.

On the RDS console, the new DB instance appears in the list of DB instances. The DB instance has a status of **creating** until the DB instance is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new instance is available.


RDS
Databases
Databases
Filter databases
DB Name
Role
Engine
mymariadb
Instance
MariaDB
myoracledb
Instance
Oracle Enterprise Edition
mypostgresql
Instance
PostgreSQL
mysqldb
Instance
SQL Server Express Edition
testauroramysql-cl
Regional
Aurora MySQL

Connecting to an Amazon RDS DB Instance

After you create an Amazon RDS DB instance, you can use any standard SQL client application to connect to the DB instance. To connect to an Amazon RDS DB instance, follow the instructions for your specific database engine.

- Connecting to a DB Instance Running the MariaDB Database Engine (p. 509)
- Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560)
- Connecting to a DB Instance Running the MySQL Database Engine (p. 722)
- Connecting to a DB Instance Running the Oracle Database Engine (p. 874)
- Connecting to a DB Instance Running the PostgreSQL Database Engine (p. 1226)

You can also use Amazon RDS Proxy to manage connections to MySQL and PostgreSQL DB instances. RDS Proxy allows applications to pool and share database connections to improve scalability.

- Managing Connections with Amazon RDS Proxy (Preview) (p. 155)

Managing Connections with Amazon RDS Proxy (Preview)

This is preview documentation for Amazon RDS Proxy. It is subject to change.

By using Amazon RDS Proxy, you can allow your applications to pool and share database connections to improve scalability. RDS Proxy makes applications more resilient to database failures by automatically connecting to a standby DB instance while preserving application connections. RDS Proxy also enables you to enforce AWS Identity and Access Management (IAM) authentication for databases, and securely store credentials in AWS Secrets Manager.

Note
RDS Proxy is fully compatible with MySQL and PostgreSQL. You can enable RDS Proxy for most applications with no code changes.

Using RDS Proxy, you can handle unpredictable surges in database traffic that otherwise could cause issues due to oversubscribing connections or creating new connections at a fast rate. RDS Proxy establishes a database connection pool and reuses connections in this pool without the memory and CPU overhead of opening a new database connection each time. To protect the database against oversubscription, you can control the number of database connections that are created.

RDS Proxy sequences or throttles application connections that can't be served immediately from the pool of connections. Although latencies might increase, your application can continue to scale without abruptly failing or overwhelming the database. If connection requests exceed the limits you specify, RDS Proxy rejects application connections (sheds load). At the same time, it maintains predictable performance for the load that can be served with available capacity.

You can reduce the overhead to process credentials and establish a secure connection for each new connection. RDS Proxy can handle some of that work on behalf of the database.

Important
Currently, Amazon RDS Proxy is in preview. Don't use RDS Proxy for production workloads. Also, we strongly recommend not putting sensitive data in databases that you use with RDS Proxy preview. You might encounter issues during the preview that cause incorrect results, corrupted

data, or both. Over the duration of the preview, we might introduce breaking changes without advance notice. These might include upgrades and changes to our API operations.

Topics

RDS Proxy Concepts and Terminology

This is preview documentation for Amazon RDS Proxy. It is subject to change.

You can simplify connection management for your Amazon RDS DB instances and Aurora DB clusters by using RDS Proxy.

RDS Proxy handles the network traffic between the client application and the database. It does so in an active way first by understanding the database protocol. It then adjusts its behavior based on the SQL operations from your application and the result sets from the database. RDS Proxy reduces the memory and CPU overhead for connection management on your database. The database needs less memory and CPU resources when applications open many simultaneous connections. It also doesn't require logic in your applications to close and reopen connections that stay idle for a long time. Similarly, it requires less application logic to reestablish connections in case of a database problem.

The infrastructure for RDS Proxy is independent of the database servers for the RDS DB instances and Aurora DB clusters. This separation helps lower overhead on your database servers, so that they can devote their resources to serving database workloads.

Topics

Overview of RDS Proxy Terminology

RDS Proxy handles the infrastructure to perform connection pooling and the other features described in this documentation. You see the proxies represented in the AWS Management Console for RDS on the **Proxies** page.

Each proxy handles connections to a single RDS DB instance or Aurora DB cluster. The proxy determines the current writer instance for RDS multi-AZ DB instances and Aurora provisioned clusters.

The connections that a proxy keeps open and available for your database application to use form the *connection pool*.

By default, RDS Proxy can reuse a connection after each transaction in your session. This transaction-level reuse is called *multiplexing*. In some cases, RDS Proxy can't be sure that it's safe to run different transactions from a session using different connections. In these cases, it keeps the session on the same connection until the session ends. This fallback behavior is called *pinning*.

A proxy has an endpoint. You connect to this endpoint when you work with an RDS DB instance or Aurora DB cluster, instead of connecting to the read-write endpoint that connects directly to the instance or cluster. The special-purpose endpoints for an Aurora cluster remain available for you to use. For example, you can still connect to the cluster endpoint for read-write connections without connection pooling. You can still connect to the reader endpoint for load-balanced read-only connections. You can still connect to the instance endpoints for diagnosis and troubleshooting of specific DB instances within an Aurora cluster. If you are using other AWS services such as AWS Lambda to connect to RDS databases, you change their connection settings to use the proxy endpoint. For example, you specify the proxy endpoint to allow Lambda functions to access your database while taking advantage of RDS Proxy functionality.

Each proxy contains a target group. This *target group* embodies the RDS DB instance or Aurora DB cluster that the proxy can connect to. For an Aurora cluster, by default the target group is associated with all the DB instances in that cluster. That way, the proxy can connect to whichever Aurora DB instance is promoted to be the writer instance in the cluster. The RDS DB instance associated with a proxy, or the Aurora DB cluster and its instances, are referred to as the *targets* of that proxy. For convenience, when you create a proxy through the AWS Management Console, RDS Proxy also creates the corresponding target group and registers the associated targets automatically.

An *engine family* is a related set of database engines that use the same DB protocol. You choose the engine family for each proxy that you create. For a global database, you can create a proxy for the primary AWS Region, but not for a read-only secondary AWS Region.

Connection Pooling

Each proxy performs connection pooling for the writer instance of its associated RDS or Aurora database. *Connection pooling* is an optimization that reduces the overhead associated with opening and closing connections and with keeping many connections open simultaneously. This overhead includes memory needed to handle each new connection. It also involves CPU overhead to close each connection and open a new one, such as Transport Layer Security/Secure Sockets Layer (TLS/SSL) handshaking, authentication, negotiating capabilities, and so on. Connection pooling simplifies your application logic. You don't need to write application code to minimize the number of simultaneous open connections.

Each proxy also performs connection multiplexing, also known as connection reuse. With *multiplexing*, RDS Proxy perform all the operations for a transaction using one underlying database connection, then can use a different connection for the next transaction. You can open many simultaneous connections to the proxy, and the proxy keeps a smaller number of connections open to the DB instance or cluster. Doing so further minimizes the memory overhead for connections on the database server. This technique also reduces the chance of "too many connections" errors.

RDS Proxy Security

RDS Proxy uses the existing RDS security mechanisms such as Transport Layer Security/Secure Sockets Layer (TLS/SSL) and AWS Identity and Access Management (IAM). For general information about those security features, see Security in Amazon RDS (p. 1356). If you aren't familiar with how RDS and Aurora work with authentication, authorization, and other areas of security, consult those resources first.

RDS Proxy can act as an additional layer of security between client applications and the underlying database. For example, you can connect to the proxy using TLS 1.2, even if the underlying DB instance only supports TLS 1.0 or 1.1. You can connect to the proxy using an IAM role, even if the proxy connects to the database using the native user/password authentication method. By using this technique, you can enforce strong authentication requirements for database applications without a costly migration effort for the DB instances themselves.

You store the database credentials used by RDS Proxy in AWS Secrets Manager. Each database user for the RDS DB instance or Aurora DB cluster accessed by a proxy must have a corresponding secret in Secrets Manager. You can also set up IAM authentication for users of RDS Proxy. By doing so, you can enforce IAM authentication for database access even if the databases still use native password authentication. These security features are a preferable alternative to embedding database credentials in your application code.

Using TLS/SSL with RDS Proxy

You can connect to RDS Proxy using the TLS/SSL protocol.

> **Note**
> RDS Proxy uses certificates from the AWS Certificate Manager (ACM). If you are using RDS Proxy, when you rotate your TLS/SSL certificate, you don't need to update applications that use RDS Proxy connections.

RDS Proxy can ensure that your session uses TLS/SSL between your client and the RDS Proxy endpoint. To have RDS Proxy do so, specify the requirement on the client side with the `--ssl-mode` parameter. SSL session variables are not set for SSL connections to a RDS Proxy database.

RDS Proxy supports TLS protocol version 1.0, 1.1, and 1.2. However, you don't need to configure RDS Proxy database for TLS. In particular, don't use the `REQUIRE` clause on your database user privileges for SSL. Doing so prevents that user from connecting.

By default, client programs establish an encrypted connection with RDS Proxy, with further control available through the `--ssl-mode` option. From the client side, RDS Proxy supports all SSL modes.

For the client, the SSL modes are the following:

PREFERRED

SSL is the first choice, but it isn't required.

DISABLED

No SSL is allowed.

REQUIRED

Enforce SSL.

VERIFY_CA

Enforce SSL and verify the certificate authority (CA).

VERIFY_IDENTITY

Enforce SSL and verify the CA and CA hostname.

When using a client with `--ssl-mode` `VERIFY_CA` or `VERIFY_IDENTITY`, specify the `--ssl-ca` option pointing to a CA in .pem format. For a .pem file that you can use, download the Amazon Root CA 1 trust store from Amazon Trust Services.

RDS Proxy uses wildcard certificates, which apply to a both a domain and its subdomains. If you use the `mysql` client to connect with SSL mode `VERIFY_IDENTITY`, currently you must use the MySQL 8.0-compatible `mysql` command.

Failover

Failover is a high-availability feature that replaces a database instance with another one when the original instance becomes unavailable. A failover might happen because of a problem with a database instance. It could also be part of normal maintenance procedures, such as during a database upgrade. Failover applies to RDS DB instances in a multi-AZ configuration, and Aurora DB clusters with one or more reader instances in addition to the writer instance.

Connecting through a proxy makes your application more resilient to database failovers. When the original DB instance becomes unavailable, RDS Proxy connects to the standby database without dropping idle application connections. Doing so helps to speed up and simplify the failover process. The result is faster failover that's less disruptive to your application than a typical reboot or database problem.

Without RDS Proxy, a failover involves a brief outage. During the outage, you can't perform write operations on that database. Any existing database connections are disrupted and your application must reopen them. The database becomes available for new connections and write operations when a read-only DB instance is promoted to take the place of the one that's unavailable.

During DB failovers, RDS Proxy continues to accept connections at the same IP address and automatically directs connections to the new master. Clients connecting through RDS Proxy are not susceptible to the following:

- DNS propagation delays on failover.
- Local DNS caching.
- Connection timeouts.
- Uncertainty about which DB instance is the current writer.
- Waiting for a query response from a former writer that became unavailable without closing connections.

For applications that maintain their own connection pool, going through RDS Proxy means that most connections stay alive during failovers or other disruptions. Only connections that are in the middle of a transaction or SQL statement are cancelled. RDS Proxy immediately accepts new connections. When the database writer is unavailable, RDS Proxy queues up incoming requests.

For applications that don't maintain their own connection pools, RDS Proxy offers faster connection rates and more open connections. It offloads the expensive overhead of frequent reconnects from the database. It does so by reusing database connections maintained in the RDS Proxy connection pool. This approach is particularly important for TLS connections, where setup costs are significant.

Transactions

All the statements within a single transaction always use the same underlying database connection. The connection becomes available for use by a different session when the transaction ends. Using the transaction as the unit of granularity has the following consequences:

- Connection reuse can happen after each individual statement when the `autocommit` setting is enabled.
- Conversely, when the `autocommit` setting is disabled, the first statement you issue in a session begins a new transaction. Thus, if you enter a sequence of `SELECT`, `INSERT`, `UPDATE`, and other data manipulation language (DML) statements, connection reuse doesn't happen until you issue a `COMMIT`, `ROLLBACK`, or otherwise end the transaction.
- Entering a data definition language (DDL) statement causes the transaction to end after that statement completes.

RDS Proxy detects when a transaction ends through the network protocol used by the database client application. Transaction detection doesn't rely on keywords such as `COMMIT` or `ROLLBACK` appearing in the text of the SQL statement.

In some cases, RDS Proxy might detect a database request that makes it impractical to move your session to a different connection. In these cases, it turns off multiplexing for that connection the remainder of your session. The same rule applies if RDS Proxy can't be certain that multiplexing is practical for the session. This operation is called *pinning*. For ways to detect and minimize pinning, see Avoiding Pinning (p. 175).

Planning for and Setting Up RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

In the following sections, you can find how to set up RDS Proxy. You can also find how to set the related security options that control who can access each proxy and how each proxy connects to DB instances.

Topics

Limitations for RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

The following limitations apply to RDS Proxy during the public preview:

- The public preview is available only in these AWS Regions:
  - US East (N. Virginia) Region
  - US East (Ohio) Region
  - US West (N. California) Region
  - US West (Oregon) Region
  - Asia Pacific (Mumbai) Region
  - Asia Pacific (Seoul) Region
  - Asia Pacific (Singapore) Region
  - Asia Pacific (Sydney) Region
  - Asia Pacific (Tokyo) Region
  - Canada (Central) Region
  - Europe (Frankfurt) Region
  - Europe (Ireland) Region
  - Europe (London) Region
- You can have up to 20 proxies for each AWS account ID.
- In an Aurora cluster, all of the connections in the connection pool are handled by the Aurora writer instance. To perform load balancing for read-intensive workloads, you still use the reader endpoint directly for the Aurora cluster.
- You can't use RDS Proxy with Aurora Serverless clusters.
- You can't use RDS Proxy with Aurora multi-master clusters.
- Your RDS Proxy must be in the same VPC as the database. The proxy can't be publicly accessible, although the database can be.
- You can't use proxy with custom DNS.
- RDS Proxy is available for the MySQL and PostgreSQL engine families.

The following RDS Proxy limitations apply to MySQL:

- The MySQL engine family includes RDS MySQL 5.6 and 5.7, and Aurora MySQL versions 1 and 2.
- Currently, all proxies listen on port 3306 for MySQL.
- Within the MySQL engine family, currently RDS Proxy supports Aurora provisioned clusters, Aurora parallel query clusters, and Aurora Global Databases.
- You can't use RDS Proxy with RDS MySQL 8.0.
- You can't use RDS Proxy with self-managed MySQL databases in EC2 instances.
- Proxies don't support MySQL compressed mode. For example, they don't support the compression used by the `--compress` or `-C` options of the `mysql` command.
- Not all logic is implemented to pin sessions to database connections based on SQL statements and functions. For the most current pinning behavior, see Avoiding Pinning (p. 175).

The following RDS Proxy limitations apply to PostgreSQL:

- The RDS PostgreSQL engine family includes version 10.10 and higher minor versions and version 11.5 and higher minor versions.
- Currently, all proxies listen on port 5432 for PostgreSQL.
- Query cancellation isn't supported for PostgreSQL.
- The results of the PostgreSQL function lastval() aren't always accurate. As a work around, use the INSERT statement with the `RETURNING` clause.

Identifying DB Instances, Clusters, and Applications to Use with RDS Proxy

You can determine which of your DB instances, clusters, and applications might benefit the most from using RDS Proxy. To do so, consider these factors:

- Any DB instance or cluster that ever encounters "too many connections" errors is a good candidate for associating with a proxy. The proxy enables applications to open many client connections, while the proxy manages a smaller number of long-lived connections to the DB instance or cluster.
- For DB instances or clusters that use smaller AWS instance classes, such as T2 or T3, using a proxy can help avoid out-of-memory conditions. It can also help reduce the CPU overhead for establishing connections. These conditions can occur when dealing with large numbers of connections.
- You can monitor certain Amazon CloudWatch metrics to determine whether a DB instance or cluster is approaching certain types of limit. These limits are for the number of connections and the memory associated with connection management. You can also monitor certain CloudWatch metrics to determine whether a DB instance or cluster is handling many short-lived connections. Opening and closing such connections can impose performance overhead on your database. For information about the metrics to monitor, see Monitoring RDS Proxy Using Amazon CloudWatch (p. 177).
- AWS Lambda functions can also be good candidates for using a proxy. These functions make frequent short database connections that benefit from connection pooling offered by RDS Proxy. You can take advantage of any IAM authentication you already have for Lambda functions, instead of managing database credentials in your Lambda application code.
- Applications that use languages and frameworks such as PHP and Ruby on Rails are typically good candidates for using a proxy. Such applications typically open and close large numbers of database connections, and don't have built-in connection pooling mechanisms.
- Applications that keep a large number of connections open for long periods are typically good candidates for using a proxy. Applications in industries such as software as a service (SaaS) or ecommerce often minimize the latency for database requests by leaving connections open.
- You might not have adopted IAM authentication and Secrets Manager due to the complexity of setting up such authentication for all DB instances and clusters. If so, you can leave the existing authentication methods in place and delegate the authentication to a proxy. The proxy can enforce

the authentication policies for client connections for particular applications. You can take advantage of any IAM authentication you already have for Lambda functions, instead of managing database credentials in your Lambda application code.

Setting Up Network Prerequisites

Using RDS Proxy requires you to have a set of networking resources in place. These include a virtual private cloud (VPC), two or more subnets, an Amazon EC2 instance within the same VPC, and an internet gateway. If you've successfully connected to any RDS DB instances or Aurora DB clusters, you already have the required network resources.

Setting Up Database Credentials in AWS Secrets Manager

For each proxy that you create, you first use the Secrets Manager service to store sets of user name and password credentials. You create a separate Secrets Manager secret for each database user account that the proxy connects to on the RDS DB instance or Aurora DB cluster.

In Secrets Manager, you create these secrets with the `username` and `password` fields. Doing so allows the proxy to connect to the corresponding database users on whichever RDS DB instances or Aurora DB clusters that you associate with the proxy. To do this, you can use the setting **Credentials for other database**, **Credentials for RDS database**, or **Other type of secrets**.

The proxy ignores other fields such as `host` and `port` if they're present in the secret. Those details are automatically supplied by the proxy. If you choose **Credentials for other database**, that option prompts you for the user name and password, but not the other connection details, which you specify in the settings for the proxy itself. If you choose **Other type of secrets**, you create the secret with keys named `username` and `password`.

Don't choose any rotation period for the secrets.

Because the secrets aren't tied to a specific database server, you can reuse a secret across multiple proxies if you use the same credentials across multiple database servers. For example, you might use the same credentials across a group of development and test servers.

If a password associated with a secret is incorrect, you can update the associated secret in Secrets Manager. For example, you might update the secret if the password for the database account changes. Until you update the secret, you can't connect through the proxy to that database account. You can still connect to other accounts where the passwords match the credentials stored in the secrets.

When you create a proxy through the AWS CLI or RDS API, you specify the Amazon Resource Names (ARNs) of the corresponding secrets for all the DB user accounts that the proxy can access. In the AWS Management Console, you choose the secrets by their descriptive names.

For instructions about creating secrets in Secrets Manager, see the Creating a Secret page in the Secrets Manager documentation. Use one of the following techniques. For instructions about creating secrets in Secrets Manager, see Creating a Secret in the *AWS Secrets Manager User Guide*. Use one of the following techniques:

- Use Secrets Manager in the console.
- To use the CLI to create a Secrets Manager secret for use with RDS Proxy, use a command such as the following.

```
aws secretsmanager create-secret
  --name "secret_name"
  --description "secret_description"
  --region region_name
  --secret-string '{"username":"db_user","password":"db_user_password"}'
```

For example, the following commands create Secrets Manager secrets for two database users, one named `admin` and the other named `app-user`.

```
aws secretsmanager create-secret \
  --name $ADMIN_SECRET --description "db admin user" \
  --secret-string '{"username":"admin","password":"choose_your_own_password"}'

aws secretsmanager create-secret \
  --name $PROXY_SECRET --description "application user" \
  --secret-string '{"username":"app-user","password":"choose_your_own_password"}'
```

Setting Up AWS Identity and Access Management (IAM) Policies

After you create the secrets in Secrets Manager, you create an IAM policy that can access those secrets.

- Follow the **Create Role** process. Include the **Add Role to Database** step.
- For the new role, perform the **Add inline policy** step. Paste the following JSON, substituting the Amazon Resource Name (ARN) for the secret that you created.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetRandomPassword",
                "secretsmanager:CreateSecret",
                "secretsmanager:ListSecrets"
            ],
            "Resource": "*"
        },
        {
            "Sid": "VisualEditor1",
            "Effect": "Allow",
            "Action": "secretsmanager:*",
            "Resource": [
                      "your_secret_ARN"
            ]
        }
    ]
}
```

- Optionally, edit the trust policy for this IAM policy. Paste the following JSON.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Service": "rds.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    },
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": "rds.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
```

```
    }
  ]
}
```

The following commands perform the same operation through the AWS CLI.

```
PREFIX=choose_an_identifier

aws iam create-role --role-name choose_role_name \
  --assume-role-policy-document '{"Version":"2012-10-17","Statement":
[{"Effect":"Allow","Principal":{"Service":
["rds.amazonaws.com"]},"Action":"sts:AssumeRole"}]}'
aws iam put-role-policy --role-name same_role_name_as_previous \
  --policy-name $PREFIX-secret-reader-policy --policy-document
 '{"Version":"2012-10-17","Statement":[{"Sid":"getsecretvalue","Effect":"Allow","Action":
["secretsmanager:GetSecretValue","kms:Decrypt"],"Resource":"*"}]}'

aws kms create-key --description "$PREFIX-test-key" --policy
 '{"Id":"$PREFIX-kms-policy","Version":"2012-10-17","Statement":
[{"Sid":"Enable IAM User Permissions","Effect":"Allow","Principal":
{"AWS":"arn:aws:iam::account_id:root"},"Action":"kms:*","Resource":"*"},
{"Sid":"Allow access for Key Administrators","Effect":"Allow","Principal":
{"AWS":["$USER_ARN","arn:aws:iam::account_id:role/Admin"]},"Action":
["kms:Create*","kms:Describe*","kms:Enable*","kms:List*","kms:Put*","kms:Update*","kms:Revoke*","kms:Di
{"Sid":"Allow use of the key","Effect":"Allow","Principal":{"AWS":"$ROLE_ARN"},"Action":
["kms:Decrypt","kms:DescribeKey"],"Resource":"*"}]}'
```

Creating an RDS Proxy

To manage connections for a specified set of DB instances, you can create a proxy. You can associate a proxy with an RDS MySQL DB instance, PostgreSQL DB instance, or an Aurora DB cluster.

AWS Management Console

To create a proxy

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Proxies**.
3. Choose **Create proxy**.
4. Choose all the settings for your proxy. For the public preview, some choices are restricted or required. Consider the following guidance:

   Proxy configuration:

   - **Proxy identifier**. Specify a name of your choosing, unique within your AWS account ID and current AWS Region.
   - **Engine compatibility**. Choose either **MySQL** or **POSTGRESQL**.
   - **Require Transport Layer Security**. Choose this setting if you want the proxy to enforce TLS / SSL for all client connections. When you use an encrypted or unencrypted connection to a proxy, the proxy uses the same encryption setting when it makes a connection to the underlying database.
   - **Idle client connection timeout**. Choose a time period that a client connection can be idle before the proxy can close it. The default is 1800 seconds (30 minutes). A client connection is considered idle when the application doesn't submit a new request within the specified time after the previous request completed. The underlying database connection stays open and is returned to the connection pool. Thus, it's available to be reused for new client connections.

Consider lowering the idle client connection timeout if you want the proxy to proactively remove stale connections. If your workload is spiking, consider raising the idle client connection timeout to save the cost of establishing connections.

Target group configuration:

- **Database**. Choose one RDS DB instance or Aurora DB cluster to access through this proxy. The list only includes DB instances and clusters with compatible database engines, engine versions, and other settings. If the list is empty, create a new DB instance or cluster that's compatible with RDS Proxy. Then try creating the proxy again.
- **Connection pool maximum connections**. Specify a value between 1 and 100. This setting represents the percentage of the `max_connections` value that RDS Proxy can use for its connections. If you only intend to use one proxy with this DB instance or cluster, you can set it to 100. For details about how RDS Proxy uses this setting, see Controlling Connection Limits and Timeouts (p. 174).
- **Session pinning filters**. This is an advanced setting, for troubleshooting performance issues with particular applications. Currently, the only choice is `EXCLUDE_VARIABLE_SETS`. Choose a filter only if your application isn't reusing connections due to certain kinds of SQL statements and you can verify that reusing connections with those SQL statements doesn't affect application correctness. For more information, see Avoiding Pinning (p. 175).
- **Connection borrow timeout**. In some cases, you might expect the proxy to sometimes use up all available connections. In such cases, you can specify how long the proxy waits for a connection to become available before returning a timeout error. This setting only applies when the proxy has the maximum number of connections open and all connections are already in use.

Connectivity:

- **Secrets Manager ARNs**. Choose at least one Secrets Manager secret associated with the RDS DB instance or Aurora DB cluster that you intend to access with this proxy.
- **IAM role**. Choose an IAM role that has permission to access the Secrets Manager secrets you chose earlier. You can also choose for the AWS Management Console to create a new IAM role for you and use that.
- **IAM Authentication**. Choose whether to require or disallow IAM authentication for connections to your proxy.
- **Subnets**. This field is prepopulated with all the subnets associated with your VPC. You can remove any subnets that you don't need for this proxy. You must leave at least two subnets.

Additional connectivity configuration:

- **VPC security group**. Choose an existing VPC security group. You can also choose for the AWS Management Console to create a new security group for you and use that.

Advanced configuration:

- **Enable enhanced logging**. You can enable this setting to troubleshoot proxy compatibility or performance issues. When this setting is enabled, RDS Proxy includes detailed information about SQL statements in its logs. This information helps you to debug issues involving SQL behavior or the performance and scalability of the proxy connections. The debug information includes the text of SQL statements that you submit through the proxy. Thus, only enable this setting when needed for debugging, and only when you have security measures in place to safeguard any sensitive information that appears in the logs.

5. Select **RDS Proxy is now available in Preview** to acknowledge the terms and conditions for the preview.
6. Choose **Create Proxy**.

AWS CLI

To create a proxy, use the AWS CLI command `create-db-proxy`. Note the `--engine-family` value is case sensitive.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-proxy \
    --db-proxy-name proxy_name \
    --role-arn iam_role \
    --engine-family { MYSQL | POSTGRESQL } \
    --vpc-subnet-ids space_separated_list \
    [--vpc-security-group-ids space_separated_list] \
    [--auth ProxyAuthenticationConfig_JSON_string] \
    [--require-tls | --no-require-tls] \
    [--idle-client-timeout value] \
    [--debug-logging | --no-debug-logging] \
    [--tags comma_separated_list]
```

For Windows:

```
aws rds create-db-proxy ^
    --db-proxy-name proxy_name ^
    --role-arn iam_role ^
    --engine-family { MYSQL | POSTGRESQL } ^
    --vpc-subnet-ids space_separated_list ^
    [--vpc-security-group-ids space_separated_list] ^
    [--auth ProxyAuthenticationConfig_JSON_string] ^
    [--require-tls | --no-require-tls] ^
    [--idle-client-timeout value] ^
    [--debug-logging | --no-debug-logging] ^
    [--tags comma_separated_list]
```

To create the required information and associations for the proxy, you also use the `create-db-proxy-target-group` and `register-db-proxy-targets` commands:

```
aws rds create-db-proxy-target-group
    --name target_group_name
    --db-proxy-name proxy_name
    --connection-pool-defaults ConnectionPoolConfiguration
    --tags comma_separated_list
```

```
aws rds register-db-proxy-targets
    --db-proxy-name value
    [--target-group-name target_group_name]
    [--db-instance-identifiers space_separated_list]  # rds db instances, or
    [--db-cluster-identifiers cluster_id]        # rds db cluster (all instances), or
    [--db-cluster-endpoint endpoint_name]          # rds db cluster endpoint (all
 instances)
```

RDS API

To create an RDS Proxy, you call the Amazon RDS API function `CreateDBProxy`. You pass a parameter with the AuthConfig data structure.

You also create the associated target group by calling the function `CreateDBProxyTargetGroup`. Then you associate an RDS DB instance or Aurora DB cluster with the target group by calling the function `RegisterDBProxyTargets`.

Viewing an RDS Proxy

After you create one or more RDS proxies, you can view them all to examine their configuration details and choose which ones to modify, delete, and so on.

In particular, you need the endpoint for the proxy to use in the connection string for any database applications that use the proxy.

AWS Management Console

To view your RDS Proxy

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the AWS Management Console, choose the AWS Region in which you created the RDS Proxy.
3. In the navigation pane, choose **Proxies**.
4. Choose the name of an RDS proxy to display its details.
5. On the details page, the **Target groups** section shows how the proxy is associated with a specific RDS DB instance or Aurora DB cluster. You can follow the link to the **default** target group page to see more details about the association between the proxy and the database. This page is where you see settings that you specified when creating the proxy, such as maximum connection percentage, connection borrow timeout, engine compatibility, and session pinning filters.

CLI

To view your RDS Proxy using the CLI, use the `describe-db-proxies` command. By default, it displays all proxies owned by your AWS account. To see details for a single proxy, specify its name with the `--db-proxy-name` parameter.

```
aws rds describe-db-proxies [--db-proxy-name proxy_name]
```

To view the other information associated with the proxy, use these commands:

```
aws rds describe-db-proxy-target-groups  --db-proxy-name proxy_name

aws rds describe-db-proxy-targets --db-proxy-name proxy_name
```

Use the following sequence of commands to see more detail about the things that are associated with the proxy:

- Run `describe-db-proxies` to get a list of proxies.
- Run `describe-db-proxy-target-groups` `--db-proxy-name` using the name of the proxy as the parameter value. This output shows connection parameters such as the maximum percentage of connections that the proxy can use.
- Run `describe-db-proxy-targets` to see the details of the RDS DB instance or Aurora DB cluster associated with the returned target group.

RDS API

To view your proxies using the RDS API, use the DescribeDBProxies operation. It returns values of the DBProxy data type.

You can use the proxy identifiers from the return value to see details of the connection settings for the proxy by using the DescribeDBProxyTargetGroups operation. It returns values of the DBProxyTargetGroup data type.

You can see the RDS instance or Aurora DB cluster associated with the proxy by using the DescribeDBProxyTargets operation. It returns values of the DBProxyTarget data type.

Connecting to a Database through RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

You connect to an RDS DB instance or Aurora DB cluster through a proxy in generally the same way as you connect directly to the database. The main difference is that you specify the proxy endpoint instead of the instance or cluster endpoint.

For an Aurora DB cluster, all proxy connections have read-write capability and use the writer instance. If you use the reader endpoint for read-only connections, you continue using the reader endpoint the same way.

For PostgreSQL, if you use JDBC we recommend that you set the connection parameter `assumeMinServerVersion` to at least 9.0 to avoid pinning. See also Avoiding Pinning (p. 175).

Topics

Connecting to a Proxy Using Native Authentication

Use the following general procedure to connect to a proxy using native authentication:

- Find the proxy endpoint. In the AWS Management Console, you can find the endpoint on the details page for the corresponding proxy. With the AWS CLI, you can use the `describe-db-proxies` command. The following example shows how:

```
# Add --output text to get output as a simple tab-separated list.
$ aws rds describe-db-proxies --query '*[*].{DBProxyName:DBProxyName,Endpoint:Endpoint}'
[
    [
        {
            "Endpoint": "the-proxy.proxy-demo.us-east-1.rds.amazonaws.com",
            "DBProxyName": "the-proxy"
        },
        {
            "Endpoint": "the-proxy-other-secret.proxy-demo.us-east-1.rds.amazonaws.com",
            "DBProxyName": "the-proxy-other-secret"
        },
        {
            "Endpoint": "the-proxy-rds-secret.proxy-demo.us-east-1.rds.amazonaws.com",
            "DBProxyName": "the-proxy-rds-secret"
        },
        {
            "Endpoint": "the-proxy-t3.proxy-demo.us-east-1.rds.amazonaws.com",
```

```
            "DBProxyName": "the-proxy-t3"
        }
    ]
]
```

- Specify that endpoint as the host parameter in the connection string for your client application. For example, specify the proxy endpoint as the value for the `mysql -h` option or `psql -h` option.
- Supply the same database user name and password as you normally do.

Connecting to a Proxy Using IAM Authentication

Follow the same general procedure as for connecting to an RDS DB instance or Aurora cluster using IAM authentication. Instead of the instance, cluster, or reader endpoint, specify the proxy endpoint. For details, see Connecting to Your DB Instance Using IAM Authentication (p. 1394).

You must use Transport Layer Security (TLS) / Secure Sockets Layer (SSL) when connecting to a proxy using IAM authentication.

You can grant a specific user access to the proxy by modifying the IAM policy. For example:

```
"Resource": "arn:aws:rds-db:us-east-2:1234567890:dbuser:db-ABCDEFGHIJKL01234/db_user"
```

Managing RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

The following explain aspects of RDS Proxy operation and configuration that help your application to make the most efficient use of database connections and achieve maximum connection reuse. The more you can take advantage of connection reuse, the more CPU and memory overhead you can save. This in turn reduces latency for your application and enables the database to devote more of its resources to processing application requests.

Topics

Deleting an RDS Proxy

You can delete a proxy if you no longer need it. You might delete a proxy because the application that was using it is no longer relevant. Or you might delete a proxy if you take the DB instance or cluster associated with it out of service.

AWS Management Console

To delete a proxy

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Proxies**.
3. Choose the proxy to delete from the list.
4. Choose **Delete Proxy**.

AWS CLI

To delete a DB proxy, use the AWS CLI command `delete-db-proxy`. To remove related associations, also use the `deregister-db-proxy-targets` command.

```
aws rds delete-db-proxy --name proxy_name
```

```
aws rds deregister-db-proxy-targets
    --db-proxy-name proxy_name
    [--target-group-name target_group_name]
    [--target-ids comma_separated_list]       # or
    [--db-instance-identifiers instance_id]       # or
    [--db-cluster-identifiers cluster_id]
```

RDS API

To delete a DB proxy, call the Amazon RDS API function `DeleteDBProxy`. To delete related items and associations, you also call the functions `DeleteDBProxyTargetGroup` and `DeregisterDBProxyTargets`.

Modifying an RDS Proxy

You can change certain settings associated with a proxy after you create the proxy. You do so by modifying the proxy itself, its associated target group, or both. Each proxy has an associated target group.

AWS Management Console

To modify the settings for a proxy

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Proxies**.
3. In the list of proxies, choose the proxy whose settings you want to modify or go to its details page.
4. For **Actions**, choose **Modify**.
5. Enter or choose the properties to modify. You can do the following:

    - Rename the proxy by entering a new identifier.
    - Turn the requirement for Transport layer Security (TLS) on or off.
    - Enter a time period for the idle connection timeout.
    - Add or remove Secrets Manager secrets. These secrets correspond to database user names and passwords.
    - Change the IAM role used to retrieve the secrets from Secrets Manager.
    - Require or disallow IAM authentication for connections to the proxy.
    - Add or remove VPC subnets for the proxy to use.
    - Add or remove VPC security groups for the proxy to use.
    - Enable or disable enhanced logging.

6. Choose **Modify**.

If you didn't find the settings you intended to change, continue with the following procedure to update the target group for the proxy. Each proxy has one associated target group, which is created automatically along with the proxy.

To modify the settings for a proxy target group

The target group associated with a proxy controls the settings related to the physical database connections. You can only modify the target group from the proxy details page, not from the list on the **Proxies** page.

1. From the **Proxies** page, go to the details page for a proxy.
2. For **Target groups**, choose the `default` link. Currently, all proxies have a single target group named `default`.
3. On the details page for the **default** target group, choose **Modify**.
4. Certain properties, such as the target group identifier and the database engine, are fixed. You can't change these properties.

   Choose new settings for the properties you can modify:

   - You can choose a different RDS DB instance or Aurora cluster.
   - You can adjust what percentage of the maximum available connections the proxy can use.
   - You can select a session pinning filter. This setting can help reduce performance issues due to insufficient transaction-level reuse for connections. Using this setting requires understanding of application behavior and the circumstances under which RDS Proxy pins a session to a database connection.
   - You can adjust the connection borrow timeout interval. This setting determines how long the proxy waits for a connection to become available before returning a timeout error, when the proxy already has the maximum number of connections being used.
5. Choose **Modify target group**.

AWS CLI

To modify a proxy using the AWS CLI, use the commands modify-db-proxy, modify-db-proxy-target-group, deregister-db-proxy-targets, and register-db-proxy-targets.

With the `modify-db-proxy` command, you can change properties such as the following:

- The set of Secrets Manager secrets used by the proxy.
- Whether TLS is required.
- The idle client timeout.
- Whether to log additional information from SQL statements for debugging.
- The IAM role used to retrieve Secrets Manager secrets.
- The security groups used by the proxy.

The following example shows how to rename an existing proxy.

```
aws rds modify-db-proxy --db-proxy-name the-proxy --new-db-proxy-name the_new_name
```

With the `modify-db-proxy-target-group` command, you can modify connection-related settings or rename the target group. Currently, all proxies have a single target group named `default`. When working with this target group, you specify the name of the proxy and `default` for the name of the target group.

The following example shows how to first check the `MaxConnectionsPercent` setting for a proxy and then change it, using the target group.

```
aws rds describe-db-proxy-target-groups --db-proxy-name the-proxy

{
    "TargetGroups": [
        {
            "Status": "available",
            "UpdatedDate": "2019-11-30T16:49:30.342Z",
            "ConnectionPoolConfig": {
                "MaxIdleConnectionsPercent": 50,
                "ConnectionBorrowTimeout": 120,
                "MaxConnectionsPercent": 100,
                "SessionPinningFilters": []
            },
            "TargetGroupName": "default",
            "CreatedDate": "2019-11-30T16:49:27.940Z",
            "DBProxyName": "the-proxy",
            "IsDefault": true
        }
    ]
}

aws rds modify-db-proxy-target-group --db-proxy-name the-proxy --target-group-name default
 --connection-pool-config '
{ "MaxIdleConnectionsPercent": 75 }'

{
    "DBProxyTargetGroup": {
        "Status": "available",
        "UpdatedDate": "2019-12-02T04:09:50.420Z",
        "ConnectionPoolConfig": {
            "MaxIdleConnectionsPercent": 75,
            "ConnectionBorrowTimeout": 120,
            "MaxConnectionsPercent": 100,
            "SessionPinningFilters": []
        },
        "TargetGroupName": "default",
        "CreatedDate": "2019-11-30T16:49:27.940Z",
        "DBProxyName": "the-proxy",
        "IsDefault": true
    }
}
```

With the `deregister-db-proxy-targets` and `register-db-proxy-targets` commands, you change which RDS DB instance or Aurora DB cluster the proxy is associated with through its target group. Currently, each proxy can connect to one RDS DB instance or Aurora DB cluster. The target group tracks the connection details for all the RDS DB instances in a multi-AZ configuration, or all the DB instances in an Aurora cluster.

The following example starts with a proxy that is associated with an Aurora MySQL cluster named `cluster-56-2020-02-25-1399`. The example shows how to change the proxy so that it can connect to a different cluster named `provisioned-cluster`. When you work with an RDS DB instance, you specify the `--db-instance-identifier` option. When you work with an Aurora DB cluster, you specify the `--db-cluster-identifier` option instead. The following example modifies an Aurora MySQL proxy. An Aurora PostgreSQL proxy would have port 5432.

```
aws rds describe-db-proxy-targets --db-proxy-name the-proxy
```

```
{
    "Targets": [
        {
            "Endpoint": "instance-9814.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "instance-9814"
        },
        {
            "Endpoint": "instance-8898.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "instance-8898"
        },
        {
            "Endpoint": "instance-1018.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "instance-1018"
        },
        {
            "Type": "TRACKED_CLUSTER",
            "Port": 0,
            "RdsResourceId": "cluster-56-2020-02-25-1399"
        },
        {
            "Endpoint": "instance-4330.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "instance-4330"
        }
    ]
}

aws rds deregister-db-proxy-targets --db-proxy-name the-proxy --db-cluster-identifier
 cluster-56-2020-02-25-1399

aws rds describe-db-proxy-targets --db-proxy-name the-proxy

{
    "Targets": []
}

aws rds register-db-proxy-targets --db-proxy-name the-proxy --db-cluster-identifier
 provisioned-cluster

{
    "DBProxyTargets": [
        {
            "Type": "TRACKED_CLUSTER",
            "Port": 0,
            "RdsResourceId": "provisioned-cluster"
        },
        {
            "Endpoint": "gkldje.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "gkldje"
        },
        {
            "Endpoint": "provisioned-1.demo.us-east-1.rds.amazonaws.com",
            "Type": "RDS_INSTANCE",
            "Port": 3306,
            "RdsResourceId": "provisioned-1"
        }
    ]
```

```
}
```

RDS API

To modify a proxy using the RDS API, you use the operations ModifyDBProxy, ModifyDBProxyTargetGroup, DeregisterDBProxyTargets, and RegisterDBProxyTargets operations.

With `ModifyDBProxy`, you can change properties such as the following:

- The set of Secrets Manager secrets used by the proxy.
- Whether TLS is required.
- The idle client timeout.
- Whether to log additional information from SQL statements for debugging.
- The IAM role used to retrieve Secrets Manager secrets.
- The security groups used by the proxy.

With `ModifyDBProxyTargetGroup`, you can modify connection-related settings or rename the target group. Currently, all proxies have a single target group named `default`. When working with this target group, you specify the name of the proxy and `default` for the name of the target group.

With `DeregisterDBProxyTargets` and `RegisterDBProxyTargets`, you change which RDS DB instance or Aurora DB cluster the proxy is associated with through its target group. Currently, each proxy can connect to one RDS DB instance or Aurora DB cluster. The target group tracks the connection details for all the RDS DB instances in a multi-AZ configuration, or all the DB instances in an Aurora cluster.

Adding a New Database User

In some cases, you might add a new database user to an RDS DB instance or Aurora cluster that's associated with a proxy. If so, add or repurpose a Secrets Manager secret to store the credentials for that user. To do this, choose one of the following options:

- Create a new Secrets Manager secret, using the procedure described in Setting Up Database Credentials in AWS Secrets Manager (p. 162).
- If the new user takes the place of an existing one, update the credentials stored in the proxy's Secrets Manager secret for the existing user.

Changing the Password for a Database User

In some cases, you might change the password for a database user in an RDS DB instance or Aurora cluster that's associated with a proxy. If so, update the corresponding Secrets Manager secret with the new password.

Controlling Connection Limits and Timeouts

RDS Proxy makes use of the `max_connections` setting for your RDS DB instance or Aurora DB cluster. This setting represents the overall upper limit on the connections that the proxy can open at any one time. In Aurora clusters and RDS multi-AZ configurations, the `max_connections` value that the proxy uses is the one for the Aurora primary instance or the RDS writer instance.

The proxy setting for maximum connections represents a percentage of the `max_connections` value. If you have multiple applications all using the same database, you can effectively divide their connection quotas by using a proxy for each application with a specific percentage of `max_connections`. If you do so, ensure that the percentages add up to 100 or less for all proxies associated with the same database.

RDS Proxy periodically disconnects idle connections and returns them to the connection pool. You can adjust this timeout interval. Doing so helps your applications to deal with stale resources, especially if the application mistakenly leaves a connection open while holding important database resources.

Monitoring and Managing Connection Pooling

As described in the concepts on Connection Pooling (p. 157), connection pooling is a crucial RDS Proxy feature. Following, you can learn how to make the most efficient use of connection pooling and transaction-level connection reuse (multiplexing).

Because the connection pool is managed by RDS Proxy, you can monitor it and adjust connection limits and timeout intervals without changing your application code.

For each proxy, you can specify an upper limit on the number of connections used by the connection pool. You specify the limit as a percentage. This percentage applies to the maximum connections configured in the database. The exact number varies depending on the DB instance size and configuration settings.

For example, suppose that you configured RDS Proxy to use 75 percent of the maximum connections for the database. For MySQL, the maximum value is defined by the `max_connections` configuration parameter. In this case, the other 25 percent of maximum connections remain available to assign to other proxies or for connections that don't go through a proxy. In some cases, the proxy might keep less than 75% of the maximum connections open at a particular time. Those cases might include situations where the database doesn't have many simultaneous connections, or some connections stay idle for long periods.

The overall number of connections available for the connection pool changes as you update the `max_connections` configuration setting that applies to an RDS DB instance or an Aurora cluster.

The proxy doesn't reserve all of these connections in advance. Thus, you can specify a relatively large percentage, and those connections are only opened when the proxy becomes busy enough to need them.

You can choose how long to wait for a connection to become available for use by your application. This setting is represented by the **Connection borrow timeout** option when you create a proxy. This setting specifies how long to wait for a connection to become available in the connection pool before returning a timeout error. It applies when the number of connections is at the maximum, and so no connections are available in the connection pool. It also applies if no writer instance is available because a failover operation is in process. This setting enables you to limit the wait period that is most suitable for your application without having to change the query timeout in your application code.

Avoiding Pinning

Multiplexing is more efficient when database requests don't rely on state information from previous requests. In that case, RDS Proxy can reuse a connection at the conclusion of each transaction. Examples of such state information include most variables and configuration parameters that you can change through `SET` or `SELECT` statements. SQL transactions on a client connection can multiplex between underlying database connections by default.

Your connections to the proxy can enter a state known as *pinning*. When a connection is pinned, each later transaction uses the same underlying database connection until the session ends. RDS Proxy automatically pins a client connection to a specific DB connection when it detects a session state change that isn't appropriate for other sessions. Pinning reduces the effectiveness of connection reuse. If all or almost all of your connections experience pinning, consider modifying your application code or workload to reduce the conditions that cause the pinning.

For example, if your application changes a session variable or configuration parameter, later statements can rely on the new variable or parameter to be in effect. Thus, when RDS Proxy processes requests to change session variables or configuration settings, it pins that session to the DB connection. That way, the session state remains in effect for all later transactions in the same session.

This rule doesn't apply to all parameters you can set. RDS Proxy tracks changes to the character set, collation, time zone, autocommit, current database, SQL mode, and `session_track_schema` settings. Thus RDS Proxy doesn't pin the session when you modify these. In this case, RDS Proxy only reuses the connection for other sessions that have the same values for those settings.

Performance tuning for RDS Proxy involves trying to maximize transaction-level connection reuse (multiplexing) by minimizing pinning. You can do so by using the following techniques:

- Avoid unnecessary database requests that could cause pinning.
- Set variables and configuration settings consistently across all connections. That way, later sessions are more likely to reuse connections that have those particular settings.

  However, for PostgreSQL setting a variable will lead to session pinning.
- Apply a session pinning filter to the proxy. You can exempt certain kinds of operations from pinning the session if you know that doing so doesn't affect the correct operation of your application.
- Monitor the CloudWatch metric `DatabaseConnectionsCurrentlySessionPinned` to see how frequently pinning occurs. For information about this and other CloudWatch metrics, see Monitoring RDS Proxy Using Amazon CloudWatch (p. 177).
- If you use `SET` statements to perform identical initialization for each client connection, you can do so while still preserving transaction-level multiplexing. In this case, you move the statements that set up the initial session state into the initialization query used by a proxy. This property is a string containing one or more SQL statements, separated by semicolons. For example, you can define an initialization query for a proxy that sets certain configuration parameters. Then, RDS Proxy applies those settings whenever it sets up a new connection for that proxy. You can remove the corresponding `SET` statements from your application code, so that they don't interfere with transaction-level multiplexing.

  You can work with the initialization query through the AWS CLI and RDS API. Currently, you can't set this property through the AWS Management Console. For PostgreSQL, the initialization query is not currently implemented.

The proxy pins the session to the current connection in the following situations where multiplexing might cause unexpected behavior:

- Any statement with a text size greater than 4 KB causes the proxy to pin the session.
- Prepared statements cause the proxy to pin the session. This rule applies whether the prepared statement uses SQL text or the binary protocol.
- Explicit MySQL statements `LOCK TABLE`, `LOCK TABLES`, or `FLUSH TABLES WITH READ LOCK` cause the proxy to pin the session.
- Setting a user variable or a system variable (with some exceptions) causes the proxy to pin the session. If this situation reduces your connection reuse too much, you can choose for `SET` operations not to cause pinning.
- Creating a temporary table causes the proxy to pin the session. That way, the contents of the temporary table are preserved throughout the session regardless of transaction boundaries.
- Calling the MySQL functions `ROW_COUNT()`, `FOUND_ROWS()`, or `LAST_INSERT_ID()` sometimes causes pinning and sometimes not.

  The behavior might be different between Aurora MySQL versions that are compatible with MySQL 5.6 and MySQL 5.7.

Calling MySQL stored procedures and stored functions doesn't cause pinning. RDS Proxy doesn't detect any session state changes resulting from such calls. Therefore, make sure your that application doesn't change session state inside stored routines and rely on that session state to persist across transactions. For example, if a stored procedure creates a temporary table that is intended to persist across transactions, that application currently isn't compatible with RDS Proxy.

For PostgreSQL, the following interactions cause pinning:

- Using SET commands

- Using the extended query protocol such as by using JDBC default settings
- Creating temporary sequences, tables, or views
- Declaring cursors
- Discarding the session state
- Listening on a notification channel
- Loading a library module such as `auto_explain`
- Manipulating sequences using functions such as `nextval()` and `setval()`
- Interacting with locks using functions such as `pg_advisory_lock()` and `pg_try_advisory_lock()`
- Using prepared statements, setting parameters, or resetting a parameter to its default

If you have expert knowledge about your application behavior, you can choose to skip the pinning behavior for certain application statements. You do so by choosing the **Session pinning filters** option when creating the proxy. Currently, you can opt out of session pinning for the following kinds of application statements:

- Setting session variables and configuration settings.

To see metrics about how often pinning occurs for a proxy, see Monitoring RDS Proxy Using Amazon CloudWatch (p. 177).

Monitoring RDS Proxy Using Amazon CloudWatch

This is preview documentation for Amazon RDS Proxy. It is subject to change.

You can monitor RDS Proxy using Amazon CloudWatch. CloudWatch collects and processes raw data from the proxies into readable, near real-time metrics. To find these metrics in the CloudWatch console, choose **Metrics**, then choose **RDS**, and choose **Per-Proxy Metrics**.

> **Note**
> RDS publishes these metrics for each underlying EC2 instance associated with the proxy. A single proxy might be served by more than one EC2 instance. Use CloudWatch statistics to aggregate the values for a proxy across all the associated instances.
> Some of these metrics might not be visible until after the first successful connection by a proxy.

All RDS Proxy metrics are in the group `proxy`, with a dimension of `ProxyName`.

Metric	Valid Period	Description
`ClientConnectionsReceived`	1 minute and above	The number of client connection requests received. The most useful statistic for this metric is Sum.
`ClientConnectionsSetupSucceeded`	1 minute and above	The number of client connections successfully established with any authentication mechanism with or without TLS. The most useful statistic for this metric is Sum.

Metric	Valid Period	Description
`ClientConnectionsSetupFailedAuth`	1 minute and above	The number of client connection attempts that failed due to bad authentication or TLS misconfiguration. The most useful statistic for this metric is Sum.
`ClientConnectionsClosed`	1 minute and above	The number of client connections closed. The most useful statistic for this metric is Sum.
`ClientConnections`	1 minute	The current number of client connections. This is reported every minute. The most useful statistic for this metric is Sum.
`QueryRequests`	1 minute and above	The number of queries received. Note: Multi-statement query is counted as one query. The most useful statistic for this metric is Sum.
`DatabaseConnectionRequests`	1 minute and above	The number of requests to create a database connection. The most useful statistic for this metric is Sum.
`DatabaseConnectionsSetupSucceeded`	1 minute and above	The number of database connections successfully established with or without TLS. The most useful statistic for this metric is Sum.
`DatabaseConnectionsSetupFailed`	1 minute and above	The number of database connection requests that failed. The most useful statistic for this metric is Sum.
`MaxDatabaseConnectionsAllowed`	1 minute	The maximum number of database connections allowed. This is reported every minute. The most useful statistic for this metric is Sum.

Metric	Valid Period	Description
`DatabaseConnections`	1 minute	The current number of database connections. This is reported every minute. The most useful statistic for this metric is Sum.
`DatabaseConnectionsCurrentlyBorrowed`	1 minute	The current number of database connections in the borrow state. This is reported every minute. The most useful statistic for this metric is Sum.
`DatabaseConnectionsCurrentlySessionPinned`	1 minute	The current number of database connections currently pinned due to session state-altering operations in client requests. This is reported every minute. The most useful statistic for this metric is Sum.
`DatabaseConnectionsCurrentlyInTransaction`	1 minute	The current number of database connections in transaction. This is reported every minute. The most useful statistic for this metric is Sum.
`TargetGroupWriterAvailableDuration`	1 minute	The number of seconds over a minute duration for which the target group had a writer. This is reported every minute. The most useful statistic for this metric is Average.

Command-Line Examples for RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

To see how combinations of connection commands and SQL statements interact with RDS Proxy, look at the following examples.

Examples

- Preserving Connections to a MySQL Database Across a Failover

- Adjusting the max_connections Setting for an Aurora DB Cluster

Example Preserving Connections to a MySQL Database Across a Failover

This MySQL example demonstrates how open connections continue working during a failover, for example when you reboot a database or it becomes unavailable due to a problem. This example uses a proxy named `the-proxy` and an Aurora DB cluster with DB instances `instance-8898` and `instance-9814`. When you run the `failover-db-cluster` command from the Linux command line, the writer instance that the proxy is connected to changes to a different DB instance. You can see that the DB instance associated with the proxy changes while the connection remains open.

```
$ mysql -h the-proxy.proxy-demo.us-east-1.rds.amazonaws.com -u admin_user -p
Enter password:
...

mysql> select @@aurora_server_id;
+--------------------+
| @@aurora_server_id |
+--------------------+
| instance-9814      |
+--------------------+
1 row in set (0.01 sec)

mysql>
[1]+  Stopped                 mysql -h the-proxy.proxy-demo.us-east-1.rds.amazonaws.com -
u admin_user -p
$ # Initially, instance-9814 is the writer.
$ aws rds failover-db-cluster --db-cluster-id cluster-56-2019-11-14-1399
JSON output
$ # After a short time, the console shows that the failover operation is complete.
$ # Now instance-8898 is the writer.
$ fg
mysql -h the-proxy.proxy-demo.us.us-east-1.rds.amazonaws.com -u admin_user -p

mysql> select @@aurora_server_id;
+--------------------+
| @@aurora_server_id |
+--------------------+
| instance-8898      |
+--------------------+
1 row in set (0.01 sec)

mysql>
[1]+  Stopped                 mysql -h the-proxy.proxy-demo.us-east-1.rds.amazonaws.com -
u admin_user -p
$ aws rds failover-db-cluster --db-cluster-id cluster-56-2019-11-14-1399
JSON output
$ # After a short time, the console shows that the failover operation is complete.
$ # Now instance-9814 is the writer again.
$ fg
mysql -h the-proxy.proxy-demo.us-east-1.rds.amazonaws.com -u admin_user -p

mysql> select @@aurora_server_id;
+--------------------+
| @@aurora_server_id |
+--------------------+
| instance-9814      |
+--------------------+
1 row in set (0.01 sec)
+---------------+---------------+
| Variable_name | Value         |
+---------------+---------------+
| hostname      | ip-10-1-3-178 |
```

```
+---------------+---------------+
1 row in set (0.02 sec)
```

Example Adjusting the max_connections Setting for an Aurora DB Cluster

This example demonstrates how you can adjust the `max_connections` setting for an Aurora MySQL DB cluster. To do so, you create your own DB cluster parameter group based on the default parameter settings for clusters that are compatible with MySQL 5.6 or 5.7. You specify a value for the `max_connections` setting, overriding the formula that sets the default value. You associate the DB cluster parameter group with your DB cluster.

```
export REGION=us-east-1
export CLUSTER_PARAM_GROUP=rds-proxy-mysql-56-max-connections-demo
export CLUSTER_NAME=rds-proxy-mysql-56

aws rds create-db-parameter-group --region $REGION \
  --db-parameter-group-family aurora5.6 \
  --db-parameter-group-name $CLUSTER_PARAM_GROUP \
  --description "Aurora MySQL 5.6 cluster parameter group for RDS Proxy demo."

aws rds modify-db-cluster --region $REGION \
  --db-cluster-identifier $CLUSTER_NAME \
  --db-cluster-parameter-group-name $CLUSTER_PARAM_GROUP

echo "New cluster param group is assigned to cluster:"
aws rds describe-db-clusters --region $REGION \
  --db-cluster-identifier $CLUSTER_NAME \
  --query '*[*].{DBClusterParameterGroup:DBClusterParameterGroup}'

echo "Current value for max_connections:"
aws rds describe-db-cluster-parameters --region $REGION \
  --db-cluster-parameter-group-name $CLUSTER_PARAM_GROUP \
  --query '*[*].{ParameterName:ParameterName,ParameterValue:ParameterValue}' \
  --output text | grep "^max_connections"

echo -n "Enter number for max_connections setting: "
read answer

aws rds modify-db-cluster-parameter-group --region $REGION --db-cluster-parameter-group-
name $CLUSTER_PARAM_GROUP \
  --parameters "ParameterName=max_connections,ParameterValue=$
$answer,ApplyMethod=immediate"

echo "Updated value for max_connections:"
aws rds describe-db-cluster-parameters --region $REGION \
  --db-cluster-parameter-group-name $CLUSTER_PARAM_GROUP \
  --query '*[*].{ParameterName:ParameterName,ParameterValue:ParameterValue}' \
  --output text | grep "^max_connections"
```

Troubleshooting for RDS Proxy

This is preview documentation for Amazon RDS Proxy. It is subject to change.

Topics

Common Issues and Solutions

You can refer to the following list of symptoms to see the possible causes and solutions to problems you might encounter using RDS Proxy. During the public preview, error handling code isn't complete, so you might experience cryptic error messages from underlying services.

You might encounter the following issues while creating a new proxy or connecting to a proxy.

Error or Symptom	Causes or Workarounds
`403: The security token included in the request is invalid`	Select an existing IAM role instead of choosing to create a new one.

You might encounter the following issues while connecting to a MySQL proxy.

Error or Symptom	Causes or Workarounds
`ERROR 1040 (HY000): Connections rate limit exceeded (*limit value*)`	The rate of connection requests from the client to the proxy has exceeded the limit.
`ERROR 1040 (HY000): IAM authentication rate limit exceeded`	The number of simultaneous requests with IAM authentication from the client to the proxy has exceeded the limit.
`ERROR 1040 (HY000): Number simultaneous connections exceeded (*limit value*)`	The number of simultaneous connection requests from the client to the proxy exceeded the limit.
`ERROR 1045 (28000): Access denied for user 'DB_USER'@'%' (using password: YES)`	Some possible reasons include the following: • The Secrets Manager secret used by the proxy has a rotation period. Don't enable rotation for secrets used by RDS proxies.
`ERROR 1105 (HY000): Unknown error`	An unknown error occurred.
`ERROR 1231 (42000): Variable ''character_set_client'' can't be set to the value of *value*`	The value set for the `character_set_client` parameter is not valid. For example, the value `ucs2` is not valid because it can crash the MySQL server.
`ERROR 2026 (HY000): SSL`	The TLS handshake to the proxy failed. Some possible reasons include the following:

Error or Symptom	Causes or Workarounds
`connection error: Internal Server *Error*`	• SSL is required but the server doesn't support it. • An internal server error occurred. • A bad handshake occurred.
`ERROR 9501 (HY000): Timed-out waiting to acquire database connection`	The proxy timed-out waiting to acquire a database connection. Some possible reasons include the following: • The proxy is unable to establish a database connection because the maximum connections have been reached • The proxy is unable to establish a database connection because the database is unavailable.

You might encounter the following issues while connecting to a PostgreSQL proxy.

Error	Cause	Solution
`IAM authentication is allowed only with SSL connections.`	The user tried to connect to the database using IAM authentication with the setting `sslmode=disable` in the PostgreSQL client.	The user needs to connect to the database using the minimum setting of `sslmode=require` in the PostgreSQL client. For more information, see the PostgreSQL SSL Support documentation.
`This RDS Proxy requires TLS connections.`	The user enabled the setting “Require Transport Layer Security” but tried to connect with “sslmode=disable” in the PostgreSQL client.	The user needs to do either of the following: • Disable the proxy's *Require Transport Layer Security* setting. • Connect to the database using the minimum setting of `sslmode=allow` in the PostgreSQL client.
`IAM authentication failed for user` *`username`*`. Check the IAM token for this user and try again.`	This error could be due to the following reasons: • The client supplied the incorrect IAM username. • The client supplied an incorrect IAM authorization token for the user • The client is using an IAM policy that does not have the necessary permissions. • The client supplied an expired IAM authorization token for the user.	To fix this error, do the following: 1. Confirm that the provided IAM user exists. 2. Confirm that the IAM authorization token belongs to the provided IAM user. 3. Confirm that the IAM policy has adequate permissions for RDS. 4. Check the validity of the IAM authorization token used.

CloudWatch Logs

You can find logs of RDS Proxy activity under CloudWatch in the AWS Management Console. Each proxy has an entry in the **Log groups** page.

> **Important**
> These logs are intended for human consumption for troubleshooting purposes and not for programmatic access. The format and content of the logs is subject to change (especially during preview).

Verifying Connectivity to a Proxy

You can use the following commands to verify that all components of the connection mechanism can communicate with the other components.

Examine the proxy itself using the `describe-db-proxies` command. Also examine the associated target groups and the targets specified in the target groups using the `describe-db-proxy-target-groups` and `describe-db-proxy-targets` commands. Check that the details of the targets match the RDS DB instance or Aurora DB cluster that you intend to associate with the proxy.

```
aws rds describe-db-proxies --db-proxy-name $DB_PROXY_NAME
aws rds describe-db-proxy-target-groups --db-proxy-name $DB_PROXY_NAME
aws rds describe-db-proxy-targets --db-proxy-name $DB_PROXY_NAME
```

If the following Netcat command (`nc`) is successful, you can access the proxy endpoint from the EC2 instance or other system where you're logged in. This command reports failure if you're not in the same VPC as the proxy and the associated database. You might be able to log directly in to the database without being in the same VPC. However, you can't log into the proxy unless you're in the same VPC.

```
nc -zx MySQL_proxy_endpoint 3306

nc -zx PostgreSQL_proxy_endpoint 5432
```

You can use the following commands to make sure that your EC2 instance has the required properties. In particular, the VPC for the EC2 instance must be the same as the VPC for the RDS DB instance or Aurora DB cluster that the proxy connects to.

```
aws ec2 describe-instances --instance-ids your_ec2_instance_id
```

Examine the Secrets Manager secrets used for the proxy.

```
aws secretsmanager list-secrets
aws secretsmanager get-secret-value --secret-id your_secret_id
```

Make sure that the `SecretString` field displayed by `get-secret-value` is encoded as a JSON string that includes `username` and `password` fields. The following example shows the format of the `SecretString` field.

```
{
  "ARN": "some_arn",
  "Name": "some_name",
  "VersionId": "some_version_id",
  "SecretString": '{"username":"some_username","password":"some_password"}',
  "VersionStages": [ "some_stage" ],
  "CreatedDate": some_timestamp
}
```

Examine the RDS DB instance or Aurora DB cluster that you associated with the proxy. For an Aurora DB cluster, also examine each of the DB instances in the cluster. Make sure that their properties match what's expected for the proxy, such as the port being 3306 for MySQL and 5432 for PostgreSQL.

```
aws rds describe-db-clusters --db-cluster-id $DB_CLUSTER_ID
aws rds describe-db-instances --db-instance-id $DB_INSTANCE_ID1
aws rds describe-db-instances --db-instance-id $DB_INSTANCE_ID2
```

Working with Option Groups

Some DB engines offer additional features that make it easier to manage data and databases, and to provide additional security for your database. Amazon RDS uses option groups to enable and configure these features. An *option group* can specify features, called options, that are available for a particular Amazon RDS DB instance. Options can have settings that specify how the option works. When you associate a DB instance with an option group, the specified options and option settings are enabled for that DB instance.

Amazon RDS supports options for the following database engines:

Database Engine	Relevant Documentation
`MariaDB`	Options for MariaDB Database Engine (p. 531)
`Microsoft SQL Server`	Options for the Microsoft SQL Server Database Engine (p. 636)
`MySQL`	Options for MySQL DB Instances (p. 794)
`Oracle`	Options for Oracle DB Instances (p. 914)
`PostgreSQL`	PostgreSQL does not use options and option groups. PostgreSQL uses extensions and modules to provide additional features. For more information, see Supported PostgreSQL Features and Extensions (p. 1328).

Option Groups Overview

Amazon RDS provides an empty default option group for each new DB instance. You cannot modify this default option group, but any new option group that you create derives its settings from the default option group. To apply an option to a DB instance, you must do the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add one or more options to the option group.
3. Associate the option group with the DB instance.

Both DB instances and DB snapshots can be associated with an option group. In some cases, you might restore from a DB snapshot or perform a point-in-time restore for a DB instance. In these cases, the option group associated with the DB snapshot or DB instance is, by default, associated with the restored DB instance. You can associate a different option group with a restored DB instance. However, the new option group must contain any persistent or permanent options that were included in the original option group. Persistent and permanent options are described following.

Options require additional memory to run on a DB instance. Thus, you might need to launch a larger instance to use them, depending on your current use of your DB instance. For example, Oracle Enterprise Manager Database Control uses about 300 MB of RAM. If you enable this option for a small DB instance, you might encounter performance problems or out-of-memory errors.

Persistent and Permanent Options

Two types of options, persistent and permanent, require special consideration when you add them to an option group.

Persistent options can't be removed from an option group while DB instances are associated with the option group. An example of a persistent option is the TDE option for Microsoft SQL Server transparent data encryption (TDE). You must disassociate all DB instances from the option group before a persistent option can be removed from the option group. In some cases, you might restore or perform a point-in-time restore from a DB snapshot. In these cases, if the option group associated with that DB snapshot contains a persistent option, you can only associate the restored DB instance with that option group.

Permanent options, such as the TDE option for Oracle Advanced Security TDE, can never be removed from an option group. You can change the option group of a DB instance that is using the permanent option. However, the option group associated with the DB instance must include the same permanent option. In some cases, you might restore or perform a point-in-time restore from a DB snapshot. In these cases, if the option group associated with that DB snapshot contains a permanent option, you can only associate the restored DB instance with an option group with that permanent option.

For Oracle DB instances, you can copy shared DB snapshots that have the options `Timezone` or `OLS` (or both). To do so, specify a target option group that includes these options when you copy the DB snapshot. The OLS option is permanent and persistent only for Oracle DB instances running Oracle version 12.2 or higher. For more information about these options, see Oracle Time Zone (p. 987) and Oracle Label Security (p. 954).

VPC and Platform Considerations

When an option group is assigned to a DB instance, it is linked to the platform that the DB instance is on. That platform can either be a VPC supported by the Amazon VPC service, or EC2-Classic (non-VPC) supported by the Amazon EC2 service. For details on these two platforms, see Amazon EC2 and Amazon Virtual Private Cloud.

If a DB instance is in a VPC, the option group associated with the instance is linked to that VPC. This means that you can't use the option group assigned to a DB instance if you try to restore the instance to a different VPC or a different platform. If you restore a DB instance to a different VPC or a different platform, you can do one of the following:

- Assign the default option group to the DB instance.
- Assign an option group that is linked to that VPC or platform.
- Create a new option group and assign it to the DB instance.

With persistent or permanent options, such as Oracle TDE, you must create a new option group that includes the persistent or permanent option when restoring a DB instance into a different VPC.

Option settings control the behavior of an option. For example, the Oracle Advanced Security option `NATIVE_NETWORK_ENCRYPTION` has a setting that you can use to specify the encryption algorithm for network traffic to and from the DB instance. Some options settings are optimized for use with Amazon RDS and cannot be changed.

Mutually Exclusive Options

Some options are mutually exclusive. You can use one or the other, but not both at the same time. The following options are mutually exclusive:

- Oracle Enterprise Manager Database Express (p. 936) and Oracle Management Agent for Enterprise Manager Cloud Control (p. 941).
- Oracle Native Network Encryption (p. 963) and Oracle Secure Sockets Layer (p. 967).

Creating an Option Group

You can create a new option group that derives its settings from the default option group, and then add one or more options to the new option group. Alternatively, if you already have an existing option group, you can copy that option group with all of its options to a new option group. For more information, see Making a Copy of an Option Group (p. 189).

After you create a new option group, it has no options. To learn how to add options to the option group, see Adding an Option to an Option Group (p. 190). After you have added the options you want, you can then associate the option group with a DB instance so that the options become available on the DB instance. For information about associating an option group with a DB instance, see the documentation for your specific engine listed at Working with Option Groups (p. 186).

Console

One way of creating an option group is by using the AWS Management Console.

To create a new option group by using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose **Create group**.
4. In the **Create option group** window, do the following:

   a. For **Name**, type a name for the option group that is unique within your AWS account. The name can contain only letters, digits, and hyphens.
   b. For **Description**, type a brief description of the option group. The description is used for display purposes.
   c. For **Engine**, choose the DB engine that you want.
   d. For **Major engine version**, choose the major version of the DB engine that you want.
5. To continue, choose **Create**. To cancel the operation instead, choose **Cancel**.

AWS CLI

To create an option group, use the AWS CLI `create-option-group` command with the following required parameters.

- `--option-group-name`
- `--engine-name`
- `--major-engine-version`
- `--option-group-description`

Example

The following example creates an option group named `testoptiongroup`, which is associated with the Oracle Enterprise Edition DB engine. The description is enclosed in quotation marks.

For Linux, macOS, or Unix:

```
aws rds create-option-group \
    --option-group-name testoptiongroup \
    --engine-name oracle-ee \
    --major-engine-version 12.1 \
    --option-group-description "Test option group"
```

For Windows:

```
aws rds create-option-group ^
    --option-group-name testoptiongroup ^
    --engine-name oracle-ee ^
    --major-engine-version 12.1 ^
    --option-group-description "Test option group"
```

RDS API

To create an option group, call the Amazon RDS API `CreateOptionGroup` operation. Include the following parameters:

- `OptionGroupName`
- `EngineName`
- `MajorEngineVersion`
- `OptionGroupDescription`

Making a Copy of an Option Group

You can use the AWS CLI or the Amazon RDS API to make a copy of an option group. Copying an option group is convenient when you have an existing option group and you want to include most of its custom parameters and values in a new option group. You can also make a copy of an option group that you use in production and then modify the copy to test other option settings.

AWS CLI

To copy an option group, use the AWS CLI copy-option-group command. Include the following required parameters:

- `--source-option-group-identifier`
- `--target-option-group-identifier`
- `--target-option-group-description`

Example

The following example creates an option group named `new-local-option-group`, which is a local copy of the option group `my-remote-option-group`.

For Linux, macOS, or Unix:

```
aws rds copy-option-group \
    --source-option-group-identifier arn:aws:rds:us-west-2:123456789012:og:my-remote-
option-group \
    --target-option-group-identifier new-local-option-group \
    --target-option-group-description "Option group 2"
```

For Windows:

```
aws rds copy-option-group ^
    --source-option-group-identifier arn:aws:rds:us-west-2:123456789012:og:my-remote-
option-group ^
    --target-option-group-identifier new-local-option-group ^
    --target-option-group-description "Option group 2"
```

RDS API

To copy an option group, call the Amazon RDS API CopyOptionGroup operation. Include the following required parameters.

- `SourceOptionGroupIdentifier`
- `TargetOptionGroupIdentifier`
- `TargetOptionGroupDescription`

Adding an Option to an Option Group

You can add an option to an existing option group. After you have added the options you want, you can then associate the option group with a DB instance so that the options become available on the DB instance. For information about associating an option group with a DB instance, see the documentation for your specific DB engine listed at Working with Option Groups (p. 186).

Option group changes must be applied immediately in two cases:

- When you add an option that adds or updates a port value, such as the `OEM` option.
- When you add or remove an option group with an option that includes a port value.

In these cases, choose the **Apply Immediately** option in the console. Or you can include the `--apply-immediately` option when using the AWS CLI or set the `ApplyImmediately` parameter to `true` when using the Amazon RDS API. Options that don't include port values can be applied immediately, or can be applied during the next maintenance window for the DB instance.

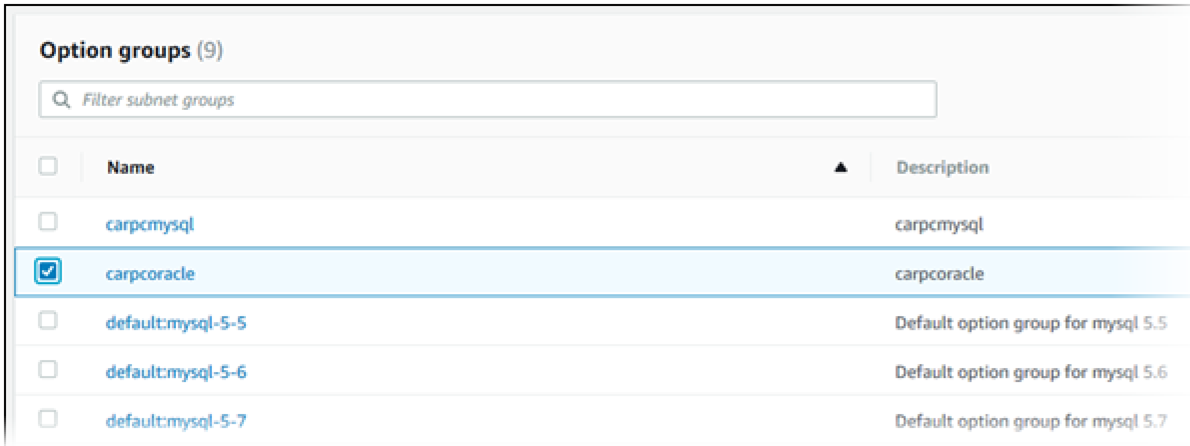
> **Note**
> If you specify a security group as a value for an option in an option group, you manage the security group by modifying the option group. You can't change or remove this security group by modifying a DB instance. Also, the security group doesn't appear in the DB instance details in the AWS Management Console or in the output for the AWS CLI command `describe-db-instances`.

Console

You can use the AWS Management Console to add an option to an option group.

To add an option to an option group by using the console

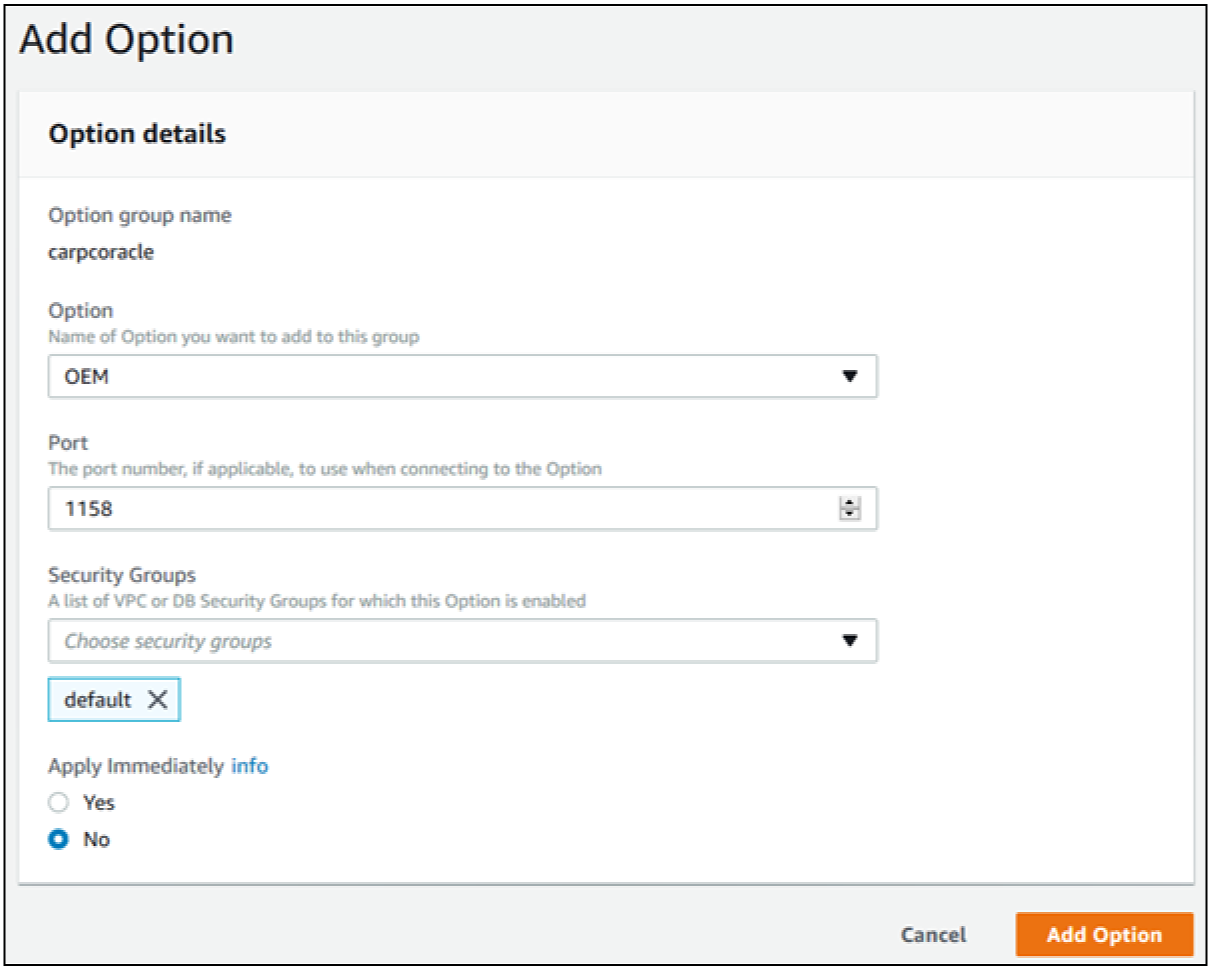
1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group that you want to modify, and then choose **Add option**.



4. In the **Add option** window, do the following:

    a. Choose the option that you want to add. You might need to provide additional values, depending on the option that you select. For example, when you choose the `OEM` option, you must also type a port value and specify a security group.

    b. To enable the option on all associated DB instances as soon as you add it, for **Apply Immediately**, choose **Yes**. If you choose **No** (the default), the option is enabled for each associated DB instance during its next maintenance window.



5. When the settings are as you want them, choose **Add option**.

AWS CLI

To add an option to an option group, run the AWS CLI add-option-to-option-group command with the option that you want to add. To enable the new option immediately on all associated DB instances, include the `--apply-immediately` parameter. By default, the option is enabled for each associated DB instance during its next maintenance window. Include the following required parameter:

- `--option-group-name`

Example

The following example adds the Oracle Enterprise Manager Database Control (OEM) option to an option group named `testoptiongroup` and immediately enables it. Even if you use the default security group, you must specify that security group.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
```

```
 --option-group-name testoptiongroup \
 --options OptionName=OEM,Port=5500,DBSecurityGroupMemberships=default \
 --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
 --option-group-name testoptiongroup ^
 --options OptionName=OEM,Port=5500,DBSecurityGroupMemberships=default ^
 --apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP   False   oracle-ee   12.1   arn:aws:rds:us-east-1:1234567890:og:testoptiongroup
 Test Option Group   testoptiongroup default
OPTIONS Oracle 12c EM Express    OEM     False    False    5500
DBSECURITYGROUPMEMBERSHIPS   default authorized
```

Example

The following example adds the Oracle OEM option to an option group. It also specifies a custom port and a pair of Amazon EC2 VPC security groups to use for that port.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
 --option-group-name testoptiongroup \
 --options OptionName=OEM,Port=5500,VpcSecurityGroupMemberships="sg-test1,sg-test2" \
 --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
 --option-group-name testoptiongroup ^
 --options OptionName=OEM,Port=5500,VpcSecurityGroupMemberships="sg-test1,sg-test2" ^
 --apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP  False   oracle-ee   12.1 arn:aws:rds:us-east-1:1234567890:og:testoptiongroup
 Test Option Group   testoptiongroup vpc-test
OPTIONS Oracle 12c EM Express    OEM     False    False    5500
VPCSECURITYGROUPMEMBERSHIPS     active   sg-test1
VPCSECURITYGROUPMEMBERSHIPS     active   sg-test2
```

Example

The following example adds the Oracle option NATIVE_NETWORK_ENCRYPTION to an option group and specifies the option settings. If no option settings are specified, default values are used.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
  --option-group-name testoptiongroup \
  --options '[{"OptionSettings":[{"Name":"SQLNET.ENCRYPTION_SERVER","Value":"REQUIRED"},
{"Name":"SQLNET.ENCRYPTION_TYPES_SERVER","Value":"AES256,AES192,DES"}],"OptionName":"NATIVE_NETWORK_ENC
 \
  --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
--option-group-name testoptiongroup ^
--options "OptionSettings"=[{"Name"="SQLNET.ENCRYPTION_SERVER","Value"="REQUIRED"},
{"Name"="SQLNET.ENCRYPTION_TYPES_SERVER","Value"="AES256\,AES192\,DES"}],"OptionName"="NATIVE_NETWORK_E
 ^
--apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP  False  oracle-ee  12.1  arn:aws:rds:us-east-1:1234567890:og:testoptiongroup
 Test Option Group   testoptiongroup
OPTIONS Oracle Advanced Security - Native Network Encryption    NATIVE_NETWORK_ENCRYPTION
     False   False
OPTIONSETTINGS
 RC4_256,AES256,AES192,3DES168,RC4_128,AES128,3DES112,RC4_56,DES,RC4_40,DES40
   STATIC  STRING
 RC4_256,AES256,AES192,3DES168,RC4_128,AES128,3DES112,RC4_56,DES,RC4_40,DES40    Specifies
 list of encryption algorithms in order of intended use
   True     True    SQLNET.ENCRYPTION_TYPES_SERVER  AES256,AES192,DES
OPTIONSETTINGS  ACCEPTED,REJECTED,REQUESTED,REQUIRED    STATIC  STRING  REQUESTED
   Specifies the desired encryption behavior  False   True  SQLNET.ENCRYPTION_SERVER
 REQUIRED
OPTIONSETTINGS  SHA1,MD5   STATIC  STRING  SHA1,MD5  Specifies list of checksumming
 algorithms in order of intended use   True  True  SQLNET.CRYPTO_CHECKSUM_TYPES_SERVER
 SHA1,MD5
```

RDS API

To add an option to an option group using the Amazon RDS API, call the ModifyOptionGroup operation with the option that you want to add. To enable the new option immediately on all associated DB instances, include the `ApplyImmediately` parameter and set it to `true`. By default, the option is enabled for each associated DB instance during its next maintenance window. Include the following required parameter:

- `OptionGroupName`

Listing the Options and Option Settings for an Option Group

You can list all the options and option settings for an option group.

Console

You can use the AWS Management Console to list all of the options and option settings for an option group.

To list the options and option settings for an option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the name of the option group to display its details. The options and option settings in the option group are listed.

AWS CLI

To list the options and option settings for an option group, use the AWS CLI `describe-option-groups` command. Specify the name of the option group whose options and settings you want to view. If you don't specify an option group name, all option groups are described.

Example

The following example lists the options and option settings for all option groups.

```
aws rds describe-option-groups
```

Example

The following example lists the options and option settings for an option group named `testoptiongroup`.

```
aws rds describe-option-groups --option-group-name testoptiongroup
```

RDS API

To list the options and option settings for an option group, use the Amazon RDS API `DescribeOptionGroups` operation. Specify the name of the option group whose options and settings you want to view. If you don't specify an option group name, all option groups are described.

Modifying an Option Setting

After you have added an option that has modifiable option settings, you can modify the settings at any time. If you change options or option settings in an option group, those changes are applied to all DB instances that are associated with that option group. For more information on what settings are available for the various options, see the documentation for your specific engine listed at Working with Option Groups (p. 186).

Option group changes must be applied immediately in two cases:

- When you add an option that adds or updates a port value, such as the `OEM` option.
- When you add or remove an option group with an option that includes a port value.

In these cases, choose the **Apply Immediately** option in the console. Or you can include the `--apply-immediately` option when using the AWS CLI or set the `ApplyImmediately` parameter to `true` when using the RDS API. Options that don't include port values can be applied immediately, or can be applied during the next maintenance window for the DB instance.

> **Note**
> If you specify a security group as a value for an option in an option group, you manage the security group by modifying the option group. You can't change or remove this security group by modifying a DB instance. Also, the security group doesn't appear in the DB instance details in the AWS Management Console or in the output for the AWS CLI command `describe-db-instances`.

Console

You can use the AWS Management Console to modify an option setting.

To modify an option setting by using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Select the option group whose option that you want to modify, and then choose **Modify option**.
4. In the **Modify option** window, from **Installed Options**, choose the option whose setting you want to modify. Make the changes that you want.
5. To enable the option as soon as you add it, for **Apply Immediately**, choose **Yes**. If you choose **No** (the default), the option is enabled for each associated DB instance during its next maintenance window.
6. When the settings are as you want them, choose **Modify Option**.

AWS CLI

To modify an option setting, use the AWS CLI `add-option-to-option-group` command with the option group and option that you want to modify. By default, the option is enabled for each associated DB instance during its next maintenance window. To apply the change immediately to all associated DB instances, include the `--apply-immediately` parameter. To modify an option setting, use the `--settings` argument.

Example

The following example modifies the port that the Oracle Enterprise Manager Database Control (OEM) uses in an option group named `testoptiongroup` and immediately applies the change.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
 --option-group-name testoptiongroup \
 --options OptionName=OEM,Port=5432,DBSecurityGroupMemberships=default \
 --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
 --option-group-name testoptiongroup ^
 --options OptionName=OEM,Port=5432,DBSecurityGroupMemberships=default ^
 --apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP   False  oracle-ee  12.1  arn:aws:rds:us-east-1:1234567890:og:testoptiongroup
 Test Option Group    testoptiongroup
OPTIONS Oracle 12c EM Express   OEM     False   False   5432
DBSECURITYGROUPMEMBERSHIPS   default  authorized
```

Example

The following example modifies the Oracle option NATIVE_NETWORK_ENCRYPTION and changes the option settings.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
--option-group-name testoptiongroup \
--options '[{"OptionSettings":[{"Name":"SQLNET.ENCRYPTION_SERVER","Value":"REQUIRED"},
{"Name":"SQLNET.ENCRYPTION_TYPES_SERVER","Value":"AES256,AES192,DES,RC4_256"}],"OptionName":"NATIVE_NET
 \
--apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
--option-group-name testoptiongroup ^
--options "OptionSettings"=[{"Name"="SQLNET.ENCRYPTION_SERVER","Value"="REQUIRED"},
{"Name"="SQLNET.ENCRYPTION_TYPES_SERVER","Value"="AES256\,AES192\,DES
\,RC4_256"}],"OptionName"="NATIVE_NETWORK_ENCRYPTION" ^
--apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP   False  oracle-ee  12.1  arn:aws:rds:us-east-1:1234567890:og:testoptiongroup
 Test Option Group    testoptiongroup
OPTIONS Oracle Advanced Security - Native Network Encryption    NATIVE_NETWORK_ENCRYPTION
     False   False
OPTIONSETTINGS
 RC4_256,AES256,AES192,3DES168,RC4_128,AES128,3DES112,RC4_56,DES,RC4_40,DES40 STATIC
 STRING
   RC4_256,AES256,AES192,3DES168,RC4_128,AES128,3DES112,RC4_56,DES,RC4_40,DES40
 Specifies list of encryption algorithms in order of intended use
   True     True    SQLNET.ENCRYPTION_TYPES_SERVER  AES256,AES192,DES,RC4_256
OPTIONSETTINGS  ACCEPTED,REJECTED,REQUESTED,REQUIRED    STATIC  STRING  REQUESTED
 Specifies the desired encryption behavior  False   True  SQLNET.ENCRYPTION_SERVER
 REQUIRED
OPTIONSETTINGS  SHA1,MD5   STATIC  STRING  SHA1,MD5    Specifies list of
 checksumming algorithms in order of intended use      True    True
 SQLNET.CRYPTO_CHECKSUM_TYPES_SERVER  SHA1,MD5
OPTIONSETTINGS  ACCEPTED,REJECTED,REQUESTED,REQUIRED  STATIC  STRING
 REQUESTED     Specifies the desired data integrity behavior    False   True
 SQLNET.CRYPTO_CHECKSUM_SERVER  REQUESTED
```

RDS API

To modify an option setting, use the Amazon RDS API `ModifyOptionGroup` command with the option group and option that you want to modify. By default, the option is enabled for each associated DB instance during its next maintenance window. To apply the change immediately to all associated DB instances, include the `ApplyImmediately` parameter and set it to `true`.

Removing an Option from an Option Group

Some options can be removed from an option group, and some cannot. A persistent option cannot be removed from an option group until all DB instances associated with that option group are disassociated. A permanent option can never be removed from an option group. For more information about what options are removable, see the documentation for your specific engine listed at Working with Option Groups (p. 186).

If you remove all options from an option group, Amazon RDS doesn't delete the option group. DB instances that are associated with the empty option group continue to be associated with it; they just won't have any active options. Alternatively, to remove all options from a DB instance, you can associate the DB instance with the default (empty) option group.

Console

You can use the AWS Management Console to remove an option from an option group.

To remove an option from an option group by using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Select the option group whose option you want to remove, and then choose **Delete option**.
4. In the **Delete option** window, do the following:

   - Select the check box for the option that you want to delete.
   - For the deletion to take effect as soon as you make it, for **Apply immediately**, choose **Yes**. If you choose **No** (the default), the option is deleted for each associated DB instance during its next maintenance window.

5. When the settings are as you want them, choose **Yes, Delete**.

AWS CLI

To remove an option from an option group, use the AWS CLI `remove-option-from-option-group` command with the option that you want to delete. By default, the option is removed from each associated DB instance during its next maintenance window. To apply the change immediately, include the `--apply-immediately` parameter.

Example

The following example removes the Oracle Enterprise Manager Database Control (OEM) option from an option group named `testoptiongroup` and immediately applies the change.

For Linux, macOS, or Unix:

```
aws rds remove-option-from-option-group \
    --option-group-name testoptiongroup \
    --options OEM \
    --apply-immediately
```

For Windows:

```
aws rds remove-option-from-option-group ^
    --option-group-name testoptiongroup ^
    --options OEM ^
    --apply-immediately
```

Command output is similar to the following:

```
OPTIONGROUP    testoptiongroup oracle-ee   12.1    Test option group
```

RDS API

To remove an option from an option group, use the Amazon RDS API `ModifyOptionGroup` action. By default, the option is removed from each associated DB instance during its next maintenance window. To apply the change immediately, include the `ApplyImmediately` parameter and set it to `true`.

Include the following parameters:

- `OptionGroupName`
- `OptionsToRemove.OptionName`

Deleting an Option Group

You can delete an option group that is not associated with any Amazon RDS resource. An option group can be associated with a DB instance, a manual DB snapshot, or an automated DB snapshot.

If you try to delete an option group that is associated with an Amazon RDS resource, an error similar to the following is returned.

```
An error occurred (InvalidOptionGroupStateFault) when calling the DeleteOptionGroup
 operation: The option group 'optionGroupName' cannot be deleted because it is in use.
```

To find the Amazon RDS resources associated with an option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the name of the option group to show its details.
4. Check the **Associated Instances and Snapshots** section for the associated Amazon RDS resources.

If a DB instance is associated with the option group, modify the DB instance to use a different option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

If a manual DB snapshot is associated with the option group, modify the DB snapshot to use a different option group using the AWS CLI `modify-db-snapshot` command.

> **Note**
> You can't modify the option group of an automated DB snapshot.

Console

One way of deleting an option group is by using the AWS Management Console.

To delete an option group by using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group.
4. Choose **Delete group**.
5. On the confirmation page, choose **Delete** to finish deleting the option group, or choose **Cancel** to cancel the deletion.

AWS CLI

To delete an option group, use the AWS CLI `delete-option-group` command with the following required parameter.

- `--option-group-name`

Example

The following example deletes an option group named `testoptiongroup`.

For Linux, macOS, or Unix:

```
aws rds delete-option-group \
    --option-group-name testoptiongroup
```

For Windows:

```
aws rds delete-option-group ^
    --option-group-name testoptiongroup
```

RDS API

To delete an option group, call the Amazon RDS API `DeleteOptionGroup` operation. Include the following parameter:

- `OptionGroupName`

Working with DB Parameter Groups

You manage your DB engine configuration by associating your DB instances with parameter groups. Amazon RDS defines parameter groups with default settings that apply to newly created DB instances . You can define your own parameter groups with customized settings. Then you can modify your DB instances to use your own parameter groups.

A *DB parameter group* acts as a container for engine configuration values that are applied to one or more DB instances.

If you create a DB instance without specifying a DB parameter group, the DB instance uses a default DB parameter group. Each default DB parameter group contains database engine defaults and Amazon RDS system defaults based on the engine, compute class, and allocated storage of the instance. You can't modify the parameter settings of a default parameter group. Instead, you create your own parameter group where you choose your own parameter settings. Not all DB engine parameters can be changed in a parameter group that you create.

If you want to use your own parameter group, you create a new parameter group and modify the parameters that you want to. You then modify your DB instance to use the new parameter group. If you update parameters within a DB parameter group, the changes apply to all DB instances that are associated with that parameter group.

You can copy an existing DB parameter group with the AWS CLI copy-db-parameter-group command. Copying a parameter group can be convenient when you want to include most of an existing DB parameter group's custom parameters and values in a new DB parameter group.

Here are some important points about working with parameters in a DB parameter group:

- When you change a dynamic parameter and save the DB parameter group, the change is applied immediately regardless of the **Apply Immediately** setting. When you change a static parameter and save the DB parameter group, the parameter change takes effect after you manually reboot the DB instance. You can reboot a DB instance using the RDS console or by explicitly calling the `RebootDbInstance` API operation (without failover, if the DB instance is in a Multi-AZ deployment). The requirement to reboot the associated DB instance after a static parameter change helps mitigate the risk of a parameter misconfiguration affecting an API call, such as calling `ModifyDBInstance` to change DB instance class or scale storage.

  If a DB instance isn't using the latest changes to its associated DB parameter group, the AWS Management Console shows the DB parameter group with a status of **pending-reboot**. The **pending-reboot** parameter groups status doesn't result in an automatic reboot during the next maintenance window. To apply the latest parameter changes to that DB instance, manually reboot the DB instance.
- When you change the DB parameter group associated with a DB instance, you must manually reboot the instance before the new DB parameter group is used by the DB instance.
- You can specify the value for a DB parameter as an integer or as an integer expression built from formulas, variables, functions, and operators. Functions can include a mathematical log expression. For more information, see DB Parameter Values (p. 210).
- Set any parameters that relate to the character set or collation of your database in your parameter group before creating the DB instance and before you create a database in your DB instance. This ensures that the default database and new databases in your DB instance use the character set and collation values that you specify. If you change character set or collation parameters for your DB instance, the parameter changes are not applied to existing databases.

  You can change character set or collation values for an existing database using the `ALTER DATABASE` command, for example:

```
ALTER DATABASE database_name CHARACTER SET character_set_name COLLATE collation;
```

- Improperly setting parameters in a DB parameter group can have unintended adverse effects, including degraded performance and system instability. Always exercise caution when modifying database parameters and back up your data before modifying a DB parameter group. Try out parameter group setting changes on a test DB instance before applying those parameter group changes to a production DB instance.
- To determine the supported parameters for your DB engine, you can view the parameters in the DB parameter group used by the DB instance. For more information, see Viewing Parameter Values for a DB Parameter Group (p. 209).

Topics

Creating a DB Parameter Group

You can create a new DB parameter group using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To create a DB parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose **Create parameter group**.

   The **Create parameter group** window appears.
4. In the **Parameter group family** list, select a DB parameter group family.
5. In the **Type** list, select **DB Parameter Group**.
6. In the **Group name** box, enter the name of the new DB parameter group.
7. In the **Description** box, enter a description for the new DB parameter group.
8. Choose **Create**.

AWS CLI

To create a DB parameter group, use the AWS CLI `create-db-parameter-group` command. The following example creates a DB parameter group named *mydbparametergroup* for MySQL version 5.6 with a description of "*My new parameter group*."

Include the following required parameters:

- `--db-parameter-group-name`
- `--db-parameter-group-family`

- `--description`

To list all of the available parameter group families, use the following command:

```
aws rds describe-db-engine-versions --query "DBEngineVersions[].DBParameterGroupFamily"
```

> **Note**
> The output contains duplicates.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-parameter-group \
    --db-parameter-group-name mydbparametergroup \
    --db-parameter-group-family MySQL5.6 \
    --description "My new parameter group"
```

For Windows:

```
aws rds create-db-parameter-group ^
    --db-parameter-group-name mydbparametergroup ^
    --db-parameter-group-family MySQL5.6 ^
    --description "My new parameter group"
```

This command produces output similar to the following:

```
DBPARAMETERGROUP  mydbparametergroup  mysql5.6  My new parameter group
```

RDS API

To create a DB parameter group, use the RDS API `CreateDBParameterGroup` operation.

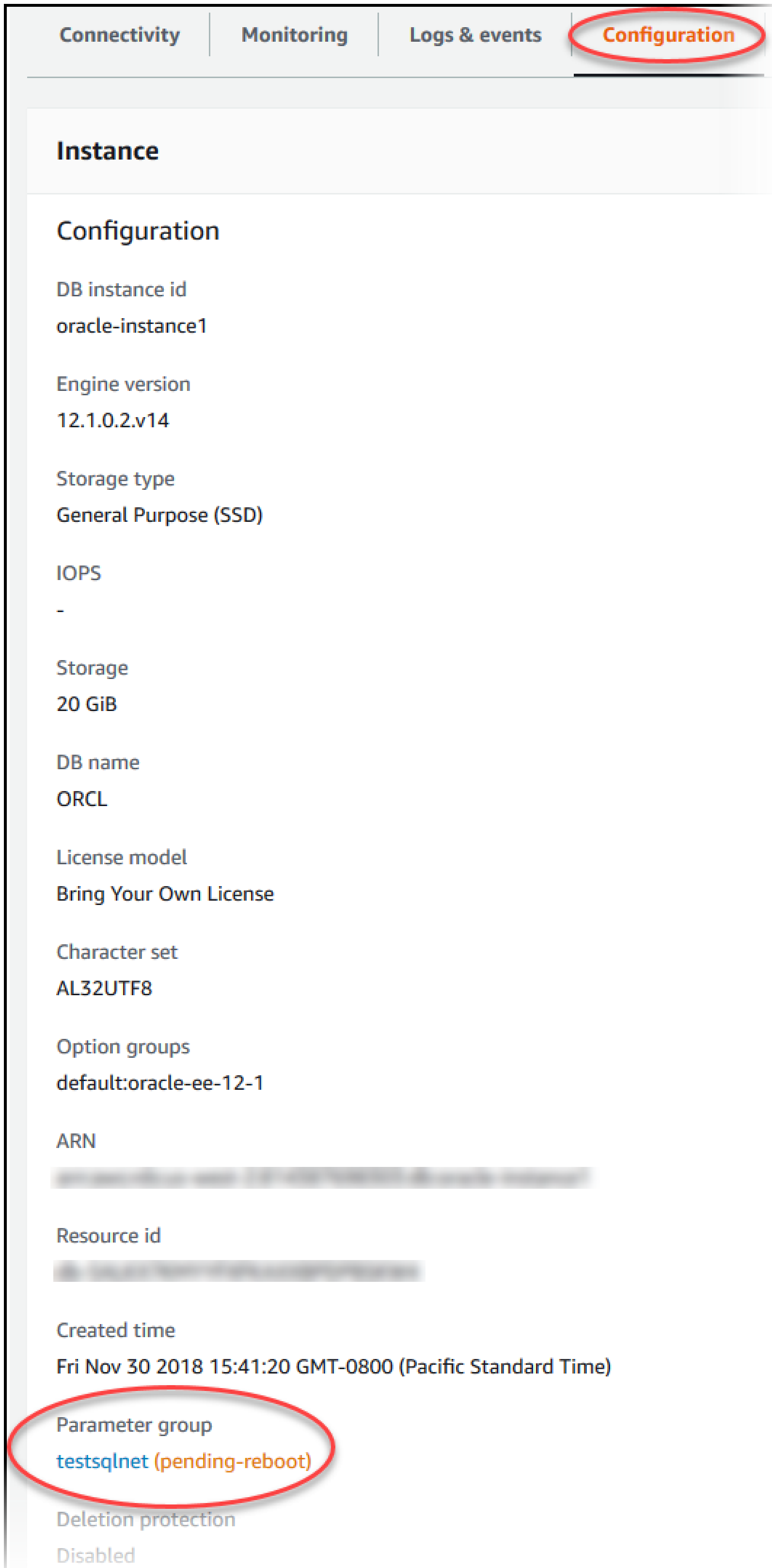
Include the following required parameters:

- `DBParameterGroupName`
- `DBParameterGroupFamily`
- `Description`

Modifying Parameters in a DB Parameter Group

You can modify parameter values in a customer-created DB parameter group; you can't change the parameter values in a default DB parameter group. Changes to parameters in a customer-created DB parameter group are applied to all DB instances that are associated with the DB parameter group.

Changes to some parameters are applied to the DB instance immediately without a reboot. Changes to other parameters are applied only after the DB instance is rebooted. The RDS console shows the status of the DB parameter group associated with a DB instance on the **Configuration** tab. For example, if the DB instance isn't using the latest changes to its associated DB parameter group, the RDS console shows the DB parameter group with a status of **pending-reboot**. To apply the latest parameter changes to that DB instance, manually reboot the DB instance.


Connectivity
Monitoring
Logs & events
Configuration
Instance
Configuration
DB instance id
oracle-instance1
Engine version
12.1.0.2.v14
Storage type
General Purpose (SSD)
IOPS
-
Storage
20 GiB
DB name
ORCL
License model
Bring Your Own License
Character set
AL32UTF8
Option groups
default:oracle-ee-12-1
ARN
Resource id
Created time
Fri Nov 30 2018 15:41:20 GMT-0800 (Pacific Standard Time)
Parameter group
testsqlnet (pending-reboot)
Deletion protection
Disabled

Console

To modify a DB parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. In the list, choose the parameter group that you want to modify.
4. For **Parameter group actions**, choose **Edit**.
5. Change the values of the parameters that you want to modify. You can scroll through the parameters using the arrow keys at the top right of the dialog box.

   You can't change values in a default parameter group.
6. Choose **Save changes**.

AWS CLI

To modify a DB parameter group, use the AWS CLI `modify-db-parameter-group` command with the following required parameters:

- `--db-parameter-group-name`
- `--parameters`

The following example modifies the `max_connections` and `max_allowed_packet` values in the DB parameter group named *mydbparametergroup*.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-parameter-group \
    --db-parameter-group-name mydbparametergroup \
    --parameters "ParameterName=max_connections,ParameterValue=250,ApplyMethod=immediate" \

 "ParameterName=max_allowed_packet,ParameterValue=1024,ApplyMethod=immediate"
```

For Windows:

```
aws rds modify-db-parameter-group ^
    --db-parameter-group-name mydbparametergroup ^
    --parameters "ParameterName=max_connections,ParameterValue=250,ApplyMethod=immediate" ^

 "ParameterName=max_allowed_packet,ParameterValue=1024,ApplyMethod=immediate"
```

The command produces output like the following:

```
DBPARAMETERGROUP  mydbparametergroup
```

RDS API

To modify a DB parameter group, use the RDS API `ModifyDBParameterGroup` command with the following required parameters:

- `DBParameterGroupName`
- `Parameters`

Copying a DB Parameter Group

You can copy custom DB parameter groups that you create. Copying a parameter group is a convenient solution when you have already created a DB parameter group and you want to include most of the custom parameters and values from that group in a new DB parameter group. You can copy a DB parameter group by using the AWS CLI copy-db-parameter-group command or the RDS API CopyDBParameterGroup operation.

After you copy a DB parameter group, wait at least 5 minutes before creating your first DB instance that uses that DB parameter group as the default parameter group. Doing this allows Amazon RDS to fully complete the copy action before the parameter group is used. This is especially important for parameters that are critical when creating the default database for a DB instance. An example is the character set for the default database defined by the `character_set_database` parameter. Use the **Parameter Groups** option of the Amazon RDS console or the describe-db-parameters command to verify that your DB parameter group is created.

> **Note**
> You can't copy a default parameter group. However, you can create a new parameter group that is based on a default parameter group.

Console

To copy a DB parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. In the list, choose the custom parameter group that you want to copy.
4. For **Parameter group actions**, choose **Copy**.
5. In **New DB parameter group identifier**, enter a name for the new parameter group.
6. In **Description**, enter a description for the new parameter group.
7. Choose **Copy**.

AWS CLI

To copy a DB parameter group, use the AWS CLI `copy-db-parameter-group` command with the following required parameters:

- `--source-db-parameter-group-identifier`
- `--target-db-parameter-group-identifier`
- `--target-db-parameter-group-description`

The following example creates a new DB parameter group named `mygroup2` that is a copy of the DB parameter group `mygroup1`.

Example

For Linux, macOS, or Unix:

```
aws rds copy-db-parameter-group \
    --source-db-parameter-group-identifier mygroup1 \
    --target-db-parameter-group-identifier mygroup2 \
    --target-db-parameter-group-description "DB parameter group 2"
```

For Windows:

```
aws rds copy-db-parameter-group ^
    --source-db-parameter-group-identifier mygroup1 ^
    --target-db-parameter-group-identifier mygroup2 ^
    --target-db-parameter-group-description "DB parameter group 2"
```

RDS API

To copy a DB parameter group, use the RDS API `CopyDBParameterGroup` operation with the following required parameters:

- `SourceDBParameterGroupIdentifier`
- `TargetDBParameterGroupIdentifier`
- `TargetDBParameterGroupDescription`

Listing DB Parameter Groups

You can list the DB parameter groups you've created for your AWS account.

> **Note**
> Default parameter groups are automatically created from a default parameter template when you create a DB instance for a particular DB engine and version. These default parameter groups contain preferred parameter settings and can't be modified. When you create a custom parameter group, you can modify parameter settings.

Console

To list all DB parameter groups for an AWS account

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.

   The DB parameter groups appear in a list.

AWS CLI

To list all DB parameter groups for an AWS account, use the AWS CLI `describe-db-parameter-groups` command.

Example

The following example lists all available DB parameter groups for an AWS account.

```
aws rds describe-db-parameter-groups
```

The command returns a response like the following:

```
DBPARAMETERGROUP  default.mysql5.5     mysql5.5  Default parameter group for MySQL5.5
DBPARAMETERGROUP  default.mysql5.6     mysql5.6  Default parameter group for MySQL5.6
DBPARAMETERGROUP  mydbparametergroup   mysql5.6  My new parameter group
```

The following example describes the *mydbparamgroup1* parameter group.

For Linux, macOS, or Unix:

```
aws rds describe-db-parameter-groups \
    --db-parameter-group-name mydbparamgroup1
```

For Windows:

```
aws rds describe-db-parameter-groups ^
    --db-parameter-group-name mydbparamgroup1
```

The command returns a response like the following:

```
DBPARAMETERGROUP  mydbparametergroup1  mysql5.5  My new parameter group
```

RDS API

To list all DB parameter groups for an AWS account, use the RDS API `DescribeDBParameterGroups` operation.

Viewing Parameter Values for a DB Parameter Group

You can get a list of all parameters in a DB parameter group and their values.

Console

To view the parameter values for a DB parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.

   The DB parameter groups appear in a list.
3. Choose the name of the parameter group to see its list of parameters.

AWS CLI

To view the parameter values for a DB parameter group, use the AWS CLI `describe-db-parameters` command with the following required parameter.

- `--db-parameter-group-name`

Example

The following example lists the parameters and parameter values for a DB parameter group named *mydbparametergroup.*

```
aws rds describe-db-parameters --db-parameter-group-name mydbparametergroup
```

The command returns a response like the following:

```
DBPARAMETER  Parameter Name            Parameter Value  Source           Data Type  Apply
 Type   Is Modifiable
DBPARAMETER  allow-suspicious-udfs                      engine-default   boolean    static
     false
DBPARAMETER  auto_increment_increment                   engine-default   integer    dynamic
     true
```

```
DBPARAMETER  auto_increment_offset                        engine-default   integer    dynamic
     true
DBPARAMETER  binlog_cache_size         32768              system           integer    dynamic
     true
DBPARAMETER  socket                    /tmp/mysql.sock    system           string     static
     false
```

RDS API

To view the parameter values for a DB parameter group, use the RDS API `DescribeDBParameters` command with the following required parameter.

- `DBParameterGroupName`

Comparing DB Parameter Groups

You can use the AWS Management Console to view the differences between two parameter groups for the same DB engine and version.

To compare two parameter groups

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. In the list, choose the two parameter groups that you want to compare.
4. For **Parameter group actions**, choose **Compare**.

   Note
   If the items you selected aren't equivalent, you can't choose **Compare**. For example, you can't compare a MySQL 5.6 and a MySQL 5.7 parameter group. You can't compare a DB parameter group and an Aurora DB cluster parameter group.

DB Parameter Values

You can specify the value for a DB parameter as any of the following:

- An integer constant
- A DB parameter formula
- A DB parameter function
- A character string constant
- A log expression (the log function represents log base 2), such as `value={log(DBInstanceClassMemory/8187281418)*1000}`

DB Parameter Formulas

A DB parameter formula is an expression that resolves to an integer value or a Boolean value, and is enclosed in braces: {}. You can specify formulas for either a DB parameter value or as an argument to a DB parameter function.

Syntax

```
{FormulaVariable}
{FormulaVariable*Integer}
{FormulaVariable*Integer/Integer}
{FormulaVariable/Integer}
```

DB Parameter Formula Variables

Each formula variable returns integer or a Boolean value. The names of the variables are case-sensitive.

AllocatedStorage

Returns the size, in bytes, of the data volume.

DBInstanceClassMemory

Returns the number of bytes of memory allocated to the DB instance class associated with the current DB instance, less the memory used by the Amazon RDS processes that manage the instance.

EndPointPort

Returns the number of the port used when connecting to the DB instance.

DBInstanceClassHugePagesDefault

Returns a Boolean value. Currently, it is only supported for Oracle engines.

For more information, see Using Huge Pages with an Oracle DB Instance (p. 867).

DB Parameter Formula Operators

DB parameter formulas support two operators: division and multiplication.

Division Operator: /

Divides the dividend by the divisor, returning an integer quotient. Decimals in the quotient are truncated, not rounded.

Syntax

```
dividend / divisor
```

The dividend and divisor arguments must be integer expressions.

*Multiplication Operator: **

Multiplies the expressions, returning the product of the expressions. Decimals in the expressions are truncated, not rounded.

Syntax

```
expression * expression
```

Both expressions must be integers.

DB Parameter Functions

The parameter arguments can be specified as either integers or formulas. Each function must have at least one argument. Multiple arguments can be specified as a comma-separated list. The list can't have any empty members, such as *argument1,,argument3*. Function names are case-insensitive.

Note
DB Parameter functions are not currently supported in the AWS CLI.

IF()

Returns an argument.

Currently, it is only supported for Oracle engines, and the only supported first argument is `{DBInstanceClassHugePagesDefault}`. For more information, see Using Huge Pages with an Oracle DB Instance (p. 867).

Syntax

```
IF(argument1, argument2, argument3)
```

Returns the second argument if the first argument evaluates to true. Returns the third argument otherwise.

GREATEST()

Returns the largest value from a list of integers or parameter formulas.

Syntax

```
GREATEST(argument1, argument2,...argumentn)
```

Returns an integer.

LEAST()

Returns the smallest value from a list of integers or parameter formulas.

Syntax

```
LEAST(argument1, argument2,...argumentn)
```

Returns an integer.

SUM()

Adds the values of the specified integers or parameter formulas.

Syntax

```
SUM(argument1, argument2,...argumentn)
```

Returns an integer.

DB Parameter Value Examples

These examples show using formulas and functions in the values for DB parameters.

Warning
Improperly setting parameters in a DB parameter group can have unintended adverse effects, including degraded performance and system instability. Always exercise caution when modifying database parameters and back up your data before modifying your DB parameter group. Try out parameter group changes on a test DB instances, created using point-in-time-restores, before applying those parameter group changes to your production DB instances.

You can specify the GREATEST function in an Oracle processes parameter to set the number of user processes to the larger of either 80 or DBInstanceClassMemory divided by 9,868,951.

```
GREATEST({DBInstanceClassMemory/9868951},80)
```

You can specify the LEAST() function in a MySQL max_binlog_cache_size parameter value to set the maximum cache size a transaction can use in a MySQL instance to the lesser of 1 MB or DBInstanceClass/256.

```
LEAST({DBInstanceClassMemory/256},10485760)
```

Managing an Amazon RDS DB Instance

Following, you can find instructions for managing and maintaining your Amazon RDS DB instance.

Topics

Stopping an Amazon RDS DB Instance Temporarily

If you use a DB instance intermittently, for temporary testing, or for a daily development activity, you can stop your Amazon RDS DB instance temporarily to save money. While your DB instance is stopped, you are charged for provisioned storage (including Provisioned IOPS) and backup storage (including manual snapshots and automated backups within your specified retention window), but not for DB instance hours. For more information, see Billing FAQs.

> **Note**
> In some cases, a large amount of time is required to stop a DB instance. If you want to stop your DB instance and restart it immediately, you can reboot the DB instance. For information about rebooting a DB instance, see Rebooting a DB Instance (p. 247).

You can stop and start DB instances that are running the following engines:

- MariaDB
- Microsoft SQL Server
- MySQL
- Oracle
- PostgreSQL

Stopping and starting a DB instance is supported for all DB instance classes, and in all AWS Regions.

You can stop and start a DB instance whether it is configured for a single Availability Zone or for Multi-AZ, for database engines that support Multi-AZ deployments. You can't stop an Amazon RDS for SQL Server DB instance in a Multi-AZ configuration.

> **Note**
> For a Multi-AZ deployment, a large amount of time might be required to stop a DB instance. If you have at least one backup after a previous failover, then you can speed up the stop DB instance operation by performing a reboot with failover operation before stopping the DB instance.

When you stop a DB instance, the DB instance performs a normal shutdown and stops running. The status of the DB instance changes to `stopping` and then `stopped`. Any storage volumes remain attached to the DB instance, and their data is kept. Any data stored in the RAM of the DB instance is deleted.

Stopping a DB instance removes pending actions, except for pending actions for the DB instance's option group or DB parameter group.

> **Important**
> You can stop a DB instance for up to seven days. If you don't manually start your DB instance after seven days, your DB instance is automatically started so that it doesn't fall behind any required maintenance updates.

Benefits

Stopping and starting a DB instance is faster than creating a DB snapshot, and then restoring the snapshot.

When you stop a DB instance it retains its ID, Domain Name Server (DNS) endpoint, parameter group, security group, and option group. When you start a DB instance, it has the same configuration as when you stopped it. In addition, if you stop a DB instance, Amazon RDS retains the Amazon Simple Storage Service (Amazon S3) transaction logs so you can do a point-in-time restore if necessary.

Limitations

The following are some limitations to stopping and starting a DB instance:

- You can't stop a DB instance that has a read replica, or that is a read replica.
- You can't stop an Amazon RDS for SQL Server DB instance in a Multi-AZ configuration.
- You can't modify a stopped DB instance.
- You can't delete an option group that is associated with a stopped DB instance.
- You can't delete a DB parameter group that is associated with a stopped DB instance.

Option and Parameter Group Considerations

You can't remove persistent options (including permanent options) from an option group if there are DB instances associated with that option group. This functionality is also true of any DB instance with a state of `stopping`, `stopped`, or `starting`.

You can change the option group or DB parameter group that is associated with a stopped DB instance, but the change does not occur until the next time you start the DB instance. If you chose to apply changes immediately, the change occurs when you start the DB instance. Otherwise the changes occurs during the next maintenance window after you start the DB instance.

VPC Considerations

When you stop a DB instance it retains its DNS endpoint. If you stop a DB instance that is not in an Amazon Virtual Private Cloud (Amazon VPC), Amazon RDS releases the IP addresses of the DB instance. If you stop a DB instance that is in a VPC, the DB instance retains its IP addresses.

> **Note**
> You should always connect to a DB instance using the DNS endpoint, not the IP address.

Console

To stop a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to stop.
3. For **Actions**, choose **Stop**.
4. (Optional) In the **Stop DB Instance** window, choose **Yes** for **Create Snapshot?** and enter the snapshot name for **Snapshot name**. Choose **Yes** if you want to create a snapshot of the DB instance before stopping it.
5. Choose **Yes, Stop Now** to stop the DB instance, or choose **Cancel** to cancel the operation.

AWS CLI

To stop a DB instance by using the AWS CLI, call the stop-db-instance command with the following parameters:

- `--db-instance-identifier` – the name of the DB instance.

Example

```
stop-db-instance --db-instance-identifier mydbinstance
```

RDS API

To stop a DB instance by using the Amazon RDS API, call the StopDBInstance operation with the following parameter:

- `DBInstanceIdentifier` – the name of the DB instance.

Starting an Amazon RDS DB Instance That Was Previously Stopped

You can stop your Amazon RDS DB instance temporarily to save money. After you stop your DB instance, you can restart it to begin using it again. For more details about stopping and starting DB instances, see Stopping an Amazon RDS DB Instance Temporarily (p. 215).

When you start a DB instance that you previously stopped, the DB instance retains the ID, Domain Name Server (DNS) endpoint, parameter group, security group, and option group. When you start a stopped instance, you are charged a full instance hour.

Console

To start a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to start.
3. For **Actions**, choose **Start**.

AWS CLI

To start a DB instance by using the AWS CLI, call the start-db-instance command with the following parameters:

- `--db-instance-identifier` – the name of the DB instance.

Example

```
start-db-instance --db-instance-identifier mydbinstance
```

RDS API

To start a DB instance by using the Amazon RDS API, call the StartDBInstance operation with the following parameters:

- `DBInstanceIdentifier` – the name of the DB instance.

Example

```
https://rds.amazonaws.com/
    ?Action=StartDBInstance
    &DBInstanceIdentifier=mydbinstance
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20131016/us-west-1/rds/aws4_request
    &X-Amz-Date=20131016T233051Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=087a8eb41cb1ab5f99e81575f23e73757ffc6a1e42d7d2b30b9cc0be988cff97
```

Related Topics

- Deleting a DB Instance (p. 286)
- Rebooting a DB Instance (p. 247)

Modifying an Amazon RDS DB Instance

You can change the settings of a DB instance to accomplish tasks such as adding additional storage or changing the DB instance class. In this topic, you can find out how to modify an Amazon RDS DB instance and learn about the settings for DB instances.

We recommend that you test any changes on a test instance before modifying a production instance, so that you fully understand the impact of each change. Testing is especially important when upgrading database versions.

Most modifications to a DB instance you can either apply immediately or defer until the next maintenance window. Some modifications, such as parameter group changes, require that you manually reboot your DB instance for the change to take effect.

> **Important**
> Some modifications result in an outage because Amazon RDS must reboot your DB instance for the change to take effect. Review the impact to your database and applications before modifying your DB instance settings.

Console

To modify a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**. The **Modify DB Instance** page appears.
4. Change any of the settings that you want. For information about each setting, see Settings for DB Instances (p. 221).
5. When all the changes are as you want them, choose **Continue** and check the summary of modifications.
6. (Optional) Choose **Apply immediately** to apply the changes immediately. Choosing this option can cause an outage in some cases. For more information, see Using the Apply Immediately Setting (p. 221).
7. On the confirmation page, review your changes. If they are correct, choose **Modify DB Instance** to save your changes.

   Or choose **Back** to edit your changes or **Cancel** to cancel your changes.

AWS CLI

To modify a DB instance by using the AWS CLI, call the modify-db-instance command. Specify the DB instance identifier and the values for the options that you want to modify. For information about each option, see Settings for DB Instances (p. 221).

Example

The following code modifies `mydbinstance` by setting the backup retention period to 1 week (7 days). The code enables deletion protection by using `--deletion-protection`. To disable deletion protection, use `--no-deletion-protection`. The changes are applied during the next maintenance window by using `--no-apply-immediately`. Use `--apply-immediately` to apply the changes immediately. For more information, see Using the Apply Immediately Setting (p. 221).

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --backup-retention-period 7 \
    --deletion-protection \
    --no-apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --backup-retention-period 7 ^
    --deletion-protection ^
    --no-apply-immediately
```

RDS API

To modify a DB instance by using the Amazon RDS API, call the ModifyDBInstance operation. Specify the DB instance identifier, and the parameters for the settings that you want to modify. For information about each parameter, see Settings for DB Instances (p. 221).

Using the Apply Immediately Setting

When you modify a DB instance, you can apply the changes immediately. To apply changes immediately, you choose the **Apply Immediately** option in the AWS Management Console. Or you use the `--apply-immediately` parameter when calling the AWS CLI or set the `ApplyImmediately` parameter to `true` when using the Amazon RDS API.

If you don't choose to apply changes immediately, the changes are put into the pending modifications queue. During the next maintenance window, any pending changes in the queue are applied. If you choose to apply changes immediately, your new changes and any changes in the pending modifications queue are applied.

> **Important**
> If any of the pending modifications require downtime, choosing the apply immediately option can cause unexpected downtime.
> When you choose to apply a change immediately, any pending modifications are also applied immediately, instead of during the next maintenance window.
> If you don't want a pending change to be applied in the next maintenance window, you can modify the DB instance to revert the change. You can do this by using the AWS CLI and specifying the `--apply-immediately` option.

Changes to some database settings are applied immediately, even if you choose to defer your changes. To see how the different database settings interact with the apply immediately setting, see Settings for DB Instances (p. 221).

Settings for DB Instances

In the following table, you can find details about which settings you can and can't modify, when changes can be applied, and whether the changes cause downtime for your DB instance.

You can modify a DB instance using the console, the `modify-db-instance` CLI command, or the `ModifyDBInstance` RDS API operation.

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Allocated storage
 	
The storage, in gibibytes, that you want to allocate for your DB instance. You can only increase the allocated storage. You can't reduce the allocated storage.
 	
You can't modify the storage of some older DB instances, or DB instances restored from older DB snapshots. The **Allocated storage** setting is disabled in the console if your DB instance isn't eligible. You can check whether you can allocate more storage by using the CLI command describe-valid-db-instance-modifications. This command returns the valid storage options for your DB instance.
 	
You can't modify allocated storage if the DB instance status is **storage-optimization** or if the allocated storage for the DB instance has been modified in the last six hours.
 	
The maximum storage allowed depends on your DB engine and the storage type. For more information, see Amazon RDS DB Instance Storage (p. 29).
	CLI option:
	
	`--allocated-storage`
	
	RDS API parameter:
	
	`AllocatedStorage`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage doesn't occur during this change. Performance might be degraded during the change.	All DB engines

Auto minor version upgrade
 	
Yes to enable your DB instance to receive preferred minor DB engine version upgrades automatically when they become available. Amazon RDS performs automatic minor version upgrades in the maintenance window. Otherwise, **No**.
 	
For more information, see Automatically
	CLI option:
	
	`--auto-minor-version-upgrade|--no-auto-minor-version-upgrade`
	
	RDS API parameter:
	
	`AutoMinorVersionUpgrade`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	Only MariaDB, MySQL, Oracle, and PostgreSQL

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines
Upgrading the Minor Engine Version (p. 242).				

Backup retention period
 	
The number of days that automatic backups are retained. To disable automatic backups, set the backup retention period to 0.
 	
For more information, see Working With Backups (p. 291).
	CLI option:
	
	`--backup-retention-period`
	
	RDS API parameter:
	
	`BackupRetentionPeriod`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, and you change the setting from a nonzero value to another nonzero value, the change is applied asynchronously, as soon as possible. Otherwise, the change occurs during the next maintenance window.
			An outage occurs if you change from 0 to a nonzero value, or from a nonzero value to 0.	All DB engines

Backup window
 	
The time range during which automated backups of your databases occur. The backup window is a start time in Universal Coordinated Time (UTC), and a duration in hours.
 	
For more information, see Working With Backups (p. 291).
	CLI option:
	
	`--preferred-backup-window`
	
	RDS API parameter:
	
	`PreferredBackupWindow`
		The change is applied asynchronously, as soon as possible.	An outage doesn't occur during this change.	All DB engines

Certificate authority
 	
The certificate that you want to use for SSL/TLS connections.
 	
For more information, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
	CLI option:
	
	`--ca-certificate-identifier`
	
	RDS API parameter:
	
	`CACertificateIdentifier`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Copy tags to snapshots
 	
If you have any DB instance tags, enable this option to copy them when you create a DB snapshot.
 	
For more information, see Tagging Amazon RDS Resources (p. 266).
	CLI option:
	
	`--copy-tags-to-snapshot` or `--no-copy-tags-to-snapshot`
	
	RDS API parameter:
	
	`CopyTagsToSnapshot`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Database port
 	
The port that you want to use to access the DB instance.
 	
The port value must not match any of the port values specified for options in the option group that is associated with the DB instance.
 	
For more information, see Connecting to an Amazon RDS DB Instance (p. 155).
	CLI option:
	
	`--db-port-number`
	
	RDS API parameter:
	
	`DBPortNumber`
		The change occurs immediately. This setting ignores the apply immediately setting.	The DB instance is rebooted immediately.	All DB engines

DB engine version
 	
The version of the DB engine that you want to use. Before you upgrade your production DB instance, we recommend that you test the upgrade process on a test DB instance to verify its duration and to validate your applications.
 	
For more information, see Upgrading a DB Instance Engine Version (p. 241).
	CLI option:
	
	`--engine-version`
	
	RDS API parameter:
	
	`EngineVersion`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

DB instance class
 	
The DB instance class that you want to use.
 	
For more information, see DB Instance Classes (p. 7).
	CLI option:
	
	`--db-instance-class`
	
	RDS API parameter:
	
	`DBInstanceClass`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	All DB engines

DB instance identifier
 	
The new DB instance identifier. This value is stored as a lowercase string.
 	
For more information about the effects of renaming a DB instance, see Renaming a DB Instance (p. 244).
	CLI option:
	
	`--new-db-instance-identifier`
	
	RDS API parameter:
	
	`NewDBInstanceIdentifier`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	All DB engines

DB parameter group
 	
The DB parameter group that you want associated with the DB instance.
 	
For more information, see Working with DB Parameter Groups (p. 202).
	CLI option:
	
	`--db-parameter-group-name`
	
	RDS API parameter:
	
	`DBParameterGroupName`
		The parameter group change occurs immediately.	An outage doesn't occur during this change. However, you must manually reboot the DB instance before the new DB parameter group is used by the DB instance.
			
			For more information, see Working with DB Parameter Groups (p. 202) and Rebooting a DB Instance (p. 247).
				All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Deletion protection
 	
Enable deletion protection to prevent your DB instance from being deleted.
 	
For more information, see Deleting a DB Instance (p. 286).
	CLI option:
	
	`--deletion-protection|--no-deletion-protection`
	
	RDS API parameter:
	
	`DeletionProtection`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Enhanced Monitoring
 	
Enable Enhanced Monitoring to enable gathering metrics in real time for the operating system that your DB instance runs on.
 	
For more information, see Enhanced Monitoring (p. 362).
	CLI option:
	
	`--monitoring-interval` and `--monitoring-role-arn`
	
	RDS API parameter:
	
	`MonitoringInterval` and `MonitoringRoleArn`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

IAM DB authentication
 	
Enable IAM DB authentication to authenticate database users through IAM users and roles.
 	
For more information, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).
	CLI option:
	
	`--enable-iam-database-authentication|--no-enable-iam-database-authentication`
	
	RDS API parameter:
	
	`EnableIAMDatabaseAuthentication`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			A brief outage occurs during this change.	Only MySQL and PostgreSQL

Kerberos authentication
 	
Choose the Active Directory to move the DB instance to. The directory must exist prior to this operation. If a directory is already selected, you can specify **None** to remove the DB instance from its current directory.
 	
For more information, see Kerberos Authentication (p. 1408).
	CLI option:
	
	`--domain` and `--domain-iam-role-name`
	
	RDS API parameter:
	
	`Domain` and `DomainIAMRoleName`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			A brief outage occurs during this change.	Only Microsoft SQL Server, MySQL, Oracle, and PostgreSQL

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

License model
 	
Choose **bring-your-own-license** to use your license for Oracle.
 	
Choose **license-included** to use the general license agreement for Microsoft SQL Server or Oracle.
 	
For more information, see Licensing Microsoft SQL Server on Amazon RDS (p. 559) and Oracle Licensing (p. 847).
	CLI option:
	
	`--license-model`
	
	RDS API parameter:
	
	`LicenseModel`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	Only Microsoft SQL Server and Oracle

Log exports
 	
The types of database log files to publish to Amazon CloudWatch Logs.
 	
For more information, see Publishing Database Logs to Amazon CloudWatch Logs (p. 455).
	CLI option:
	
	`--cloudwatch-logs-export-configuration`
	
	RDS API parameter:
	
	`CloudwatchLogsExportConfiguration`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Maintenance window
 	
The time range during which system maintenance occurs. System maintenance includes upgrades, if applicable. The maintenance window is a start time in Universal Coordinated Time (UTC), and a duration in hours.
 	
If you set the window to the current time, there must be at least 30 minutes between the current time and the end of the window to ensure that any pending changes are applied.
 	
For more information, see The Amazon RDS Maintenance Window (p. 238).
	CLI option:
	
	`--preferred-maintenance-window`
	
	RDS API parameter:
	
	`PreferredMaintenanceWindow`
		The change occurs immediately. This setting ignores the apply immediately setting.	If there are one or more pending actions that cause an outage, and the maintenance window is changed to include the current time, those pending actions are applied immediately and an outage occurs.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Multi-AZ deployment
 	
Yes to deploy your DB instance in multiple Availability Zones. Otherwise, **No**.
 	
For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).
	CLI option:
	
	`--multi-az|--no-multi-az`
	
	RDS API parameter:
	
	`MultiAZ`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage doesn't occur during this change.	All DB engines

New master password
 	
The password for your master user. The password must contain 8–41 alphanumeric characters.
	CLI option:
	
	`--master-user-password`
	
	RDS API parameter:
	
	`MasterUserPassword`
		The change is applied asynchronously, as soon as possible. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Option group
 	
The option group that you want associated with the DB instance.
 	
For more information, see Working with Option Groups (p. 186).
	CLI option:
	
	`--option-group-name`
	
	RDS API parameter:
	
	`OptionGroupName`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage doesn't occur during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Performance Insights
 	
Enable Performance Insights to monitor your DB instance load so that you can analyze and troubleshoot your database performance.
 	
Performance Insights isn't available for some DB engine versions and DB instance classes. The **Performance Insights** section doesn't appear in the console if it isn't available for your DB instance.
 	
For more information, see Using Amazon RDS Performance Insights (p. 376).
	CLI option:
	
	`--enable-performance-insights|--no-enable-performance-insights`
	
	RDS API parameter:
	
	`EnablePerformanceInsights`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Performance Insights Master key
 	
The AWS KMS key identifier for encryption of Performance Insights data. The KMS key ID is the Amazon Resource Name (ARN), KMS key identifier, or the KMS key alias for the KMS encryption key.
 	
For more information, see Enabling Performance Insights (p. 377).
	CLI option:
	
	`--performance-insights-kms-key-id`
	
	RDS API parameter:
	
	`PerformanceInsightsKMSKeyId`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Performance Insights Retention period
 	
The amount of time, in days, to retain Performance Insights data. Valid values are 7 or 731 (2 years).
 	
For more information, see Enabling Performance Insights (p. 377).
	CLI option:
	
	`--performance-insights-retention-period`
	
	RDS API parameter:
	
	`PerformanceInsightsRetentionPeriod`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Processor features
 	
The number of CPU cores and the number of threads per core for the DB instance class of the DB instance.
 	
For more information, see Configuring the Processor for a DB Instance Class (p. 17).
	CLI option:
	
	`--processor-features` and `--use-default-processor-features` | `--no-use-default-processor-features`
	
	RDS API parameter:
	
	`ProcessorFeatures` and `UseDefaultProcessorFeatures`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	Only Oracle

Provisioned IOPS
 	
The new Provisioned IOPS (I/O operations per second) value for the DB instance. The setting is available only if **Provisioned IOPS (SSD)** is chosen for **Storage type**.
 	
For more information, see Provisioned IOPS SSD Storage (p. 31).
	CLI option:
	
	`--iops`
	
	RDS API parameter:
	
	`Iops`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage doesn't occur during this change.	All DB engines

Public accessibility
 	
Yes to give the DB instance a public IP address, meaning that it's accessible outside the VPC. To be publicly accessible, the DB instance also has to be in a public subnet in the VPC.
 	
No to make the DB instance accessible only from inside the VPC.
 	
For more information, see Hiding a DB Instance in a VPC from the Internet (p. 1443).
	CLI option:
	
	`--publicly-accessible|--no-publicly-accessible`
	
	RDS API parameter:
	
	`PubliclyAccessible`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Security group
 	
The VPC security group that you want associated with the DB instance.
 	
For more information, see Controlling Access with Security Groups (p. 1414).
	CLI option:
	
	`--vpc-security-group-ids`
	
	RDS API parameter:
	
	`VpcSecurityGroupIds`
		The change is applied asynchronously, as soon as possible. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Storage autoscaling
 	
Enable storage autoscaling to enable Amazon RDS to automatically increase storage when needed to avoid having your DB instance run out of storage space.
 	
Use **Maximum storage threshold** to set the upper limit for Amazon RDS to automatically increase storage for your DB instance. The default is 1,000 GiB.
 	
For more information, see Managing Capacity Automatically with Amazon RDS Storage Autoscaling (p. 279).
	CLI option:
	
	`--max-allocated-storage`
	
	RDS API parameter:
	
	`MaxAllocatedStorage`
		The change occurs immediately. This setting ignores the apply immediately setting.	An outage doesn't occur during this change.	All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines

Storage type
 	
The storage type that you want to use.
 	
After Amazon RDS begins to modify your DB instance to change the storage size or type, you can't submit another request to change the storage size or type for six hours.
 	
For more information, see Amazon RDS Storage Types (p. 29).
	CLI option:
	
	`--storage-type`
	
	RDS API parameter:
	
	`StorageType`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			The following changes all result in a brief outage while the process starts. After that, you can use your database normally while the change takes place.
			
			• From **General Purpose (SSD)** to **Magnetic**.
			• From **General Purpose (SSD)** to **Provisioned IOPS (SSD)**. The outage only happens if the DB instance is Single-AZ and you are using a custom parameter group. There is no outage for a Multi-AZ DB instance.
			• From **Magnetic** to **General Purpose (SSD)**.
			• From **Magnetic** to **Provisioned IOPS (SSD)**.
			• From **Provisioned IOPS (SSD)** to **Magnetic**.
			• From **Provisioned IOPS (SSD)** to **General Purpose (SSD)**. The outage only happens if the DB instance is Single-AZ and you are using a custom parameter group. There is no outage for
				All DB engines

Console Setting and Description	CLI Option and RDS API Parameter	When the Change Occurs	Downtime Notes	Supported DB Engines
			a Multi-AZ DB instance.	

Subnet group
 	
The subnet group for the DB instance. You can use this setting to move your DB instance to a different VPC. If your DB instance isn't in a VPC, you can use this setting to move your DB instance into a VPC.
 	
For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
	CLI option:
	
	`--db-subnet-group-name`
	
	RDS API parameter:
	
	`DBSubnetGroupName`
		If you choose to apply the change immediately, it occurs immediately.
		
		If you don't choose to apply the change immediately, it occurs during the next maintenance window.
			An outage occurs during this change.	All DB engines

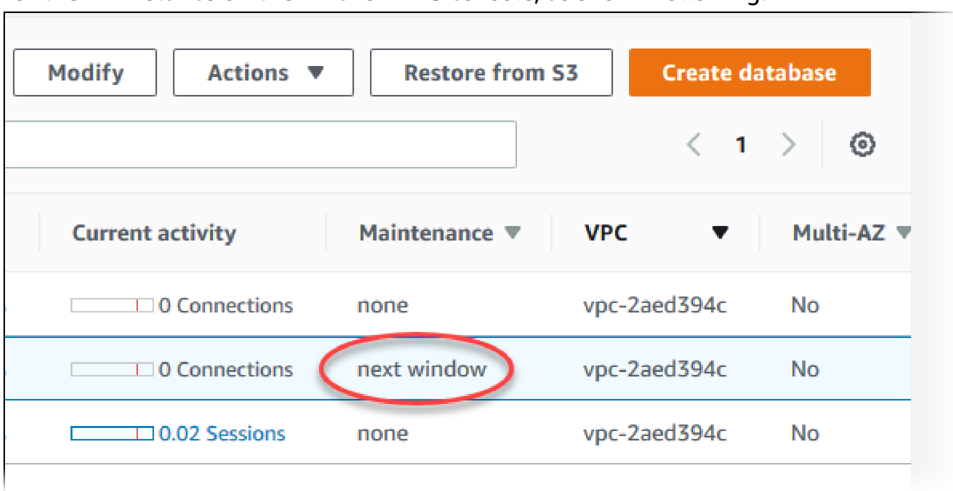
Maintaining a DB Instance

Periodically, Amazon RDS performs maintenance on Amazon RDS resources. Maintenance most often involves updates to the DB instance's underlying hardware, underlying operating system (OS), or database engine version. Updates to the operating system most often occur for security issues and should be done as soon as possible.

Some maintenance items require that Amazon RDS take your DB instance offline for a short time. Maintenance items that require a resource to be offline include required operating system or database patching. Required patching is automatically scheduled only for patches that are related to security and instance reliability. Such patching occurs infrequently (typically once every few months) and seldom requires more than a fraction of your maintenance window.

Deferred DB instance modifications that you have chosen not to apply immediately are applied during the maintenance window. For example, you may choose to change the DB instance class or parameter group during the maintenance window. For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

You can view whether a maintenance update is available for your DB instance by using the RDS console, the AWS CLI, or the Amazon RDS API. If an update is available, it is indicated in the **Maintenance** column for the DB instance on the Amazon RDS console, as shown following.



If no maintenance update is available for a DB instance, the column value is **none** for it.

If a maintenance update is available for a DB instance, the following column values are possible:

- **required** – The maintenance action will be applied to the resource and can't be deferred.
- **available** – The maintenance action is available, but it will not be applied to the resource automatically. You can apply it manually.
- **next window** – The maintenance action will be applied to the resource during the next maintenance window.
- **In progress** – The maintenance action is in the process of being applied to the resource.

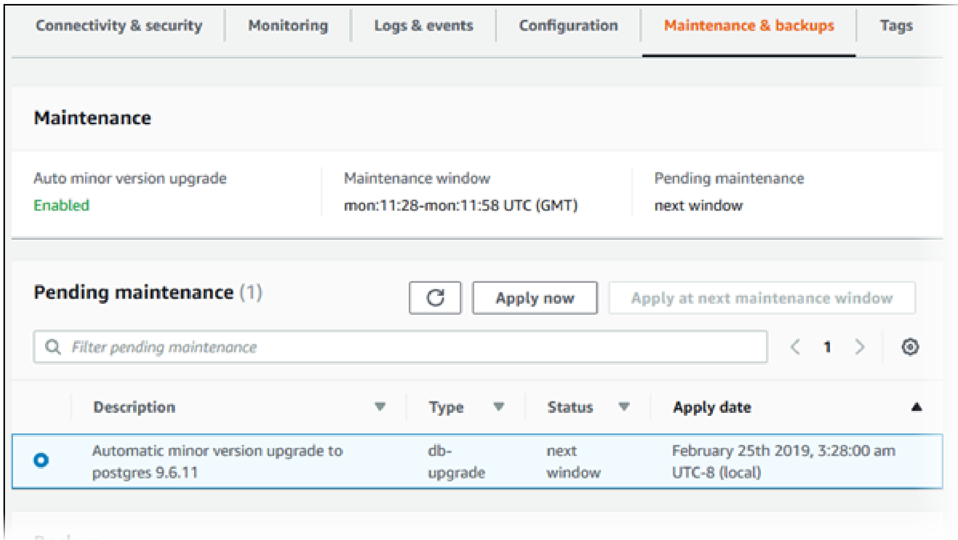
If an update is available, you can take one of the actions:

- If the maintenance value is **next window**, defer the maintenance items by choosing **Defer upgrade** from **Actions**. You can't defer a maintenance action if it has already started.
- Apply the maintenance items immediately.
- Schedule the maintenance items to start during your next maintenance window.

- Take no action.

> **Note**
> Certain OS updates are marked as **required**. If you defer a required update, you get a notice from Amazon RDS indicating when the update will be performed. Other updates are marked as **available**, and these you can defer indefinitely.

To take an action, choose the DB instance to show its details, then choose **Maintenance & backups**. The pending maintenance items appear.



The maintenance window determines when pending operations start, but doesn't limit the total execution time of these operations. Maintenance operations aren't guaranteed to finish before the maintenance window ends, and can continue beyond the specified end time. For more information, see The Amazon RDS Maintenance Window (p. 238).

Applying Updates for a DB Instance

With Amazon RDS, you can choose when to apply maintenance operations. You can decide when Amazon RDS applies updates by using the RDS console, AWS Command Line Interface (AWS CLI), or RDS API.

Console

To manage an update for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that has a required update.
4. For **Actions**, choose one of the following:
   - **Upgrade now**
   - **Upgrade at next window**

   > **Note**
   > If you choose **Upgrade at next window** and later want to delay the update, you can choose **Defer upgrade**. You can't defer a maintenance action if it has already started.
   > To cancel a maintenance action, modify the DB instance and disable **Auto minor version upgrade**.

AWS CLI

To apply a pending update to a DB instance, use the apply-pending-maintenance-action AWS CLI command.

Example

For Linux, macOS, or Unix:

```
aws rds apply-pending-maintenance-action \
    --resource-identifier arn:aws:rds:us-west-2:001234567890:db:mysql-db \
    --apply-action system-update \
    --opt-in-type immediate
```

For Windows:

```
aws rds apply-pending-maintenance-action ^
    --resource-identifier arn:aws:rds:us-west-2:001234567890:db:mysql-db ^
    --apply-action system-update ^
    --opt-in-type immediate
```

> **Note**
> To defer a maintenance action, specify `undo-opt-in` for `--opt-in-type`. You can't specify `undo-opt-in` for `--opt-in-type` if the maintenance action has already started.
> To cancel a maintenance action, run the modify-db-instance AWS CLI command and specify `--no-auto-minor-version-upgrade`.

To return a list of resources that have at least one pending update, use the describe-pending-maintenance-actions AWS CLI command.

Example

For Linux, macOS, or Unix:

```
aws rds describe-pending-maintenance-actions \
    --resource-identifier arn:aws:rds:us-west-2:001234567890:db:mysql-db
```

For Windows:

```
aws rds describe-pending-maintenance-actions ^
    --resource-identifier arn:aws:rds:us-west-2:001234567890:db:mysql-db
```

You can also return a list of resources for a DB instance by specifying the `--filters` parameter of the `describe-pending-maintenance-actions` AWS CLI command. The format for the `--filters` command is `Name=filter-name,Value=resource-id,...`.

The following are the accepted values for the `Name` parameter of a filter:

- `db-instance-id` – Accepts a list of DB instance identifiers or Amazon Resource Names (ARNs). The returned list only includes pending maintenance actions for the DB instances identified by these identifiers or ARNs.
- `db-cluster-id` – Accepts a list of DB cluster identifiers or ARNs for Amazon Aurora. The returned list only includes pending maintenance actions for the DB clusters identified by these identifiers or ARNs.

For example, the following example returns the pending maintenance actions for the `sample-instance1` and `sample-instance2` DB instances.

Example

For Linux, macOS, or Unix:

```
aws rds describe-pending-maintenance-actions \
 --filters Name=db-instance-id,Values=sample-instance1,sample-instance2
```

For Windows:

```
aws rds describe-pending-maintenance-actions ^
 --filters Name=db-instance-id,Values=sample-instance1,sample-instance2
```

RDS API

To apply an update to a DB instance, call the Amazon RDS API `ApplyPendingMaintenanceAction` operation.

To return a list of resources that have at least one pending update, call the Amazon RDS API `DescribePendingMaintenanceActions` operation.

Maintenance for Multi-AZ Deployments

Running a DB instance as a Multi-AZ deployment can further reduce the impact of a maintenance event, because Amazon RDS applies operating system updates by following these steps:

1. Perform maintenance on the standby.

2. Promote the standby to primary.
3. Perform maintenance on the old primary, which becomes the new standby.

When you modify the database engine for your DB instance in a Multi-AZ deployment, then Amazon RDS upgrades both the primary and secondary DB instances at the same time. In this case, the database engine for the entire Multi-AZ deployment is shut down during the upgrade.

For more information on Multi-AZ deployments, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

The Amazon RDS Maintenance Window

Every DB instance has a weekly maintenance window during which any system changes are applied. You can think of the maintenance window as an opportunity to control when modifications and software patching occur, in the event either are requested or required. If a maintenance event is scheduled for a given week, it is initiated during the 30-minute maintenance window you identify. Most maintenance events also complete during the 30-minute maintenance window, although larger maintenance events may take more than 30 minutes to complete.

The 30-minute maintenance window is selected at random from an 8-hour block of time per region. If you don't specify a preferred maintenance window when you create the DB instance, then Amazon RDS assigns a 30-minute maintenance window on a randomly selected day of the week.

RDS will consume some of the resources on your DB instance while maintenance is being applied. You might observe a minimal effect on performance. For a DB instance, on rare occasions, a Multi-AZ failover might be required for a maintenance update to complete.

Following, you can find the time blocks for each region from which default maintenance windows are assigned.

Region Name	Region	Time Block
US East (Ohio)	us-east-2	03:00–11:00 UTC
US East (N. Virginia)	us-east-1	03:00–11:00 UTC
US West (N. California)	us-west-1	06:00–14:00 UTC
US West (Oregon)	us-west-2	06:00–14:00 UTC
Asia Pacific (Hong Kong)	ap-east-1	06:00–14:00 UTC
Asia Pacific (Mumbai)	ap-south-1	17:30–01:30 UTC
Asia Pacific (Osaka-Local)	ap-northeast-3	22:00–23:59 UTC
Asia Pacific (Seoul)	ap-northeast-2	13:00–21:00 UTC
Asia Pacific (Singapore)	ap-southeast-1	14:00–22:00 UTC
Asia Pacific (Sydney)	ap-southeast-2	12:00–20:00 UTC
Asia Pacific (Tokyo)	ap-northeast-1	13:00–21:00 UTC
Canada (Central)	ca-central-1	03:00–11:00 UTC
China (Beijing)	cn-north-1	06:00–14:00 UTC

Region Name	Region	Time Block
China (Ningxia)	cn-northwest-1	06:00–14:00 UTC
Europe (Frankfurt)	eu-central-1	23:00–07:00 UTC
Europe (Ireland)	eu-west-1	22:00–06:00 UTC
Europe (London)	eu-west-2	22:00–06:00 UTC
Europe (Paris)	eu-west-3	23:59–07:29 UTC
Europe (Stockholm)	eu-north-1	23:00–07:00 UTC
Middle East (Bahrain)	me-south-1	06:00–14:00 UTC
South America (São Paulo)	sa-east-1	00:00–08:00 UTC
AWS GovCloud (US-West)	us-gov-west-1	06:00–14:00 UTC

Adjusting the Preferred DB Instance Maintenance Window

The maintenance window should fall at the time of lowest usage and thus might need modification from time to time. Your DB instance will only be unavailable during this time if the system changes, such as a change in DB instance class, are being applied and require an outage, and only for the minimum amount of time required to make the necessary changes.

In the following example, you adjust the preferred maintenance window for a DB instance.

For the purpose of this example, we assume that the DB instance named *mydbinstance* exists and has a preferred maintenance window of "Sun:05:00-Sun:06:00" UTC.

Console

To adjust the preferred maintenance window

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then select the DB instance that you want to modify.
3. Choose **Modify**. The **Modify DB Instance** page appears.
4. In the **Maintenance** section, update the maintenance window.

   Note
   The maintenance window and the backup window for the DB instance cannot overlap. If you enter a value for the maintenance window that overlaps the backup window, an error message appears.
5. Choose **Continue**.

   On the confirmation page, review your changes.
6. To apply the changes to the maintenance window immediately, select **Apply immediately**.
7. Choose **Modify DB Instance** to save your changes.

   Alternatively, choose **Back** to edit your changes, or choose **Cancel** to cancel your changes.

AWS CLI

To adjust the preferred maintenance window, use the AWS CLI `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--preferred-maintenance-window`

Example

The following code example sets the maintenance window to Tuesdays from 4:00-4:30AM UTC.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
--db-instance-identifier mydbinstance \
--preferred-maintenance-window Tue:04:00-Tue:04:30
```

For Windows:

```
aws rds modify-db-instance ^
--db-instance-identifier mydbinstance ^
--preferred-maintenance-window Tue:04:00-Tue:04:30
```

RDS API

To adjust the preferred maintenance window, use the Amazon RDS API `ModifyDBInstance` operation with the following parameters:

- `DBInstanceIdentifier = mydbinstance`
- `PreferredMaintenanceWindow = Tue:04:00-Tue:04:30`

Example

The following code example sets the maintenance window to Tuesdays from 4:00-4:30AM UTC.

```
https://rds.us-west-2.amazonaws.com/
?Action=ModifyDBInstance
&DBInstanceIdentifier=mydbinstance
&PreferredMaintenanceWindow=Tue:04:00-Tue:04:30
&SignatureMethod=HmacSHA256
&SignatureVersion=4
&Version=2014-09-01
&X-Amz-Algorithm=AWS4-HMAC-SHA256
&X-Amz-Credential=AKIADQKE4SARGYLE/20140425/us-east-1/rds/aws4_request
&X-Amz-Date=20140425T192732Z
&X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
&X-Amz-Signature=1dc9dd716f4855e9bdf188c70f1cf9f6251b070b68b81103b59ec70c3e7854b3
```

Upgrading a DB Instance Engine Version

Amazon RDS provides newer versions of each supported database engine so you can keep your DB instance up-to-date. Newer versions can include bug fixes, security enhancements, and other improvements for the database engine. When Amazon RDS supports a new version of a database engine, you can choose how and when to upgrade your database DB instances.

There are two kinds of upgrades: major version upgrades and minor version upgrades. In general, a *major engine version upgrade* can introduce changes that are not compatible with existing applications. In contrast, a *minor version upgrade* includes only changes that are backward-compatible with existing applications.

The version numbering sequence is specific to each database engine. For example, Amazon RDS MySQL 5.7 and 8.0 are major engine versions and upgrading from any 5.7 version to any 8.0 version is a major version upgrade. Amazon RDS MySQL version 5.7.22 and 5.7.23 are minor versions and upgrading from 5.7.22 to 5.7.23 is a minor version upgrade.

For more information about major and minor version upgrades for a specific DB engine, see the following documentation for your DB engine:

- Upgrading the MariaDB DB Engine (p. 517)
- Upgrading the Microsoft SQL Server DB Engine (p. 572)
- Upgrading the MySQL DB Engine (p. 733)
- Upgrading the Oracle DB Engine (p. 888)
- Upgrading the PostgreSQL DB Engine for Amazon RDS (p. 1235)

For major version upgrades, you must manually modify the DB engine version through the AWS Management Console, AWS CLI, or RDS API. For minor version upgrades, you can manually modify the engine version, or you can choose to enable auto minor version upgrades.

Topics

Manually Upgrading the Engine Version

To manually upgrade the engine version of a DB instance, you can use the AWS Management Console, the AWS CLI, or the RDS API.

Console

To upgrade the engine version of a DB instance by using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to upgrade.
3. Choose **Modify**. The **Modify DB Instance** page appears.
4. For **DB engine version**, choose the new version.
5. Choose **Continue** and check the summary of modifications.
6. To apply the changes immediately, choose **Apply immediately**. Choosing this option can cause an outage in some cases. For more information, see Using the Apply Immediately Setting (p. 221).

7. On the confirmation page, review your changes. If they are correct, choose **Modify DB Instance** to save your changes.

   Alternatively, choose **Back** to edit your changes, or choose **Cancel** to cancel your changes.

AWS CLI

To upgrade the engine version of a DB instance, use the CLI modify-db-instance command. Specify the following parameters:

- `--db-instance-identifier` – the name of the DB instance.
- `--engine-version` – the version number of the database engine to upgrade to.

  For information about valid engine versions, use the AWS CLI describe-db-engine-versions command.
- `--allow-major-version-upgrade` – to upgrade the major version.
- `--no-apply-immediately` – to apply changes during the next maintenance window. To apply changes immediately, use `--apply-immediately`.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --engine-version new_version \
    --allow-major-version-upgrade \
    --no-apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --engine-version new_version ^
    --allow-major-version-upgrade ^
    --no-apply-immediately
```

RDS API

To upgrade the engine version of a DB instance, use the ModifyDBInstance action. Specify the following parameters:

- `DBInstanceIdentifier` – the name of the DB instance, for example *`mydbinstance`*.
- `EngineVersion` – the version number of the database engine to upgrade to. For information about valid engine versions, use the DescribeDBEngineVersions operation.
- `AllowMajorVersionUpgrade` – whether to allow a major version upgrade. To do so, set the value to `true`.
- `ApplyImmediately` – whether to apply changes immediately or during the next maintenance window. To apply changes immediately, set the value to `true`. To apply changes during the next maintenance window, set the value to `false`.

Automatically Upgrading the Minor Engine Version

A *minor engine version* is an update to a DB engine version within a major engine version. For example, a major engine version might be 9.6 with the minor engine versions 9.6.11 and 9.6.12 within it.

If you want Amazon RDS to upgrade the DB engine version of a database automatically, you can enable auto minor version upgrades for the database.

When Amazon RDS designates a minor engine version as the preferred minor engine version, each database that meets both of the following conditions is upgraded to the minor engine version automatically:

- The database is running a minor version of the DB engine that is lower than the preferred minor engine version.
- The database has auto minor version upgrade enabled.

You can control whether auto minor version upgrade is enabled for a DB instance when you perform the following tasks:

- Creating a DB instance (p. 136)
- Modifying a DB instance (p. 220)
- Creating a read replica (p. 253)
- Restoring a DB instance from a snapshot (p. 303)
- Restoring a DB instance to a specific time (p. 336)
- Importing a DB instance from Amazon S3 (p. 747) (for a MySQL backup on Amazon S3)

When you perform these tasks, you can control whether auto minor version upgrade is enabled for the DB instance in the following ways:

- Using the console, set the **Auto minor version upgrade** option.
- Using the AWS CLI, set the `--auto-minor-version-upgrade|--no-auto-minor-version-upgrade` option.
- Using the RDS API, set the `AutoMinorVersionUpgrade` parameter.

To determine whether a maintenance update, such as a DB engine version upgrade, is available for your DB instance, you can use the console, AWS CLI, or RDS API. You can also upgrade the DB engine version manually and adjust the maintenance window. For more information, see Maintaining a DB Instance (p. 234).

Renaming a DB Instance

You can rename a DB instance by using the AWS Management Console, the AWS CLI `modify-db-instance` command, or the Amazon RDS API `ModifyDBInstance` action. Renaming a DB instance can have far-reaching effects; the following is a list of things you should know before you rename a DB instance.

- When you rename a DB instance, the endpoint for the DB instance changes, because the URL includes the name you assigned to the DB instance. You should always redirect traffic from the old URL to the new one.
- When you rename a DB instance, the old DNS name that was used by the DB instance is immediately deleted, although it could remain cached for a few minutes. The new DNS name for the renamed DB instance becomes effective in about 10 minutes. The renamed DB instance is not available until the new name becomes effective.
- You cannot use an existing DB instance name when renaming an instance.
- All read replicas associated with a DB instance remain associated with that instance after it is renamed. For example, suppose you have a DB instance that serves your production database and the instance has several associated read replicas. If you rename the DB instance and then replace it in the production environment with a DB snapshot, the DB instance that you renamed will still have the read replicas associated with it.
- Metrics and events associated with the name of a DB instance are maintained if you reuse a DB instance name. For example, if you promote a read replica and rename it to be the name of the previous master, the events and metrics associated with the master are associated with the renamed instance.
- DB instance tags remain with the DB instance, regardless of renaming.
- DB snapshots are retained for a renamed DB instance.

Renaming to Replace an Existing DB Instance

The most common reasons for renaming a DB instance are that you are promoting a read replica or you are restoring data from a DB snapshot or PITR. By renaming the database, you can replace the DB instance without having to change any application code that references the DB instance. In these cases, you would do the following:

1. Stop all traffic going to the master DB instance. This can involve redirecting traffic from accessing the databases on the DB instance or some other way you want to use to prevent traffic from accessing your databases on the DB instance.
2. Rename the master DB instance to a name that indicates it is no longer the master as described later in this topic.
3. Create a new master DB instance by restoring from a DB snapshot or by promoting a read replica, and then give the new instance the name of the previous master DB instance.
4. Associate any read replicas with the new master DB instance.

If you delete the old master DB instance, you are responsible for deleting any unwanted DB snapshots of the old master instance.

For information about promoting a read replica, see Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

Console

To rename a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to rename.
4. Choose **Modify**.
5. In **Settings**, enter a new name for **DB instance identifier**.
6. Choose **Continue**.
7. To apply the changes immediately, choose **Apply immediately**. Choosing this option can cause an outage in some cases. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
8. On the confirmation page, review your changes. If they are correct, choose **Modify DB Instance** to save your changes.

   Alternatively, choose **Back** to edit your changes, or choose **Cancel** to cancel your changes.

AWS CLI

To rename a DB instance, use the AWS CLI command `modify-db-instance`. Provide the current `--db-instance-identifier` value and `--new-db-instance-identifier` parameter with the new name of the DB instance.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier DBInstanceIdentifier \
    --new-db-instance-identifier NewDBInstanceIdentifier
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier DBInstanceIdentifier ^
    --new-db-instance-identifier NewDBInstanceIdentifier
```

RDS API

To rename a DB instance, call Amazon RDS API function `ModifyDBInstance` with the following parameters:

- `DBInstanceIdentifier` = existing name for the instance
- `NewDBInstanceIdentifier` = new name for the instance

```
https://rds.amazonaws.com/
 ?Action=ModifyDBInstance
 &DBInstanceIdentifier=mydbinstance
 &NewDBInstanceIdentifier=mynewdbinstanceidentifier
 &Version=2012-01-15
 &SignatureVersion=2
```

```
&SignatureMethod=HmacSHA256
&Timestamp=2012-01-20T22%3A06%3A23.624Z
&AWSAccessKeyId=<AWS Access Key ID>
&Signature=<Signature>
```

Rebooting a DB Instance

You might need to reboot your DB instance, usually for maintenance reasons. For example, if you make certain modifications, or if you change the DB parameter group associated with the DB instance , you must reboot the instance for the changes to take effect.

Note
If a DB instance isn't using the latest changes to its associated DB parameter group, the AWS Management Console shows the DB parameter group with a status of **pending-reboot**. The **pending-reboot** parameter groups status doesn't result in an automatic reboot during the next maintenance window. To apply the latest parameter changes to that DB instance, manually reboot the DB instance. For more information about parameter groups, see Working with DB Parameter Groups (p. 202).

Rebooting a DB instance restarts the database engine service. Rebooting a DB instance results in a momentary outage, during which the DB instance status is set to *rebooting*.

If the Amazon RDS instance is configured for Multi-AZ, you can perform the reboot with a failover. An Amazon RDS event is created when the reboot is completed. If your DB instance is a Multi-AZ deployment, you can force a failover from one Availability Zone (AZ) to another when you reboot. When you force a failover of your DB instance, Amazon RDS automatically switches to a standby replica in another Availability Zone, and updates the DNS record for the DB instance to point to the standby DB instance. As a result, you need to clean up and re-establish any existing connections to your DB instance. Rebooting with failover is beneficial when you want to simulate a failure of a DB instance for testing, or restore operations to the original AZ after a failover occurs. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

Note
When you force a failover from one Availability Zone to another when you reboot, the Availability Zone change might not be reflected in the AWS Management Console, and in calls to the AWS CLI and RDS API, for several minutes.

You can't reboot your DB instance if it is not in the available state. Your database can be unavailable for several reasons, such as an in-progress backup, a previously requested modification, or a maintenance-window action.

The time required to reboot your DB instance depends on the crash recovery process, database activity at the time of reboot, and the behavior of your specific DB engine. To improve the reboot time, we recommend that you reduce database activity as much as possible during the reboot process. Reducing database activity reduces rollback activity for in-transit transactions.

Console

To reboot a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to reboot.
3. For **Actions**, choose **Reboot**.

   The **Reboot DB Instance** page appears.
4. (Optional) Choose **Reboot with failover?** to force a failover from one AZ to another.
5. Choose **Reboot** to reboot your DB instance.

   Alternatively, choose **Cancel**.

AWS CLI

To reboot a DB instance by using the AWS CLI, call the `reboot-db-instance` command.

Example Simple Reboot

For Linux, macOS, or Unix:

```
aws rds reboot-db-instance \
    --db-instance-identifier mydbinstance
```

For Windows:

```
aws rds reboot-db-instance ^
    --db-instance-identifier mydbinstance
```

Example Reboot with Failover

To force a failover from one AZ to the other, use the `--force-failover` parameter.

For Linux, macOS, or Unix:

```
aws rds reboot-db-instance \
    --db-instance-identifier mydbinstance \
    --force-failover
```

For Windows:

```
aws rds reboot-db-instance ^
    --db-instance-identifier mydbinstance ^
    --force-failover
```

RDS API

To reboot a DB instance by using the Amazon RDS API, call the `RebootDBInstance` action.

Example Simple Reboot

```
https://rds.amazonaws.com/
 ?Action=RebootDBInstance
    &DBInstanceIdentifier=mydbinstance
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20131016/us-west-1/rds/aws4_request
    &X-Amz-Date=20131016T233051Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=087a8eb41cb1ab5f99e81575f23e73757ffc6a1e42d7d2b30b9cc0be988cff97
```

Example Reboot with Failover

To force a failover from one AZ to the other, set the `ForceFailover` parameter to `true`.

```
https://rds.amazonaws.com/
    ?Action=RebootDBInstance
    &DBInstanceIdentifier=mydbinstance
    &ForceFailover=true
```

```
&Version=2014-10-31
&X-Amz-Algorithm=AWS4-HMAC-SHA256
&X-Amz-Credential=AKIADQKE4SARGYLE/20131016/us-west-1/rds/aws4_request
&X-Amz-Date=20131016T233051Z
&X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
&X-Amz-Signature=087a8eb41cb1ab5f99e81575f23e73757ffc6a1e42d7d2b30b9cc0be988cff97
```

Working with Read Replicas

Amazon RDS uses the MariaDB, MySQL, Oracle, PostgreSQL, and Microsoft SQL Server DB engines' built-in replication functionality to create a special type of DB instance called a read replica from a source DB instance. Updates made to the source DB instance are asynchronously copied to the read replica. You can reduce the load on your source DB instance by routing read queries from your applications to the read replica. Using read replicas, you can elastically scale out beyond the capacity constraints of a single DB instance for read-heavy database workloads.

> **Note**
> The information following applies to creating Amazon RDS read replicas either in the same AWS Region as the source DB instance, or in a separate AWS Region. The information following doesn't apply to setting up replication with an instance that is running on an Amazon EC2 instance or that is on-premises.

When you create a read replica, you first specify an existing DB instance as the source. Then Amazon RDS takes a snapshot of the source instance and creates a read-only instance from the snapshot. Amazon RDS then uses the asynchronous replication method for the DB engine to update the read replica whenever there is a change to the source DB instance. The read replica operates as a DB instance that allows only read-only connections. Applications connect to a read replica the same way they do to any DB instance. Amazon RDS replicates all databases in the source DB instance.

In some cases, a read replica resides in a different AWS Region than its source DB instance. In these cases, Amazon RDS sets up a secure communications channel between the source DB instance and the read replica. Amazon RDS establishes any AWS security configurations needed to enable the secure channel, such as adding security group entries.

Read replicas are supported by the MariaDB, MySQL, Oracle, PostgreSQL, and Microsoft SQL Server engines. In this section, you can find general information about using read replicas with all of these engines. For information about using read replicas with a specific engine, see the following sections:

- Working with MySQL Read Replicas (p. 773)
- Working with MariaDB Read Replicas (p. 523)
- Working with Oracle Read Replicas for Amazon RDS (p. 908)
- Working with PostgreSQL Read Replicas in Amazon RDS (p. 1244)
- Working with Read Replicas for Microsoft SQL Server in Amazon RDS (p. 601)

Overview of Amazon RDS Read Replicas

Deploying one or more read replicas for a given source DB instance might make sense in a variety of scenarios, including the following:

- Scaling beyond the compute or I/O capacity of a single DB instance for read-heavy database workloads. You can direct this excess read traffic to one or more read replicas.
- Serving read traffic while the source DB instance is unavailable. In some cases, your source DB instance might not be able to take I/O requests, for example due to I/O suspension for backups or scheduled maintenance. In these cases, you can direct read traffic to your read replicas. For this use case, keep in mind that the data on the read replica might be "stale" because the source DB instance is unavailable.
- Business reporting or data warehousing scenarios where you might want business reporting queries to run against a read replica, rather than your primary, production DB instance.
- Implementing disaster recovery. You can promote a read replica to a standalone instance as a disaster recovery solution if the source DB instance fails.

By default, a read replica is created with the same storage type as the source DB instance. However, you can create a read replica that has a different storage type from the source DB instance based on the options listed in the following table.

Source DB Instance Storage Type	Source DB Instance Storage Allocation	Read Replica Storage Type Options
PIOPS	100 GiB–32 TiB	PIOPS, GP2, Standard
GP2	100 GiB–32 TiB	PIOPS, GP2, Standard
GP2	<100 GiB	GP2, Standard
Standard	100 GiB–6 TiB	PIOPS, GP2, Standard
Standard	<100 GiB	GP2, Standard

Amazon RDS doesn't support circular replication. You can't configure a DB instance to serve as a replication source for an existing DB instance. You can only create a new read replica from an existing DB instance. For example, if **`MyDBInstance`** replicates to **`ReadReplica1`**, you can't configure **`ReadReplica1`** to replicate back to **`MyDBInstance`**. For MariaDB, MySQL, and PostgreSQL, you can create a read replica from an existing read replica. For example, from **`ReadReplica1`**, you can create a new read replica, such as **`ReadReplica2`**. For Oracle and SQL Server, you can't create a read replica from an existing read replica.

Differences Between Read Replicas for Different DB Engines

Because Amazon RDS DB engines implement replication differently, there are several significant differences you should know about, as shown in the following table.

Feature or Behavior	MySQL and MariaDB	Oracle	PostgreSQL	SQL Server
What is the replication method?	Logical replication.	Physical replication.	Physical replication.	Physical replication.
How are transaction logs purged?	RDS MySQL and RDS MariaDB keep any binary logs that haven't been applied.	If a source DB instance has no cross-Region read replicas, Amazon RDS for Oracle keeps a minimum of two hours of transaction logs on the source DB instance. Logs are purged from the source DB instance after two hours or after the archive log retention hours setting has passed, whichever is longer. Logs are purged from the read replica after the archive	PostgreSQL has the parameter `wal_keep_segments` that dictates how many write ahead log (WAL) files are kept to provide data to the read replicas. The parameter value specifies the number of logs to keep.	The Virtual Log File (VLF) of the transaction log file on the primary replica can be truncated after it is no longer required for the secondary replicas. The VLF can only be marked as inactive when the

Feature or Behavior	MySQL and MariaDB	Oracle	PostgreSQL	SQL Server
		log retention hours setting has passed only if they have been successfully applied to the database. In some cases, a source DB instance might have one or more cross-Region read replicas. If so, Amazon RDS for Oracle keeps the transaction logs on the source DB instance until they have been transmitted and applied to all cross-Region read replicas. For information about setting `archivelog retention hours`, see Retaining Archived Redo Logs (p. 1029).		log records have been hardened in the replicas. Regardless of how fast the disk subsystems are in the primary replica, the transaction log will keep the VLFs until the slowest replica has hardened it.
Can a replica be made writable?	Yes. You can enable the MySQL or MariaDB read replica to be writable.	No. An Oracle read replica is a physical copy, and Oracle doesn't allow for writes in a read replica. You can promote the read replica to make it writable. The promoted read replica has the replicated data to the point when the request was made to promote it.	No. A PostgreSQL read replica is a physical copy, and PostgreSQL doesn't allow for a read replica to be made writable.	No. A SQL Server read replica is a physical copy and also doesn't allow for writes. You can promote the read replica to make it writable. The promoted read replica has the replicated data up to the point when the request was made to promote it.

Feature or Behavior	MySQL and MariaDB	Oracle	PostgreSQL	SQL Server
Can backups be performed on the replica?	Yes. You can enable automatic backups on a MySQL or MariaDB read replica.	No. You can't create manual snapshots of Amazon RDS for Oracle read replicas or enable automatic backups for them.	Yes, you can create a manual snapshot of a PostgreSQL read replica, but you can't enable automatic backups.	No. You can't create manual snapshots of Amazon RDS for SQL Server read replicas or enable automatic backups for them.
Can you use parallel replication?	Yes. MySQL version 5.6 and later and all supported MariaDB versions allow for parallel replication threads.	Yes. Redo log data is always transmitted in parallel from the source database to all of its read replicas.	No. PostgreSQL has a single process handling replication.	Yes. Redo log data is always transmitted in parallel from the source database to all of its read replicas.

Creating a Read Replica

You can create a read replica from an existing MySQL, MariaDB, Oracle, PostgreSQL DB, or SQL Server instance using the AWS Management Console, AWS CLI, or RDS API. You create a read replica by specifying `SourceDBInstanceIdentifier`, which is the DB instance identifier of the source DB instance that you want to replicate from.

When you create a read replica, Amazon RDS takes a DB snapshot of your source DB instance and begins replication. As a result, you experience a brief I/O suspension on your source DB instance while the DB snapshot occurs. The I/O suspension typically lasts about one minute. You can avoid the I/O suspension if the source DB instance is a Multi-AZ deployment, because in that case the snapshot is taken from the secondary DB instance. An active, long-running transaction can slow the process of creating the read replica. We recommend that you wait for long-running transactions to complete before creating a read replica. If you create multiple read replicas in parallel from the same source DB instance, Amazon RDS takes only one snapshot at the start of the first create action.

When creating a read replica, there are a few things to consider. First, you must enable automatic backups on the source DB instance by setting the backup retention period to a value other than 0. This requirement also applies to a read replica that is the source DB instance for another read replica. For MySQL DB instances, automatic backups are supported only for read replicas running MySQL 5.6 and later, but not for MySQL versions 5.5. To enable automatic backups on an Amazon RDS MySQL version 5.6 and later read replica, first create the read replica, then modify the read replica to enable automatic backups.

> **Note**
> Within an AWS Region, all read replicas must be created in the same virtual private cloud (VPC) based on Amazon VPC as the source DB instance. This requirement applies even if VPC peering is configured in the AWS Region.

Console

To create a read replica from a source MySQL, MariaDB, Oracle, PostgreSQL, or SQL Server DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the MySQL, MariaDB, Oracle, PostgreSQL, or SQL Server DB instance that you want to use as the source for a read replica.
4. For **Actions**, choose **Create read replica**.
5. Choose the instance specifications that you want to use. We recommend that you use the same DB instance class and storage type as the source DB instance for the read replica. For **Multi-AZ deployment**, choose **Yes** to create a standby of your replica in another Availability Zone for failover support for the replica. Creating your read replica as a Multi-AZ DB instance is independent of whether the source database is a Multi-AZ DB instance.
6. Choose the settings that you want to use. For **DB instance identifier**, enter a name for the read replica. Adjust other settings as needed.
7. Choose the other settings that you want to use.
8. Choose **Create read replica**.

AWS CLI

To create a read replica from a source MySQL, MariaDB, Oracle, PostgreSQL, or SQL Server DB instance, use the AWS CLI command `create-db-instance-read-replica`.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-instance-read-replica \
    --db-instance-identifier myreadreplica \
    --source-db-instance-identifier mydbinstance
```

For Windows:

```
aws rds create-db-instance-read-replica ^
    --db-instance-identifier myreadreplica ^
    --source-db-instance-identifier mydbinstance
```

RDS API

To create a read replica from a source MySQL, MariaDB, Oracle, PostgreSQL, or SQL Server DB instance, call the Amazon RDS API function `CreateDBInstanceReadReplica`.

```
https://rds.amazonaws.com/
 ?Action=CreateDBInstanceReadReplica
 &DBInstanceIdentifier=myreadreplica
 &SourceDBInstanceIdentifier=mydbinstance
 &Version=2012-01-15
 &SignatureVersion=2
 &SignatureMethod=HmacSHA256
 &Timestamp=2012-01-20T22%3A06%3A23.624Z
 &AWSAccessKeyId=<AWS Access Key ID>
```

```
&Signature=<Signature>
```

Promoting a Read Replica to Be a Standalone DB Instance

You can promote a MySQL, MariaDB, Oracle, PostgreSQL, or SQL Server read replica into a standalone DB instance. When you promote a read replica, the DB instance is rebooted before it becomes available.

There are several reasons you might want to promote a read replica to a standalone DB instance:

- **Performing DDL operations (MySQL and MariaDB only)** – DDL operations, such as creating or rebuilding indexes, can take time and impose a significant performance penalty on your DB instance. You can perform these operations on a MySQL or MariaDB read replica once the read replica is in sync with its source DB instance. Then you can promote the read replica and direct your applications to use the promoted instance.
- **Sharding** – Sharding embodies the "share-nothing" architecture and essentially involves breaking a large database into several smaller databases. One common way to split a database is splitting tables that are not joined in the same query onto different hosts. Another method is duplicating a table across multiple hosts and then using a hashing algorithm to determine which host receives a given update. You can create read replicas corresponding to each of your shards (smaller databases) and promote them when you decide to convert them into standalone shards. You can then carve out the key space (if you are splitting rows) or distribution of tables for each of the shards depending on your requirements.
- **Implementing failure recovery** – You can use read replica promotion as a data recovery scheme if the source DB instance fails. This approach complements synchronous replication, automatic failure detection, and failover.

  If you are aware of the ramifications and limitations of asynchronous replication and you still want to use read replica promotion for data recovery, you can. To do this, first create a read replica and then monitor the source DB instance for failures. In the event of a failure, do the following:
  1. Promote the read replica.
  2. Direct database traffic to the promoted DB instance.
  3. Create a replacement read replica with the promoted DB instance as its source.

When you promote a read replica, the new DB instance that is created retains the backup retention period, the backup window, the option group, and the parameter group of the former read replica source. The promotion process can take several minutes or longer to complete, depending on the size of the read replica. After you promote the read replica to a new DB instance, it's just like any other DB instance. For example, you can create read replicas from the new DB instance and perform point-in-time restore operations. Because the promoted DB instance is no longer a read replica, you can't use it as a replication target. If a source DB instance has several read replicas, promoting one of the read replicas to a DB instance has no effect on the other replicas.

Backup duration is a function of the number of changes to the database since the previous backup. If you plan to promote a read replica to a standalone instance, we recommend that you enable backups and complete at least one backup prior to promotion. In addition, you can't promote a read replica to a standalone instance when it has the `backing-up` status. If you have enabled backups on your read replica, configure the automated backup window so that daily backups don't interfere with read replica promotion.

The following steps show the general process for promoting a read replica to a DB instance:

1. Stop any transactions from being written to the read replica source DB instance, and then wait for all updates to be made to the read replica. Database updates occur on the read replica after they have

occurred on the source DB instance, and this replication lag can vary significantly. Use the Replica Lag metric to determine when all updates have been made to the read replica.

2. For MySQL and MariaDB only: If you need to make changes to the MySQL or MariaDB read replica, you must set the `read_only` parameter to `0` in the DB parameter group for the read replica. You can then perform all needed DDL operations, such as creating indexes, on the read replica. Actions taken on the read replica don't affect the performance of the source DB instance.
3. Promote the read replica by using the **Promote** option on the Amazon RDS console, the AWS CLI command `promote-read-replica`, or the `PromoteReadReplica` Amazon RDS API operation.

   Note
   The promotion process takes a few minutes to complete. When you promote a read replica, replication is stopped and the read replica is rebooted. When the reboot is complete, the read replica is available as a new DB instance.
4. (Optional) Modify the new DB instance to be a Multi-AZ deployment. For more information, see Modifying an Amazon RDS DB Instance (p. 220) and High Availability (Multi-AZ) for Amazon RDS (p. 41).

Console

To promote a read replica to a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the Amazon RDS console, choose **Databases**.

   The **Databases** pane appears. Each read replica shows **Replica** in the **Role** column.
3. Choose the read replica that you want to promote.
4. For **Actions**, choose **Promote read replica**.
5. On the **Promote Read Replica** page, enter the backup retention period and the backup window for the new promoted DB instance.
6. When the settings are as you want them, choose **Continue**.
7. On the acknowledgment page, choose **Promote Read Replica**.

AWS CLI

To promote a read replica to a DB instance, use the AWS CLI `promote-read-replica` command.

Example

For Linux, macOS, or Unix:

```
aws rds promote-read-replica \
    --db-instance-identifier myreadreplica
```

For Windows:

```
aws rds promote-read-replica ^
    --db-instance-identifier myreadreplica
```

RDS API

To promote a read replica to a DB instance, call `PromoteReadReplica`.

```
https://rds.amazonaws.com/
```

```
?Action=PromoteReadReplica
&DBInstanceIdentifier=myreadreplica
&Version=2012-01-15
&SignatureVersion=2
&SignatureMethod=HmacSHA256
&Timestamp=2012-01-20T22%3A06%3A23.624Z
&AWSAccessKeyId=<AWS Access Key ID>
&Signature=<Signature>
```

Creating a Read Replica in a Different AWS Region

With Amazon RDS, you can create a MariaDB, MySQL, Oracle, or PostgreSQL read replica in a different AWS Region than the source DB instance. Creating a cross-Region read replica isn't supported for SQL Server on Amazon RDS.

You create a read replica in a different AWS Region to do the following:

- Improve your disaster recovery capabilities.
- Scale read operations into an AWS Region closer to your users.
- Make it easier to migrate from a data center in one AWS Region to a data center in another AWS Region.

Creating a read replica in a different AWS Region from the source instance is similar to creating a replica in the same AWS Region. You can use the AWS Management Console, run the `create-db-instance-read-replica` command, or call the `CreateDBInstanceReadReplica` API operation.

To create an encrypted read replica in a different AWS Region than the source DB instance, the source DB instance must be encrypted.

Cross-Region read replicas aren't supported in the following opt-in AWS Regions:

- Africa (Cape Town)
- Asia Pacific (Hong Kong)
- Europe (Milan)
- Middle East (Bahrain)

The following procedures show how to create a read replica from a source MariaDB, MySQL, Oracle, or PostgreSQL DB instance in a different AWS Region.

Console

You can create a read replica across AWS Regions using the AWS Management Console.

To create a read replica across AWS Regions with the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the MariaDB, MySQL, Oracle, or PostgreSQL DB instance that you want to use as the source for a read replica. For **Actions**, choose **Create read replica**. To create an encrypted read replica, the source DB instance must be encrypted. To learn more about encrypting the source DB instance, see Encrypting Amazon RDS Resources (p. 1358).
4. Choose the instance specifications you want to use. We recommend that you use the same DB instance class and storage type for the read replica.
5. Choose the other settings that you want to use:

- For **DB instance identifier**, enter a name for the read replica.
- In the **Network & Security** section, choose a value for **Destination region** and **Destination DB subnet group**.
- To create an encrypted read replica in another AWS Region, choose **Enable Encryption**, and then choose the **Master key**. For the **Master key**, choose the AWS Key Management Service (AWS KMS) key identifier of the destination AWS Region.
- Choose the other settings that you want to use.

6. Choose **Create read replica**.

AWS CLI

To create a read replica from a source MySQL, MariaDB, Oracle, or PostgreSQL DB instance in a different AWS Region, you can use the `create-db-instance-read-replica` command. In this case, you use `create-db-instance-read-replica` from the AWS Region where you want the read replica and specify the Amazon Resource Name (ARN) for the source DB instance. An ARN uniquely identifies a resource created in Amazon Web Services.

For example, if your source DB instance is in the US East (N. Virginia) Region, the ARN looks similar to this example:

```
arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
```

For information about ARNs, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).

To create an encrypted read replica in a different AWS Region than the source DB instance, you can use the AWS CLI `create-db-instance-read-replica` command from the destination AWS Region. The following parameters are used to create an encrypted read replica in another AWS Region:

- `--source-region` — The AWS Region that the encrypted read replica is created in. If `source-region` is not specified, you must specify a `pre-signed-url` value. A `pre-signed-url` is an URL that contains a Signature Version 4 signed request for the `CreateDBInstanceReadReplica` operation that is called in the source AWS Region that the read replica is created from. To learn more about `pre-signed-url`, see `CreateDBInstanceReadReplica`.
- `--source-db-instance-identifier` — The DB instance identifier for the encrypted read replica that is created. This identifier must be in the ARN format for the source AWS Region. The AWS Region specified in `source-db-instance-identifier` must match the AWS Region specified as `source-region`.
- `--db-instance-identifier` — The identifier for the encrypted read replica in the destination AWS Region.
- `--kms-key-id` — The AWS KMS key identifier for the key to use to encrypt the read replica in the destination AWS Region.

The following code creates a read replica in the `us-west-2` Region.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-instance-read-replica \
    --db-instance-identifier DBInstanceIdentifier \
    --region us-west-2 \
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
```

For Windows:

```
aws rds create-db-instance-read-replica ^
    --db-instance-identifier DBInstanceIdentifier ^
    --region us-west-2 ^
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
```

The following code creates a read replica in a different AWS Region than the source DB instance. The AWS Region where you call the `create-db-instance-read-replica` command is the destination AWS Region for the encrypted read replica.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-instance-read-replica \
    --db-instance-identifier DBInstanceIdentifier \
    --region us-west-2 \
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
 \
    --source-region us-east-1 \
    --kms-key-id my-us-east-1-key
```

For Windows:

```
aws rds create-db-instance-read-replica ^
    --db-instance-identifier DBInstanceIdentifier ^
    --region us-west-2 ^
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
 ^
    --source-region us-east-1 ^
    --kms-key-id my-us-east-1-key
```

RDS API

To create a read replica from a source MySQL, MariaDB, Oracle, or PostgreSQL DB instance in a different AWS Region, you can call the Amazon RDS API function CreateDBInstanceReadReplica. In this case, you call CreateDBInstanceReadReplica from the AWS Region where you want the read replica and specify the Amazon Resource Name (ARN) for the source DB instance. An ARN uniquely identifies a resource created in Amazon Web Services.

To create an encrypted read replica in a different AWS Region than the source DB instance, you can use the Amazon RDS API `CreateDBInstanceReadReplica` operation from the destination AWS Region. To create an encrypted read replica in another AWS Region, you must specify a value for `PreSignedURL`. `PreSignedURL` should contain a request for the `CreateDBInstanceReadReplica` operation to call in the source AWS Region where the read replica is created in. To learn more about `PreSignedUrl`, see `CreateDBInstanceReadReplica`.

For example, if your source DB instance is in the US East (N. Virginia) Region, the ARN looks similar to the following.

```
arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
```

For information about ARNs, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).

Example

```
https://us-west-2.rds.amazonaws.com/
    ?Action=CreateDBInstanceReadReplica
    &KmsKeyId=my-us-east-1-key
    &PreSignedUrl=https%253A%252F%252Frds.us-west-2.amazonaws.com%252F
         %253FAction%253D CreateDBInstanceReadReplica
         %2526DestinationRegion%253Dus-east-1
         %2526KmsKeyId%253Dmy-us-east-1-key
         %2526SourceDBInstanceIdentifier%253Darn%25253Aaws%25253Ards%25253Aus-
west-2%1234567890
12%25253Adb%25253Amy-mysql-instance
         %2526SignatureMethod%253DHmacSHA256
         %2526SignatureVersion%253D4%2526SourceDBInstanceIdentifier%253Darn%25253Aaws
%25253Ards%25253Aus-west-2%25253A123456789012%25253Ainstance%25253Amysql-instance1-
instance-20161115
         %2526Version%253D2014-10-31
         %2526X-Amz-Algorithm%253DAWS4-HMAC-SHA256
         %2526X-Amz-Credential%253DAKIADQKE4SARGYLE%252F20161117%252Fus-west-2%252Frds
%252Faws4_request
         %2526X-Amz-Date%253D20161117T215409Z
         %2526X-Amz-Expires%253D3600
         %2526X-Amz-SignedHeaders%253Dcontent-type%253Bhost%253Buser-agent%253Bx-amz-
content-sha256%253Bx-amz-date
         %2526X-Amz-Signature
%253D255a0f17b4e717d3b67fad163c3ec26573b882c03a65523522cf890a67fca613
    &DBInstanceIdentifier=myreadreplica
    &SourceDBInstanceIdentifier=arn:aws:rds:us-east-1:123456789012:db:my-mysql-instance
    &Version=2012-01-15
    &SignatureVersion=2
    &SignatureMethod=HmacSHA256
    &Timestamp=2012-01-20T22%3A06%3A23.624Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Cross-Region Replication Considerations

All of the considerations for performing replication within an AWS Region apply to cross-Region replication. The following extra considerations apply when replicating between AWS Regions:

- You can only replicate between AWS Regions when using the following Amazon RDS DB instances:
  - MariaDB (all versions).
  - MySQL version 5.6 and later.
  - Oracle Enterprise Edition (EE) engine version 12.1.0.2.v10 and higher 12.1 versions, all versions of 12.2, and all versions of 18.0.

    An Active Data Guard license is required. For information about limitations for Oracle cross-Region read replicas, see Read Replica Limitations with Oracle (p. 909).
  - PostgreSQL version 9.4.7 and later.
- A source DB instance can have cross-Region read replicas in multiple AWS Regions.
- You can only create a cross-Region Amazon RDS read replica from a source Amazon RDS DB instance that is not a read replica of another Amazon RDS DB instance.
- You can't set up a replication channel into or out of the AWS GovCloud (US-West) Region.
- You can expect to see a higher level of lag time for any read replica that is in a different AWS Region than the source instance. This lag time comes from the longer network channels between regional data centers.
- Within an AWS Region, all cross-Region read replicas created from the same source DB instance must either be in the same VPC or be outside of a VPC. For cross-Region read replicas, any of the create read

replica commands that specify the `--db-subnet-group-name` parameter must specify a DB subnet group from the same VPC.

- You can create a cross-Region read replica in a VPC from a source DB instance that is in a VPC in another AWS Region. You can also create a cross-Region read replica in a VPC from a source DB instance that is not in a VPC. You can also create a cross-Region read replica that is not in a VPC from a source DB instance that is in a VPC.
- Due to the limit on the number of access control list (ACL) entries for a VPC, we can't guarantee more than five cross-Region read replica instances.
- The read replica uses the default DB parameter group for the specified DB engine.
- The read replica uses the default security group.
- For MariaDB, MySQL, and Oracle DB instances, when the source for a cross-Region read replica is deleted, the read replica is promoted.
- For PostgreSQL DB instances, when the source for a cross-Region read replica is deleted, the replication status of the read replica is set to `terminated`. The read replica isn't promoted.

Cross-Region Replication Costs

The data transferred for cross-Region replication incurs Amazon RDS data transfer charges. These cross-Region replication actions generate charges for the data transferred out of the source AWS Region:

- When you create a read replica, Amazon RDS takes a snapshot of the source instance and transfers the snapshot to the read replica AWS Region.
- For each data modification made in the source databases, Amazon RDS transfers data from the source AWS Region to the read replica AWS Region.

For more information about data transfer pricing, see Amazon RDS Pricing.

For MySQL and MariaDB instances, you can reduce your data transfer costs by reducing the number of cross-Region read replicas that you create. For example, suppose that you have a source DB instance in one AWS Region and want to have three read replicas in another AWS Region. In this case, you create only one of the read replicas from the source DB instance. You create the other two replicas from the first read replica instead of the source DB instance.

For example, if you have `source-instance-1` in one AWS Region, you can do the following:

- Create `read-replica-1` in the new AWS Region, specifying `source-instance-1` as the source.
- Create `read-replica-2` from `read-replica-1`.
- Create `read-replica-3` from `read-replica-1`.

In this example, you are only charged for the data transferred from `source-instance-1` to `read-replica-1`. You aren't charged for the data transferred from `read-replica-1` to the other two replicas because they are all in the same AWS Region. If you create all three replicas directly from `source-instance-1`, you are charged for the data transfers to all three replicas.

How Amazon RDS Does Cross-Region Replication

Amazon RDS uses the following process to create a cross-Region read replica. Depending on the AWS Regions involved and the amount of data in the databases, this process can take hours to complete. You can use this information to determine how far the process has proceeded when you create a cross-Region read replica:

1. Amazon RDS begins configuring the source DB instance as a replication source and sets the status to *modifying*.

2. Amazon RDS begins setting up the specified read replica in the destination AWS Region and sets the status to *creating*.
3. Amazon RDS creates an automated DB snapshot of the source DB instance in the source AWS Region. The format of the DB snapshot name is rds:<InstanceID>-<timestamp>, where <InstanceID> is the identifier of the source instance, and <timestamp> is the date and time the copy started. For example, `rds:mysourceinstance-2013-11-14-09-24` was created from the instance `mysourceinstance` at `2013-11-14-09-24`. During the creation of an automated DB snapshot, the source DB instance status remains *modifying*, the read replica status remains *creating*, and the DB snapshot status is *creating*. The progress column of the DB snapshot page in the console reports how far the DB snapshot creation has progressed. When the DB snapshot is complete, the status of both the DB snapshot and source DB instance are set to *available*.
4. Amazon RDS begins a cross-Region snapshot copy for the initial data transfer. The snapshot copy is listed as an automated snapshot in the destination AWS Region with a status of *creating*. It has the same name as the source DB snapshot. The progress column of the DB snapshot display indicates how far the copy has progressed. When the copy is complete, the status of the DB snapshot copy is set to *available*.
5. Amazon RDS then uses the copied DB snapshot for the initial data load on the read replica. During this phase, the read replica is in the list of DB instances in the destination, with a status of *creating*. When the load is complete, the read replica status is set to *available*, and the DB snapshot copy is deleted.
6. When the read replica reaches the available status, Amazon RDS starts by replicating the changes made to the source instance since the start of the create read replica operation. During this phase, the replication lag time for the read replica is greater than 0.

   For information about replication lag time, see Monitoring Read Replication (p. 263).

Cross-Region Replication Examples

Example Create a Cross-Region Read Replica Outside of Any VPC

The following example creates a read replica in us-west-2 from a source DB instance in us-east-1. The read replica is created outside of a VPC:

For Linux, macOS, or Unix:

```
aws rds create-db-instance-read-replica \
    --db-instance-identifier SimCoProd01Replica01 \
    --region us-west-2
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:SimcoProd01
```

For Windows:

```
aws rds create-db-instance-read-replica ^
    --db-instance-identifier SimCoProd01Replica01 ^
    --region us-west-2
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:SimcoProd01
```

Example Create Cross-Region Read Replica in a VPC

This example creates a read replica in us-west-2 from a source DB instance in us-east-1. The read replica is created in the VPC associated with the specified DB subnet group:

For Linux, macOS, or Unix:

```
aws rds create-db-instance-read-replica \
    --db-instance-identifier SimCoProd01Replica01 \
    --region us-west-2
```

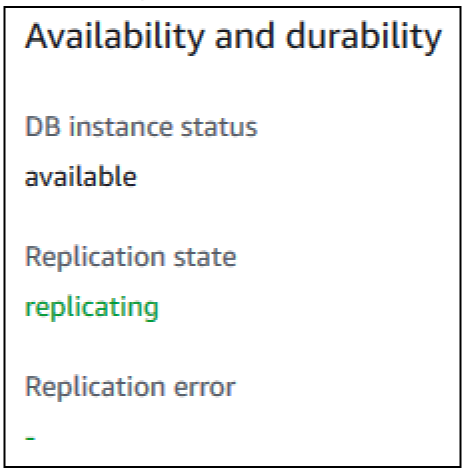
```
    --db-subnet-group-name my-us-west-2-subnet
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:SimcoProd01
```

For Windows:

```
aws rds create-db-instance-read-replica ^
    --db-instance-identifier SimCoProd01Replica01 ^
    --region us-west-2
    --db-subnet-group-name my-us-west-2-subnet
    --source-db-instance-identifier arn:aws:rds:us-east-1:123456789012:db:SimcoProd01
```

Monitoring Read Replication

You can monitor the status of a read replica in several ways. The Amazon RDS console shows the status of a read replica in the **Availability and durability** section of the read replica details. To view the details for a read replica, choose the name of the read replica in the list of instances in the Amazon RDS console.



You can also see the status of a read replica using the AWS CLI `describe-db-instances` command or the Amazon RDS API `DescribeDBInstances` operation.

The status of a read replica can be one of the following:

- **replicating** – The read replica is replicating successfully.
- **replication degraded (SQL Server only) –** Replicas are receiving data from the master instance, but one or more databases might be not getting updates. This can occur, for example, when a replica is in the process of setting up newly created databases.

  The status doesn't transition from `replication degraded` to `error`, unless an error occurs during the degraded state.
- **error** – An error has occurred with the replication. Check the **Replication Error** field in the Amazon RDS console or the event log to determine the exact error. For more information about troubleshooting a replication error, see Troubleshooting a MySQL Read Replica Problem (p. 777).
- **terminated (MariaDB, MySQL, or PostgreSQL only)** – Replication is terminated. This occurs if replication is stopped for more than 30 consecutive days, either manually or due to a replication error. In this case, Amazon RDS terminates replication between the source DB instance and all read replicas. Amazon RDS does this to prevent increased storage requirements on the source DB instance and long failover times.

  Broken replication can affect storage because the logs can grow in size and number due to the high volume of errors messages being written to the log. Broken replication can also affect failure recovery

due to the time Amazon RDS requires to maintain and process the large number of logs during recovery.
- **stopped (MariaDB or MySQL only)** – Replication has stopped because of a customer-initiated request.
- **replication stop point set (MySQL only)** – A customer-initiated stop point was set using the mysql.rds_start_replication_until (p. 832) stored procedure and the replication is in progress.
- **replication stop point reached (MySQL only)** – A customer-initiated stop point was set using the mysql.rds_start_replication_until (p. 832) stored procedure and replication is stopped because the stop point was reached.

Monitoring Replication Lag

You can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric.

For MySQL and MariaDB, the `ReplicaLag` metric reports the value of the `Seconds_Behind_Master` field of the `SHOW SLAVE STATUS` command. Common causes for replication lag for MySQL and MariaDB are the following:

- A network outage.
- Writing to tables with indexes on a read replica. If the `read_only` parameter is not set to 0 on the read replica, it can break replication.
- Using a nontransactional storage engine such as MyISAM. Replication is only supported for the InnoDB storage engine on MySQL and the XtraDB storage engine on MariaDB.

When the `ReplicaLag` metric reaches 0, the replica has caught up to the source DB instance. If the `ReplicaLag` metric returns `-1`, then replication is currently not active. `ReplicaLag = -1` is equivalent to `Seconds_Behind_Master = NULL`.

For Oracle, the `ReplicaLag` metric is the sum of the `Apply Lag` value and the difference between the current time and the apply lag's `DATUM_TIME` value. The `DATUM_TIME` value is the last time the read replica received data from its source DB instance. For more information, see V$DATAGUARD_STATS in the Oracle documentation.

For SQL Server, the `ReplicaLag` metric is the maximum lag of databases that have fallen behind, in seconds. For example, if you have two databases that lag 5 seconds and 10 seconds, respectively, then `ReplicaLag` is 10 seconds. The `ReplicaLag` metric returns the value of the following query.

```
select ag.name name, MAX(hdrs.secondary_lag_seconds) max_lag from
 sys.dm_hadr_database_replica_state
```

For more information, see secondary_lag_seconds in the Microsoft documentation.

`ReplicaLag` returns `-1` if RDS can't determine the lag, such as during replica setup, or when the read replica is in the `error` state.

Note
New databases aren't included in the lag calculation until they are accessible on the read replica.

For PostgreSQL, the `ReplicaLag` metric returns the value of the following query.

```
SELECT extract(epoch from now() - pg_last_xact_replay_timestamp()) AS slave_lag
```

PostgreSQL versions 9.4.7 and 9.5.2 and later use physical replication slots to manage write ahead log (WAL) retention on the source instance. For each cross-Region read replica instance, Amazon RDS creates a physical replication slot and associates it with the instance. Two Amazon CloudWatch metrics, `Oldest`

`Replication Slot Lag` and `Transaction Logs Disk Usage`, show how far behind the most lagging replica is in terms of WAL data received and how much storage is being used for WAL data. The `Transaction Logs Disk Usage` value can substantially increase when a cross-Region read replica is lagging significantly.

For more information about monitoring a DB instance with CloudWatch, see Monitoring with Amazon CloudWatch (p. 348).

Tagging Amazon RDS Resources

You can use Amazon RDS tags to add metadata to your Amazon RDS resources. You can also use these tags with IAM policies to manage access to Amazon RDS resources and to control what actions can be applied to the Amazon RDS resources. Finally, you can use these tags to track costs by grouping expenses for similarly tagged resources.

All Amazon RDS resources can be tagged

- DB instances
- DB clusters
- Read replicas
- DB snapshots
- DB cluster snapshots
- Reserved DB instances
- Event subscriptions
- DB option groups
- DB parameter groups
- DB cluster parameter groups
- DB security groups
- DB subnet groups

For information on managing access to tagged resources with IAM policies, see Identity and Access Management in Amazon RDS (p. 1371).

Overview of Amazon RDS Resource Tags

An Amazon RDS tag is a name-value pair that you define and associate with an Amazon RDS resource. The name is referred to as the key. Supplying a value for the key is optional. You can use tags to assign arbitrary information to an Amazon RDS resource. You can use a tag key, for example, to define a category, and the tag value might be an item in that category. For example, you might define a tag key of "project" and a tag value of "Salix", indicating that the Amazon RDS resource is assigned to the Salix project. You can also use tags to designate Amazon RDS resources as being used for test or production by using a key such as `environment=test` or `environment=production`. We recommend that you use a consistent set of tag keys to make it easier to track metadata associated with Amazon RDS resources.

Use tags to organize your AWS bill to reflect your own cost structure. To do this, sign up to get your AWS account bill with tag key values included. Then, to see the cost of combined resources, organize your billing information according to resources with the same tag key values. For example, you can tag several resources with a specific application name, and then organize your billing information to see the total cost of that application across several services. For more information, see Cost Allocation and Tagging in *About AWS Billing and Cost Management*.

Each Amazon RDS resource has a tag set, which contains all the tags that are assigned to that Amazon RDS resource. A tag set can contain as many as 50 tags, or it can be empty. If you add a tag to an Amazon RDS resource that has the same key as an existing tag on resource, the new value overwrites the old value.

AWS does not apply any semantic meaning to your tags; tags are interpreted strictly as character strings. Amazon RDS can set tags on a DB instance or other Amazon RDS resources, depending on the settings that you use when you create the resource. For example, Amazon RDS might add a tag indicating that a DB instance is for production or for testing.

- The tag key is the required name of the tag. The string value can be from 1 to 128 Unicode characters in length and cannot be prefixed with "aws:" or "rds:". The string can contain only the set of Unicode letters, digits, white-space, '_', '.', ':', '/', '=', '+', '-', '@' (Java regex: "^([\\p{L}\\p{Z}\\p{N}_.:/=+\\-]*)$").

- The tag value is an optional string value of the tag. The string value can be from 1 to 256 Unicode characters in length and cannot be prefixed with "aws:". The string can contain only the set of Unicode letters, digits, white-space, '_', '.', ':', '/', '=', '+', '-', '@' (Java regex: "^([\\p{L}\\p{Z}\\p{N}_.:/=+\\-]*)$").

  Values do not have to be unique in a tag set and can be null. For example, you can have a key-value pair in a tag set of `project=Trinity` and `cost-center=Trinity`.

> **Note**
> You can add a tag to a snapshot, however, your bill will not reflect this grouping.

You can use the AWS Management Console, the command line interface, or the Amazon RDS API to add, list, and delete tags on Amazon RDS resources. When using the command line interface or the Amazon RDS API, you must provide the Amazon Resource Name (ARN) for the Amazon RDS resource you want to work with. For more information about constructing an ARN, see Constructing an ARN for Amazon RDS (p. 271).

Tags are cached for authorization purposes. Because of this, additions and updates to tags on Amazon RDS resources can take several minutes before they are available.

Copying Tags

When you create or restore a DB instance, you can specify that the tags from the DB instance are copied to snapshots of the DB instance. Copying tags ensures that the metadata for the DB snapshots matches that of the source DB instance and any access policies for the DB snapshot also match those of the source DB instance. Tags are not copied by default.

You can specify that tags are copied to DB snapshots for the following actions:

- Creating a DB instance.
- Restoring a DB instance.
- Creating a read replica.
- Copying a DB snapshot.

> **Note**
> If you include a value for the `--tag-key` parameter of the create-db-snapshot AWS CLI command (or supply at least one tag to the CreateDBSnapshot API operation) then RDS doesn't copy tags from the source DB instance to the new DB snapshot. This functionality applies even if the source DB instance has the `--copy-tags-to-snapshot` (`CopyTagsToSnapshot`) option enabled. If you take this approach, you can create a copy of a DB instance from a DB snapshot and avoid adding tags that don't apply to the new DB instance. Once you have created your DB snapshot using the AWS CLI `create-db-snapshot` command (or the `CreateDBSnapshot` Amazon RDS API operation) you can then add tags as described later in this topic.

Console

The process to tag an Amazon RDS resource is similar for all resources. The following procedure shows how to tag an Amazon RDS DB instance.

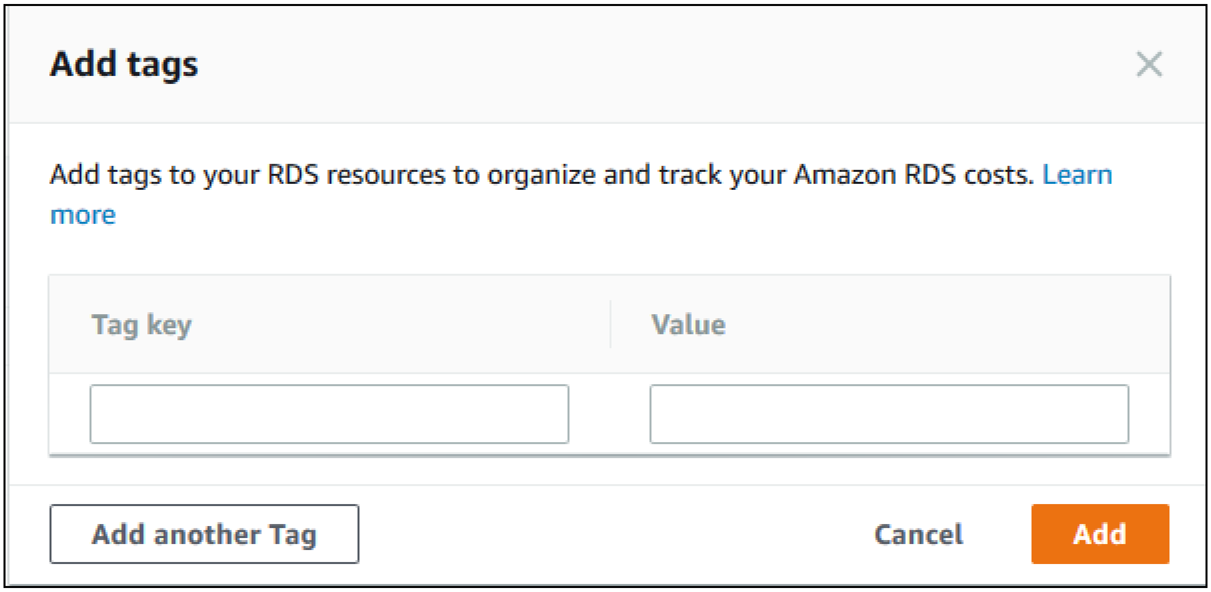
To add a tag to a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Databases**.

   Note
   To filter the list of DB instances in the **Databases** pane, enter a text string for **Filter databases**. Only DB instances that contain the string appear.

3. Choose the name of the DB instance that you want to tag to show its details.
4. In the details section, scroll down to the **Tags** section.
5. Choose **Add**. The **Add tags** window appears.



6. Enter a value for **Tag key** and **Value**.
7. To add another tag, you can choose **Add another Tag** and enter a value for its **Tag key** and **Value**.

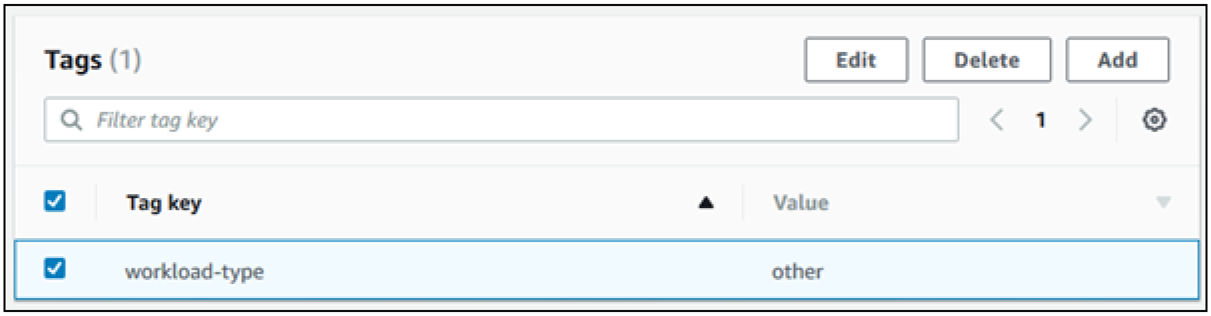
   Repeat this step as many times as necessary.
8. Choose **Add**.

To delete a tag from a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.

   Note
   To filter the list of DB instances in the **Databases** pane, enter a text string in the **Filter databases** box. Only DB instances that contain the string appear.

3. Choose the name of the DB instance to show its details.
4. In the details section, scroll down to the **Tags** section.
5. Choose the tag you want to delete.



6. Choose **Delete**, and then choose **Delete** in the **Delete tags** window.

AWS CLI

You can add, list, or remove tags for a DB instance using the AWS CLI.

- To add one or more tags to an Amazon RDS resource, use the AWS CLI command `add-tags-to-resource`.
- To list the tags on an Amazon RDS resource, use the AWS CLI command `list-tags-for-resource`.
- To remove one or more tags from an Amazon RDS resource, use the AWS CLI command `remove-tags-from-resource`.

To learn more about how to construct the required ARN, see Constructing an ARN for Amazon RDS (p. 271).

RDS API

You can add, list, or remove tags for a DB instance using the Amazon RDS API.

- To add a tag to an Amazon RDS resource, use the `AddTagsToResource` operation.
- To list tags that are assigned to an Amazon RDS resource, use the `ListTagsForResource`.
- To remove tags from an Amazon RDS resource, use the `RemoveTagsFromResource` operation.

To learn more about how to construct the required ARN, see Constructing an ARN for Amazon RDS (p. 271).

When working with XML using the Amazon RDS API, tags use the following schema:

```
<Tagging>
    <TagSet>
        <Tag>
            <Key>Project</Key>
            <Value>Trinity</Value>
        </Tag>
        <Tag>
            <Key>User</Key>
            <Value>Jones</Value>
        </Tag>
    </TagSet>
</Tagging>
```

The following table provides a list of the allowed XML tags and their characteristics. Values for Key and Value are case-dependent. For example, project=Trinity and PROJECT=Trinity are two distinct tags.

Tagging Element	Description
TagSet	A tag set is a container for all tags assigned to an Amazon RDS resource. There can be only one tag set per resource. You work with a TagSet only through the Amazon RDS API.
Tag	A tag is a user-defined key-value pair. There can be from 1 to 50 tags in a tag set.
Key	A key is the required name of the tag. The string value can be from 1 to 128 Unicode characters in length and cannot be prefixed with "rds:" or "aws:". The string can only contain only the set of Unicode letters, digits, white-space, '_', '.', '/', '=', '+', '-' (Java regex: "^([\\p{L}\\p{Z}\\p{N}_.:/=+\\-]*)$"). Keys must be unique to a tag set. For example, you cannot have a key-pair in a tag set with the key the same but with different values, such as project/Trinity and project/Xanadu.
Value	A value is the optional value of the tag. The string value can be from 1 to 256 Unicode characters in length and cannot be prefixed with "rds:" or "aws:". The string can only contain only the set of Unicode letters, digits, white-space, '_', '.', '/', '=', '+', '-' (Java regex: "^([\\p{L}\\p{Z}\\p{N}_.:/=+\\-]*)$"). Values do not have to be unique in a tag set and can be null. For example, you can have a key-value pair in a tag set of project/Trinity and cost-center/Trinity.

Working with Amazon Resource Names (ARNs) in Amazon RDS

Resources created in Amazon Web Services are each uniquely identified with an Amazon Resource Name (ARN). For certain Amazon RDS operations, you must uniquely identify an Amazon RDS resource by specifying its ARN. For example, when you create an RDS DB instance read replica, you must supply the ARN for the source DB instance.

Constructing an ARN for Amazon RDS

Resources created in Amazon Web Services are each uniquely identified with an Amazon Resource Name (ARN). You can construct an ARN for an Amazon RDS resource using the following syntax.

```
arn:aws:rds:<region>:<account number>:<resourcetype>:<name>
```

Region Name	Region	Endpoint	Protocol	
US East (Ohio)	us-east-2	rds.us-east-2.amazonaws.com rds-fips.us-east-2.amazonaws.com	HTTPS HTTPS	
US East (N. Virginia)	us-east-1	rds.us-east-1.amazonaws.com rds-fips.us-east-1.amazonaws.com	HTTPS HTTPS	
US West (N. California)	us-west-1	rds.us-west-1.amazonaws.com rds-fips.us-west-1.amazonaws.com	HTTPS HTTPS	
US West (Oregon)	us-west-2	rds.us-west-2.amazonaws.com rds-fips.us-west-2.amazonaws.com	HTTPS HTTPS	
Africa (Cape Town)	af-south-1	rds.af-south-1.amazonaws.com	HTTPS	
Asia Pacific (Hong Kong)	ap-east-1	rds.ap-east-1.amazonaws.com	HTTPS	
Asia Pacific (Mumbai)	ap-south-1	rds.ap-south-1.amazonaws.com	HTTPS	
Asia Pacific (Osaka-Local)	ap-northeast-3	rds.ap-northeast-3.amazonaws.com	HTTPS	
Asia Pacific (Seoul)	ap-northeast-2	rds.ap-northeast-2.amazonaws.com	HTTPS	

Region Name	Region	Endpoint	Protocol	
Asia Pacific (Singapore)	ap-southeast-1	rds.ap-southeast-1.amazonaws.com	HTTPS	
Asia Pacific (Sydney)	ap-southeast-2	rds.ap-southeast-2.amazonaws.com	HTTPS	
Asia Pacific (Tokyo)	ap-northeast-1	rds.ap-northeast-1.amazonaws.com	HTTPS	
Canada (Central)	ca-central-1	rds.ca-central-1.amazonaws.com rds-fips.ca-central-1.amazonaws.com	HTTPS HTTPS	
China (Beijing)	cn-north-1	rds.cn-north-1.amazonaws.com.cn	HTTPS	
China (Ningxia)	cn-northwest-1	rds.cn-northwest-1.amazonaws.com.cn	HTTPS	
Europe (Frankfurt)	eu-central-1	rds.eu-central-1.amazonaws.com	HTTPS	
Europe (Ireland)	eu-west-1	rds.eu-west-1.amazonaws.com	HTTPS	
Europe (London)	eu-west-2	rds.eu-west-2.amazonaws.com	HTTPS	
Europe (Milan)	eu-south-1	rds.eu-south-1.amazonaws.com	HTTPS	
Europe (Paris)	eu-west-3	rds.eu-west-3.amazonaws.com	HTTPS	
Europe (Stockholm)	eu-north-1	rds.eu-north-1.amazonaws.com	HTTPS	
Middle East (Bahrain)	me-south-1	rds.me-south-1.amazonaws.com	HTTPS	
South America (São Paulo)	sa-east-1	rds.sa-east-1.amazonaws.com	HTTPS	
AWS GovCloud (US-East)	us-gov-east-1	rds.us-gov-east-1.amazonaws.com rds.us-gov-east-1.amazonaws.com	HTTPS HTTPS	
AWS GovCloud (US)	us-gov-west-1	rds.us-gov-west-1.amazonaws.com rds.us-gov-west-1.amazonaws.com	HTTPS HTTPS	

The following table shows the format that you should use when constructing an ARN for a particular Amazon RDS resource type.

Resource Type	ARN Format
DB instance	arn:aws:rds:*<region>*:*<account>*:db:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:db:my-mysql-instance-1`
Event subscription	arn:aws:rds:*<region>*:*<account>*:es:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:es:my-subscription`
DB option group	arn:aws:rds:*<region>*:*<account>*:og:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:og:my-og`
DB parameter group	arn:aws:rds:*<region>*:*<account>*:pg:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:pg:my-param-enable-logs`
Reserved DB instance	arn:aws:rds:*<region>*:*<account>*:ri:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:ri:my-reserved-postgresql`
DB security group	arn:aws:rds:*<region>*:*<account>*:secgrp:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:secgrp:my-public`
Automated DB snapshot	arn:aws:rds:*<region>*:*<account>*:snapshot:rds:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:snapshot:rds:my-mysql-db-2019-07-22-07-23`
Manual DB snapshot	arn:aws:rds:*<region>*:*<account>*:snapshot:*<name>* For example:

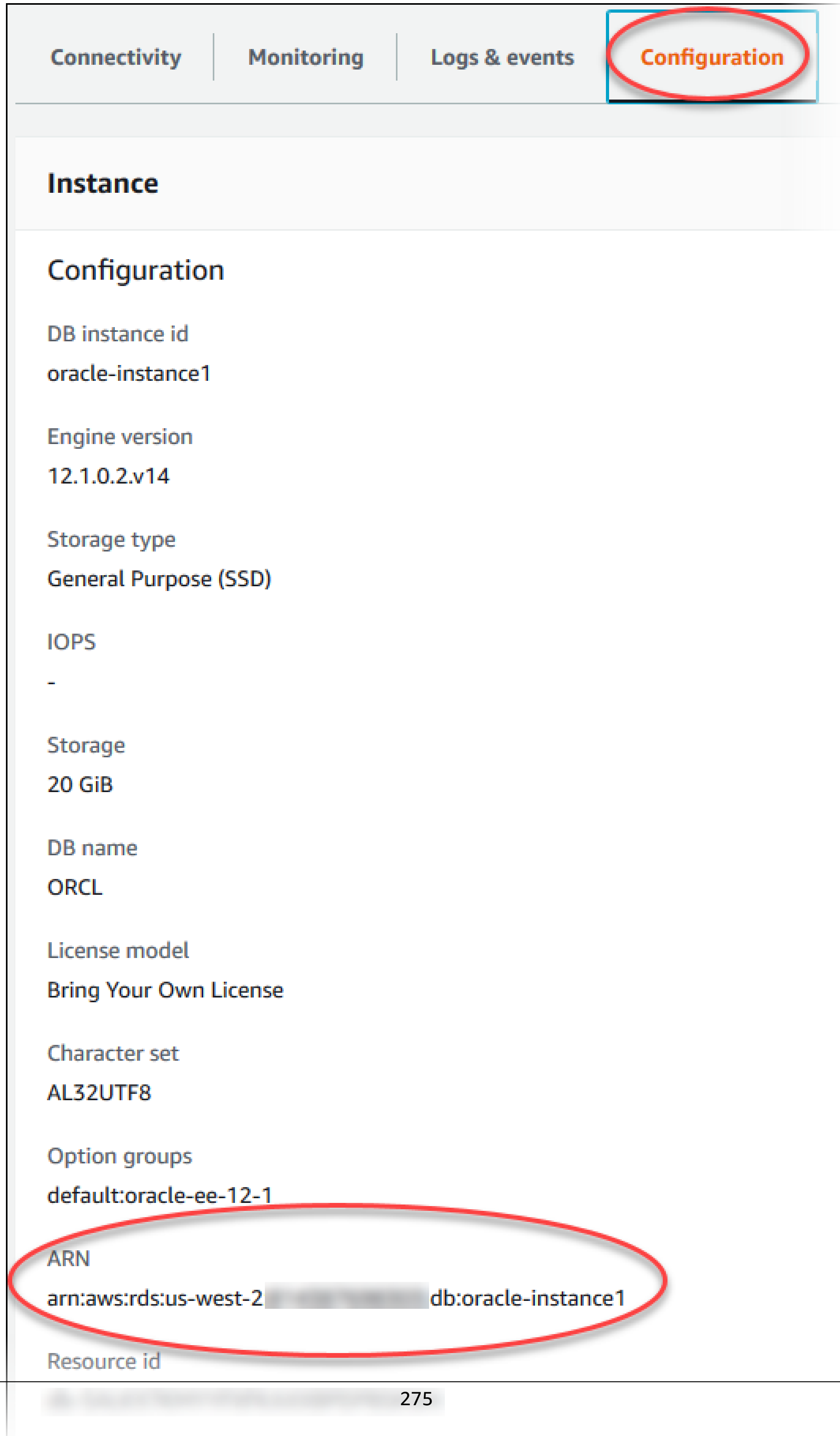
Resource Type	ARN Format
	`arn:aws:rds:us-east-2:123456789012:snapshot:my-mysql-db-snap`
DB subnet group	arn:aws:rds:*<region>*:*<account>*:subgrp:*<name>* For example: `arn:aws:rds:us-east-2:123456789012:subgrp:my-subnet-10`

Getting an Existing ARN

You can get the ARN of an RDS resource by using the AWS Management Console, AWS Command Line Interface (AWS CLI), or RDS API.

Console

To get an ARN from the AWS Management Console, navigate to the resource you want an ARN for, and view the details for that resource. For example, you can get the ARN for a DB instance from the **Configuration** tab of the DB instance details, as shown following.


Connectivity
Monitoring
Logs & events
Configuration
Instance
Configuration
DB instance id
oracle-instance1
Engine version
12.1.0.2.v14
Storage type
General Purpose (SSD)
IOPS
-
Storage
20 GiB
DB name
ORCL
License model
Bring Your Own License
Character set
AL32UTF8
Option groups
default:oracle-ee-12-1
ARN
arn:aws:rds:us-west-2 db:oracle-instance1
Resource id

AWS CLI

To get an ARN from the AWS CLI for a particular RDS resource, you use the `describe` command for that resource. The following table shows each AWS CLI command, and the ARN property used with the command to get an ARN.

AWS CLI Command	ARN Property
describe-event-subscriptions	EventSubscriptionArn
describe-certificates	CertificateArn
describe-db-parameter-groups	DBParameterGroupArn
describe-db-instances	DBInstanceArn
describe-db-security-groups	DBSecurityGroupArn
describe-db-snapshots	DBSnapshotArn
describe-events	SourceArn
describe-reserved-db-instances	ReservedDBInstanceArn
describe-db-subnet-groups	DBSubnetGroupArn
describe-option-groups	OptionGroupArn

For example, the following AWS CLI command gets the ARN for a DB instance.

Example

For Linux, macOS, or Unix:

```
aws rds describe-db-instances \
--db-instance-identifier DBInstanceIdentifier \
--region us-west-2 \
--query "*[].{DBInstanceIdentifier:DBInstanceIdentifier,DBInstanceArn:DBInstanceArn}"
```

For Windows:

```
aws rds describe-db-instances ^
--db-instance-identifier DBInstanceIdentifier ^
--region us-west-2 ^
--query "*[].{DBInstanceIdentifier:DBInstanceIdentifier,DBInstanceArn:DBInstanceArn}"
```

The output of that command is like the following:

```
[
    {
        "DBInstanceArn": "arn:aws:rds:us-west-2:account_id:db:instance_id",
        "DBInstanceIdentifier": "instance_id"
    }
]
```

RDS API

To get an ARN for a particular RDS resource, you can call the following RDS API operations and use the ARN properties shown following.

RDS API Operation	ARN Property
DescribeEventSubscriptions	EventSubscriptionArn
DescribeCertificates	CertificateArn
DescribeDBParameterGroups	DBParameterGroupArn
DescribeDBInstances	DBInstanceArn
DescribeDBSecurityGroups	DBSecurityGroupArn
DescribeDBSnapshots	DBSnapshotArn
DescribeEvents	SourceArn
DescribeReservedDBInstances	ReservedDBInstanceArn
DescribeDBSubnetGroups	DBSubnetGroupArn
DescribeOptionGroups	OptionGroupArn

Working with Storage for Amazon RDS DB Instances

To specify how you want your data stored in Amazon RDS, choose a storage type and provide a storage size when you create or modify a DB instance. Later, you can increase the amount or change the type of storage by modifying the DB instance. For more information about which storage type to use for your workload, see Amazon RDS Storage Types (p. 29).

Topics

Increasing DB Instance Storage Capacity

If you need space for additional data, you can scale up the storage of an existing DB instance. To do so, you can use the Amazon RDS Management Console, the Amazon RDS API, or the AWS Command Line Interface (AWS CLI). For information about storage limits, see Amazon RDS DB Instance Storage (p. 29).

> **Note**
> Scaling storage for Amazon RDS for Microsoft SQL Server DB instances is supported only for General Purpose SSD or Provisioned IOPS SSD storage types.

To monitor the amount of free storage for your DB instance so you can respond when necessary, we recommend that you create an Amazon CloudWatch alarm. For more information on setting CloudWatch alarms, see Using CloudWatch Alarms.

In most cases, scaling storage doesn't require any outage and doesn't degrade performance of the server. After you modify the storage size for a DB instance, the status of the DB instance is **storage-optimization**. The DB instance is fully operational after a storage modification.

> **Note**
> You can't make further storage modifications until six (6) hours after storage optimization has completed on the instance.

However, a special case is if you have a SQL Server DB instance and haven't modified the storage configuration since November 2017. In this case, you might experience a short outage of a few minutes when you modify your DB instance to increase the allocated storage. After the outage, the DB instance is online but in the `storage-optimization` state. Performance might be degraded during storage optimization.

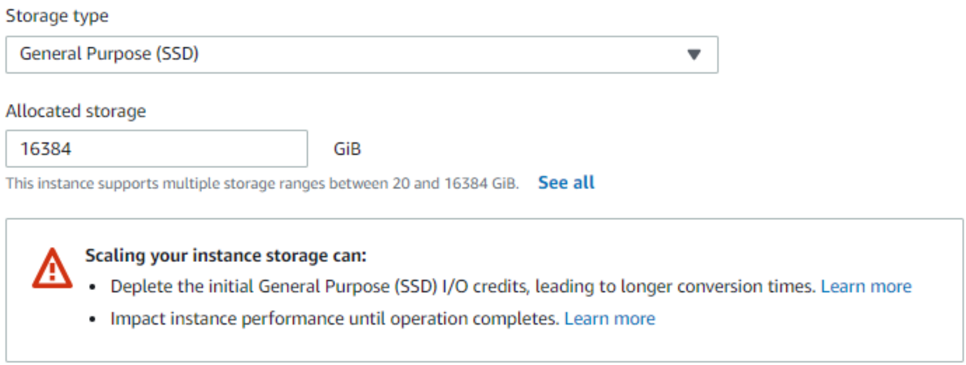
> **Note**
> You can't reduce the amount of storage for a DB instance after storage has been allocated.

Console

To increase storage for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to modify.
4. Choose **Modify**.

5. Enter a new value for **Allocated storage**. It must be greater than the current value.



   Note
   When you increase the allocated storage, it must be by at least 10 percent. If you try to increase the value by less than 10 percent, you get an error.
6. Choose **Continue** to move to the next screen.
7. Choose **Apply immediately** in the **Scheduling of modifications** section to apply the storage changes to the DB instance immediately. Or choose **Apply during the next scheduled maintenance window** to apply the changes during the next maintenance window.
8. When the settings are as you want them, choose **Modify DB instance**.

AWS CLI

To increase the storage for a DB instance, use the AWS CLI command `modify-db-instance`. Set the following parameters:

- `--allocated-storage` – Amount of storage to be allocated for the DB instance, in gibibytes.
- `--apply-immediately` – Use `--apply-immediately` to change to the new storage type immediately. Or use `--no-apply-immediately` (the default) to apply storage changes during the next maintenance window. An immediate outage occurs when the changes are applied.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Amazon RDS API

To increase storage for a DB instance, use the Amazon RDS API operation `ModifyDBInstance`. Set the following parameters:

- `AllocatedStorage` – Amount of storage to be allocated for the DB instance, in gibibytes.
- `ApplyImmediately` – Set this option to `True` to apply scaling changes immediately. Set this option to `False` (the default) to apply scaling changes during the next maintenance window. An immediate outage occurs when the changes are applied.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Managing Capacity Automatically with Amazon RDS Storage Autoscaling

If your workload is unpredictable, you can enable storage autoscaling for an Amazon RDS DB instance. To do so, you can use the Amazon RDS console, the Amazon RDS API, or the AWS CLI.

For example, you might use this feature for a new mobile gaming application that users are adopting rapidly. In this case, a rapidly increasing workload might exceed the available database storage. To avoid having to manually scale up database storage, you can use Amazon RDS storage autoscaling.

With storage autoscaling enabled, when Amazon RDS detects that you are running out of free database space it automatically scales up your storage. Amazon RDS starts a storage modification for an autoscaling-enabled DB instance when these factors apply:

- Free available space is less than 10 percent of the allocated storage.
- The low-storage condition lasts at least five minutes.
- At least six hours have passed since the last storage modification.

The additional storage is in increments of whichever of the following is greater:

- 5 GiB
- 10 percent of currently allocated storage
- Storage growth prediction based on the `FreeStorageSpace` metrics change in the past hour. For more information on metrics, see Monitoring with Amazon CloudWatch.

The maximum storage threshold is the limit to which the DB instance can be autoscaled. You can't set the maximum storage threshold for autoscaling-enabled instances to a value greater than the maximum allocated storage.

For example, SQL Server Standard Edition on db.m5.xlarge has a default allocated storage for the instance of 20 GiB (the minimum) and a maximum allocated storage of 16,384 GiB. The default maximum storage threshold for autoscaling is 1,000 GiB. If you use this default, the instance doesn't autoscale above 1,000 GiB. This is true even though the maximum allocated storage for the instance is 16,384 GiB.

The following limitations apply to storage autoscaling:

- Autoscaling doesn't occur if the maximum storage threshold would be exceeded by the storage increment.
- Autoscaling can't completely prevent storage-full situations for large data loads, because further storage modifications can't be made until six hours after storage optimization has completed on the instance. If you perform a large data load, and autoscaling doesn't provide enough space, the database might remain in the storage-full state for several hours. This can harm the database.
- If you start a storage scaling operation at the same time that Amazon RDS starts an autoscaling operation, your storage modification takes precedence. The autoscaling operation is canceled.
- Autoscaling can't be used with magnetic storage.
- Autoscaling can't be used with the following previous-generation instance classes that have less than 6 TiB of orderable storage: db.m3.large, db.m3.xlarge, and db.m3.2xlarge.

Although automatic scaling helps you to increase storage on your Amazon RDS DB instance dynamically, you should still configure the initial storage for your DB instance to an appropriate size for your typical workload.

Enabling Storage Autoscaling for a New DB Instance

When you create a new Amazon RDS DB instance, you can choose whether to enable storage autoscaling. You can also set an upper limit on the storage that Amazon RDS can allocate for the DB instance.

> **Note**
> When you clone an Amazon RDS DB instance that has storage autoscaling enabled, that setting isn't automatically inherited by the cloned instance. The new DB instance has the same amount

of allocated storage as the original instance. You can turn storage autoscaling on again for the new instance if the cloned instance continues to increase its storage requirements.

Console

To enable storage autoscaling for a new DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region where you want to create the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose **Create database**. On the **Select engine** page, choose your database engine and specify your DB instance information as described in Getting Started with Amazon RDS (p. 64).
5. In the **Storage autoscaling** section, set the **Maximum storage threshold** value for the DB instance.
6. Specify the rest of your DB instance information as described in Getting Started with Amazon RDS (p. 64).

AWS CLI

To enable storage autoscaling for a new DB instance, use the AWS CLI command `create-db-instance`. Set the following parameter:

- `--max-allocated-storage` – Turns on storage autoscaling and sets the upper limit on storage size, in gibibytes.

To verify that Amazon RDS storage autoscaling is available for your DB instance, use the AWS CLI `describe-valid-db-instance-modifications` command. To check based on the instance class before creating an instance, use the `describe-orderable-db-instance-options` command. Check the following field in the return value:

- `SupportsStorageAutoscaling` – Indicates whether the DB instance or instance class supports storage autoscaling.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Amazon RDS API

To enable storage autoscaling for a new DB instance, use the Amazon RDS API operation `CreateDBInstance`. Set the following parameter:

- `MaxAllocatedStorage` – Turns on Amazon RDS storage autoscaling and sets the upper limit on storage size, in gibibytes.

To verify that Amazon RDS storage autoscaling is available for your DB instance, use the Amazon RDS API `DescribeValidDbInstanceModifications` operation for an existing instance, or the `DescribeOrderableDBInstanceOptions` operation before creating an instance. Check the following field in the return value:

- `SupportsStorageAutoscaling` – Indicates whether the DB instance supports storage autoscaling.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Changing the Storage Autoscaling Settings for a DB Instance

You can turn storage autoscaling on for an existing Amazon RDS DB instance. You can also change the upper limit on the storage that Amazon RDS can allocate for the DB instance.

Console

To change the storage autoscaling settings for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to modify, and choose **Modify**. The **Modify DB instance** page appears.
4. Change the storage limit in the **Autoscaling** section. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
5. When all the changes are as you want them, choose **Continue** and check your modifications.
6. On the confirmation page, review your changes. If they're correct, choose **Modify DB Instance** to save your changes. If they aren't correct, choose **Back** to edit your changes or **Cancel** to cancel your changes.

   Changing the storage autoscaling limit occurs immediately. This setting ignores the **Apply immediately** setting.

AWS CLI

To change the storage autoscaling settings for a DB instance, use the AWS CLI command `modify-db-instance`. Set the following parameter:

- `--max-allocated-storage` – Sets the upper limit on storage size, in gibibytes. If the value is greater than the `--allocated-storage` parameter, storage autoscaling is turned on. If the value is the same as the `--allocated-storage` parameter, storage autoscaling is turned off.

To verify that Amazon RDS storage autoscaling is available for your DB instance, use the AWS CLI `describe-valid-db-instance-modifications` command. To check based on the instance class before creating an instance, use the `describe-orderable-db-instance-options` command. Check the following field in the return value:

- `SupportsStorageAutoscaling` – Indicates whether the DB instance supports storage autoscaling.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Amazon RDS API

To change the storage autoscaling settings for a DB instance, use the Amazon RDS API operation `ModifyDBInstance`. Set the following parameter:

- `MaxAllocatedStorage` – Sets the upper limit on storage size, in gibibytes.

To verify that Amazon RDS storage autoscaling is available for your DB instance, use the Amazon RDS API `DescribeValidDbInstanceModifications` operation for an existing instance, or the `DescribeOrderableDBInstanceOptions` operation before creating an instance. Check the following field in the return value:

- `SupportsStorageAutoscaling` – Indicates whether the DB instance supports storage autoscaling.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Turning Off Storage Autoscaling for a DB Instance

If you no longer need Amazon RDS to automatically increase the storage for an Amazon RDS DB instance, you can turn off storage autoscaling. After you do, you can still manually increase the amount of storage for your DB instance.

Console

To turn off storage autoscaling for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to modify and choose **Modify**. The **Modify DB instance** page appears.
4. Clear the **Enable storage autoscaling** check box in the **Storage autoscaling** section. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
5. When all the changes are as you want them, choose **Continue** and check the modifications.
6. On the confirmation page, review your changes. If they're correct, choose **Modify DB Instance** to save your changes. If they aren't correct, choose **Back** to edit your changes or **Cancel** to cancel your changes.

Changing the storage autoscaling limit occurs immediately. This setting ignores the **Apply immediately** setting.

AWS CLI

To turn off storage autoscaling for a DB instance, use the AWS CLI command `modify-db-instance` and the following parameter:

- `--max-allocated-storage` – Specify a value equal to the `--allocated-storage` setting to prevent further Amazon RDS storage autoscaling for the specified DB instance.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Amazon RDS API

To turn off storage autoscaling for a DB instance, use the Amazon RDS API operation `ModifyDBInstance`. Set the following parameter:

- `MaxAllocatedStorage` – Specify a value equal to the `AllocatedStorage` setting to prevent further Amazon RDS storage autoscaling for the specified DB instance.

For more information about storage, see Amazon RDS DB Instance Storage (p. 29).

Modifying SSD Storage Settings for Provisioned IOPS

You can modify the settings for a DB instance that uses Provisioned IOPS SSD storage by using the Amazon RDS console, AWS CLI, or Amazon RDS API. Specify the storage type, allocated storage, and the amount of Provisioned IOPS that you require. You can choose from a range between 1,000 IOPS and 100 GiB of storage up to 80,000 IOPS and 64 TiB (64,000 GiB) of storage. The range depends on your database engine and instance type.

Although you can reduce the amount of IOPS provisioned for your instance, you can't reduce the amount of General Purpose SSD or magnetic storage allocated.

In most cases, scaling storage doesn't require any outage and doesn't degrade performance of the server. After you modify the storage IOPS for a DB instance, the status of the DB instance is **storage-optimization**. The DB instance is fully operational after a storage modification.

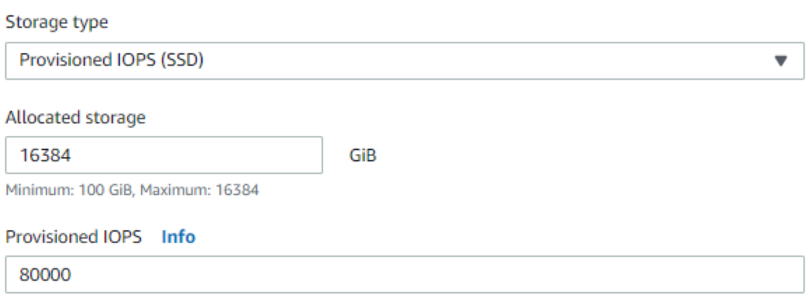
> **Note**
> You can't make further storage modifications until six (6) hours after storage optimization has completed on the instance.

Console

To change the Provisioned IOPS settings for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.

   > **Note**
   > To filter the list of DB instances, for **Filter databases** enter a text string for Amazon RDS to use to filter the results. Only DB instances whose names contain the string appear.
3. Choose the DB instance with Provisioned IOPS that you want to modify.
4. Choose **Modify**.
5. On the **Modify DB Instance page**, choose Provisioned IOPS for **Storage type** and then provide a Provisioned IOPS value.

   If the value you specify for either **Allocated storage** or **Provisioned IOPS** is outside the limits supported by the other parameter, a warning message is displayed. This message gives the range of values required for the other parameter.
6. Choose **Continue**.
7. To apply the changes to the DB instance immediately, choose **Apply immediately** in the **Scheduling of modifications** section. Or choose **Apply during the next scheduled maintenance window** to apply the changes during the next maintenance window.

   An immediate outage occurs when the storage type changes. For more information about storage, see Amazon RDS DB Instance Storage (p. 29).
8. Review the parameters to be changed, and choose **Modify DB instance** to complete the modification.

   The new value for allocated storage or for Provisioned IOPS appears in the **Status** column.

AWS CLI

To change the Provisioned IOPS setting for a DB instance, use the AWS CLI command `modify-db-instance`. Set the following parameters:

- `--storage-type` – Set to `io1` for Provisioned IOPS.
- `--allocated-storage` – Amount of storage to be allocated for the DB instance, in gibibytes.
- `--iops` – The new amount of Provisioned IOPS for the DB instance, expressed in I/O operations per second.
- `--apply-immediately` – Use `--apply-immediately` to apply changes immediately. Use `--no-apply-immediately` (the default) to apply changes during the next maintenance window.

Amazon RDS API

To change the Provisioned IOPS settings for a DB instance, use the Amazon RDS API operation `ModifyDBInstance`. Set the following parameters:

- `StorageType` – Set to `io1` for Provisioned IOPS.
- `AllocatedStorage` – Amount of storage to be allocated for the DB instance, in gibibytes.
- `Iops` – The new IOPS rate for the DB instance, expressed in I/O operations per second.
- `ApplyImmediately` – Set this option to `True` to apply changes immediately. Set this option to `False` (the default) to apply changes during the next maintenance window.

Deleting a DB Instance

To delete a DB instance, you must do the following:

- Provide the name of the instance
- Enable or disable the option to take a final DB snapshot of the instance
- Enable or disable the option to retain automated backups

If the DB instance that you want to delete has a read replica, you should either promote the read replica or delete it. For more information, see Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

Deletion Protection

You can only delete instances that don't have deletion protection enabled. When you create or modify a DB instance, you have the option to enable deletion protection so that users can't delete the DB instance. Deletion protection is disabled by default for you when you use AWS CLI and API commands. Deletion protection is enabled for you when you use the AWS Management Console to create a production DB instance. However, Amazon RDS enforces deletion protection when you use the console, the CLI, or the API to delete a DB instance. To delete a DB instance that has deletion protection enabled, first modify the instance and disable deletion protection. Enabling or disabling deletion protection doesn't cause an outage.

Creating a Final Snapshot and Retaining Automated Backups

When you delete a DB instance, you can choose whether to create a final snapshot of the DB instance. You can also choose to retain automated backups after the DB instance is deleted, up to the retention period set on your DB instance. To be able to restore the DB instance later, create a final snapshot, retain automated backups, or both.

When you delete a DB instance, you have the following choices:

- Create a final DB snapshot.

  To be able to restore your deleted DB instance later, create a final DB snapshot.

  To delete a DB instance quickly, you can skip creating a final DB snapshot.

  Important
  If you skip the final DB snapshot, to restore your DB instance you will need to do one of the following:
  - Use an earlier manual snapshot of the DB instance to restore the DB instance to that DB snapshot's point in time.
  - Retain automated backups. You can use those to restore your DB instance during your retention period, but not after your retention period has ended.

  You can't create a final DB snapshot of your DB instance if it has the status `creating`, `failed`, `incompatible-restore`, or `incompatible-network`. For more information about DB instance statuses, see DB Instance Status (p. 359).
- Retain automated backups.

  You can choose to retain automated backups when you delete a DB instance. Your automated backups are retained for the retention period that is set on the DB instance at the time that you delete it. This set retention period occurs whether or not you choose to create a final DB snapshot.

To delete a retained automated backup, follow the instructions in Deleting Retained Automated Backups (p. 297).

If you don't choose to retain automated backups, your automated backups are deleted and can't be recovered when you delete a DB instance. You typically don't need to retain automated backups if you create a final DB snapshot.

Note
Regardless of your choice, earlier manual DB snapshots aren't deleted.

Deleting a DB Instance by Using the Console, CLI, and API

You can delete a DB instance using the AWS Management Console, the AWS CLI, or the RDS API.

Note
You can't delete a DB instance when deletion protection is enabled for it. For more information, see Deletion Protection (p. 286).
You can disable deletion protection by modifying the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Console

To delete a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to delete.
3. For **Actions**, choose **Delete**.
4. To create a final DB snapshot for the DB instance, enable **Create final snapshot?**.
5. If you enabled **Create final snapshot?** in the previous step, for **Final snapshot name** enter the name of your final DB snapshot.
6. To retain automated backups, choose **Retain automated backups**.
7. Enter **`delete me`** in the box.
8. Choose **Delete**.

AWS CLI

To delete a DB instance by using the AWS CLI, call the delete-db-instance command with the following options:

- `--db-instance-identifier`
- `--final-db-snapshot-identifier` or `--skip-final-snapshot`

Example With a final snapshot and no retained automated backups

For Linux, macOS, or Unix:

```
aws rds delete-db-instance \
    --db-instance-identifier mydbinstance  \
    --final-db-snapshot-identifier mydbinstancefinalsnapshot \
```

```
    --delete-automated-backups
```

For Windows:

```
aws rds delete-db-instance ^
    --db-instance-identifier mydbinstance  ^
    --final-db-snapshot-identifier mydbinstancefinalsnapshot ^
    --delete-automated-backups
```

Example With retained automated backups and no final snapshot

For Linux, macOS, or Unix:

```
aws rds delete-db-instance \
    --db-instance-identifier mydbinstance \
    --skip-final-snapshot \
    --no-delete-automated-backups
```

For Windows:

```
aws rds delete-db-instance ^
    --db-instance-identifier mydbinstance ^
    --skip-final-snapshot ^
    --no-delete-automated-backups
```

RDS API

To delete a DB instance by using the Amazon RDS API, call the `DeleteDBInstance` operation with the following parameters:

- `DBInstanceIdentifier`
- `FinalDBSnapshotIdentifier` or `SkipFinalSnapshot`

Example With a final snapshot and no retained automated backups

```
https://rds.amazonaws.com/
    ?Action=DeleteDBInstance
    &DBInstanceIdentifier=mydbinstance
    &FinalDBSnapshotIdentifier=mydbinstancefinalsnapshot
    &DeleteAutomatedBackups=true
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20140305/us-west-1/rds/aws4_request
    &X-Amz-Date=20140305T185838Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=b441901545441d3c7a48f63b5b1522c5b2b37c137500c93c45e209d4b3a064a3
```

Example With retained automated backups and no final snapshot

```
https://rds.amazonaws.com/
    ?Action=DeleteDBInstance
    &DBInstanceIdentifier=mydbinstance
    &SkipFinalSnapshot=true
    &DeleteAutomatedBackups=false
    &SignatureMethod=HmacSHA256
```

```
&SignatureVersion=4
&Version=2014-10-31
&X-Amz-Algorithm=AWS4-HMAC-SHA256
&X-Amz-Credential=AKIADQKE4SARGYLE/20140305/us-west-1/rds/aws4_request
&X-Amz-Date=20140305T185838Z
&X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
&X-Amz-Signature=b441901545441d3c7a48f63b5b1522c5b2b37c137500c93c45e209d4b3a064a3
```

Backing Up and Restoring an Amazon RDS DB Instance

This section shows how to back up and restore a DB instance.

Topics

Working With Backups

Amazon RDS creates and saves automated backups of your DB instance during the backup window of your DB instance. RDS creates a storage volume snapshot of your DB instance, backing up the entire DB instance and not just individual databases. RDS saves the automated backups of your DB instance according to the backup retention period that you specify. If necessary, you can recover your database to any point in time during the backup retention period.

Automated backups follow these rules:

- Your DB instance must be in the `AVAILABLE` state for automated backups to occur. Automated backups don't occur while your DB instance is in a state other than `AVAILABLE`, for example `STORAGE_FULL`.
- Automated backups and automated snapshots don't occur while a copy is executing in the same region for the same DB instance.

You can also back up your DB instance manually, by manually creating a DB snapshot. For more information about creating a DB snapshot, see Creating a DB Snapshot (p. 301).

The first snapshot of a DB instance contains the data for the full DB instance. Subsequent snapshots of the same DB instance are incremental, which means that only the data that has changed after your most recent snapshot is saved.

You can copy both automatic and manual DB snapshots, and share manual DB snapshots. For more information about copying a DB snapshot, see Copying a Snapshot (p. 306). For more information about sharing a DB snapshot, see Sharing a DB Snapshot (p. 315).

> **Note**
> You can also use AWS Backup to manage backups of Amazon RDS DB instances. Backups managed by AWS Backup are considered manual snapshots for the manual snapshot limit. For information about AWS Backup, see the *AWS Backup Developer Guide*.

Backup Storage

Your Amazon RDS backup storage for each region is composed of the automated backups and manual DB snapshots for that region. Total backup storage space equals the sum of the storage for all backups in that region. Moving a DB snapshot to another region increases the backup storage in the destination region.

For more information about backup storage costs, see Amazon RDS Pricing.

If you chose to retain automated backups when you delete a DB instance, the automated backups are saved for the full retention period. If you don't choose **Retain automated backups** when you delete a DB instance, all automated backups are deleted with the DB instance. After they are deleted, the automated backups can't be recovered. If you choose to have Amazon RDS create a final DB snapshot before it deletes your DB instance, you can use that to recover your DB instance. Or you can use a previously created manual snapshot. Manual snapshots are not deleted. You can have up to 100 manual snapshots per region.

Backup Window

Automated backups occur daily during the preferred backup window. If the backup requires more time than allotted to the backup window, the backup continues after the window ends, until it finishes. The backup window can't overlap with the weekly maintenance window for the DB instance.

During the automatic backup window, storage I/O might be suspended briefly while the backup process initializes (typically under a few seconds). You might experience elevated latencies for a few minutes during backups for Multi-AZ deployments. For MariaDB, MySQL, Oracle, and PostgreSQL, I/O activity is not suspended on your primary during backup for Multi-AZ deployments, because the backup is taken from the standby. For SQL Server, I/O activity is suspended briefly during backup for Multi-AZ deployments.

If you don't specify a preferred backup window when you create the DB instance, Amazon RDS assigns a default 30-minute backup window. This window is selected at random from an 8-hour block of time for each AWS Region. The following table lists the time blocks for each region from which the default backups windows are assigned.

Region	Time Block
US East (Ohio) Region	03:00–11:00 UTC
US East (N. Virginia) Region	03:00–11:00 UTC
US West (N. California) Region	06:00–14:00 UTC
US West (Oregon) Region	06:00–14:00 UTC
Asia Pacific (Hong Kong) Region	06:00–14:00 UTC
Asia Pacific (Mumbai) Region	16:30–00:30 UTC
Asia Pacific (Osaka-Local) Region	00:00–08:00 UTC
Asia Pacific (Seoul) Region	13:00–21:00 UTC
Asia Pacific (Singapore) Region	14:00–22:00 UTC
Asia Pacific (Sydney) Region	12:00–20:00 UTC
Asia Pacific (Tokyo) Region	13:00–21:00 UTC
Canada (Central) Region	06:29–14:29 UTC
China (Beijing) Region	06:00–14:00 UTC
China (Ningxia) Region	06:00–14:00 UTC
Europe (Frankfurt) Region	20:00–04:00 UTC
Europe (Ireland) Region	22:00–06:00 UTC
Europe (London) Region	06:00–14:00 UTC
Europe (Paris) Region	07:29–14:29 UTC
Europe (Stockholm) Region	23:00–07:00 UTC
Middle East (Bahrain) Region	06:00–14:00 UTC
South America (São Paulo) Region	23:00–07:00 UTC

Region	Time Block
AWS GovCloud (US-West)	03:00–11:00 UTC

Backup Retention Period

You can set the backup retention period when you create a DB instance. If you don't set the backup retention period, the default backup retention period is one day if you create the DB instance using the Amazon RDS API or the AWS CLI. The default backup retention period is seven days if you create the DB instance using the console. After you create a DB instance, you can modify the backup retention period. You can set the backup retention period to between 0 and 35 days. Setting the backup retention period to 0 disables automated backups. Manual snapshot limits (100 per region) do not apply to automated backups.

> **Important**
> An outage occurs if you change the backup retention period from 0 to a non-zero value or from a non-zero value to 0.

Disabling Automated Backups

You might want to temporarily disable automated backups in certain situations; for example, while loading large amounts of data.

> **Important**
> We highly discourage disabling automated backups because it disables point-in-time recovery. Disabling automatic backups for a DB instance deletes all existing automated backups for the instance. If you disable and then re-enable automated backups, you are only able to restore starting from the time you re-enabled automated backups.

In this example, you disable automated backups for a DB instance named *mydbinstance* by setting the backup retention parameter to 0.

Console

To disable automated backups immediately

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**. The **Modify DB Instance** page appears.
4. For **Backup Retention Period**, choose **0 days**.
5. Choose **Continue**.
6. Choose **Apply Immediately**.
7. On the confirmation page, choose **Modify DB Instance** to save your changes and disable automated backups.

AWS CLI

To disable automated backups immediately, use the modify-db-instance command and set the backup retention period to 0 with `--apply-immediately`.

Example

The following example immediately disabled automatic backups.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --backup-retention-period 0 \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --backup-retention-period 0 ^
    --apply-immediately
```

To know when the modification is in effect, call `describe-db-instances` for the DB instance until the value for backup retention period is 0 and mydbinstance status is available.

```
aws rds describe-db-instances --db-instance-identifier mydbinstance
```

RDS API

To disable automated backups immediately, call the ModifyDBInstance operation with the following parameters:

- `DBInstanceIdentifier = mydbinstance`
- `BackupRetentionPeriod = 0`

Example

```
https://rds.amazonaws.com/
    ?Action=ModifyDBInstance
    &DBInstanceIdentifier=mydbinstance
    &BackupRetentionPeriod=0
    &SignatureVersion=2
    &SignatureMethod=HmacSHA256
    &Timestamp=2009-10-14T17%3A48%3A21.746Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Enabling Automated Backups

If your DB instance doesn't have automated backups enabled, you can enable them at any time. You enable automated backups by setting the backup retention period to a positive non-zero value. When automated backups are enabled, your RDS instance and database is taken offline and a backup is immediately created.

In this example, you enable automated backups for a DB instance named *mydbinstance* by setting the backup retention period to a positive non-zero value (in this case, 3).

Console

To enable automated backups immediately

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**. The **Modify DB Instance** page appears.
4. For **Backup Retention Period**, choose a positive nonzero value, for example 3 days.
5. Choose **Continue**.
6. Choose **Apply Immediately**.
7. On the confirmation page, choose **Modify DB Instance** to save your changes and enable automated backups.

AWS CLI

To enable automated backups immediately, use the AWS CLI `modify-db-instance` command.

In this example, we enable automated backups by setting the backup retention period to three days.

Include the following parameters:

- `--db-instance-identifier`
- `--backup-retention-period`
- `--apply-immediately` or `--no-apply-immediately`

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance  \
    --backup-retention-period 3 \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance  ^
    --backup-retention-period 3 ^
    --apply-immediately
```

RDS API

To enable automated backups immediately, use the RDS API `ModifyDBInstance` operation.

In this example, we enable automated backups by setting the backup retention period to three days.

Include the following parameters:

- `DBInstanceIdentifier`
- `BackupRetentionPeriod`
- `ApplyImmediately = true`

Example

```
https://rds.amazonaws.com/
 ?Action=ModifyDBInstance
 &DBInstanceIdentifier=mydbinstance
```

```
&BackupRetentionPeriod=3
&ApplyImmediately=true
&SignatureVersion=2
&SignatureMethod=HmacSHA256
&Timestamp=2009-10-14T17%3A48%3A21.746Z
&AWSAccessKeyId=<AWS Access Key ID>
&Signature=<Signature>
```

Retaining Automated Backups

When you delete a DB instance, you can retain automated backups.

Retained automated backups contain system snapshots and transaction logs from a DB instance. They also include your DB instance properties like allocated storage and DB instance class, which are required to restore it to an active instance.

You can retain automated backups for RDS instances running MySQL, MariaDB, PostgreSQL, Oracle, and Microsoft SQL Server engines.

You can restore or remove retained automated backups using the AWS Management Console, RDS API, and AWS CLI.

Topics

Retention Period

The system snapshots and transaction logs in a retained automated backup expire the same way that they expire for the source DB instance. Because there are no new snapshots or logs created for this instance, the retained automated backups eventually expire completely. Effectively, they live as long their last system snapshot would have done, based on the settings for retention period the source instance had when you deleted it. Retained automated backups are removed by the system after their last system snapshot expires.

You can remove a retained automated backup in the same way that you can delete a DB instance. You can remove retained automated backups using the console or the RDS API operation `DeleteDBInstanceAutomatedBackup`.

Final snapshots are independent of retained automated backups. We strongly suggest that you take a final snapshot even if you retain automated backups, because the retained automated backups eventually expire. The final snapshot doesn't expire.

Restoration

To view your retained automated backups, switch to the automated backups page. You can view individual snapshots associated with a retained automated backup on the database snapshots page in the console. Alternatively, you can describe individual snapshots associated with a retained automated backup. From there, you can restore a DB instance directly from one of those snapshots.

Restored DB instances are automatically associated with the default parameter and option groups. However, you can apply a custom parameter group and option group by specifying them during a restore.

In this example, you restore a DB instance to a point in time using the retained automated backup. First, you describe your retained automated backups, so you can see which of them to restore.

To describe your retained automated backups using the RDS API, call the `DescribeDBInstanceAutomatedBackups` action with one of the following parameters:

- `DBInstanceIdentifier`
- `DbiResourceId`

```
aws rds describe-db-instance-automated-backups --db-instance-
identifier DBInstanceIdentifier
OR
aws rds describe-db-instance-automated-backups --dbi-resource-idDbiResourceId
```

Next, to restore your retained automated backup to a point in time, using the RDS API, call the `RestoreDBInstanceToPointInTime` action with the following parameters:

- `SourceDbiResourceId`
- `TargetDBInstanceIdentifier`

```
aws rds restore-db-instance-to-point-in-time --source-dbi-resource-id SourceDbiResourceId
 --target-db-instance-identifier TargetDBInstanceIdentifier --use-latest-restorable-time
```

Retention Costs

The cost of a retained automated backup is the cost of total storage of the system snapshots that are associated with it. There is no additional charge for transaction logs or instance metadata. All other pricing rules for backups apply to restorable instances.

For example, suppose that your total allocated storage of running instances is 100 GB. Suppose also that you have 50 GB of manual snapshots plus 75 GB of system snapshots associated with a retained automated backup. In this case, you are charged only for the additional 25 GB of backup storage, like this: (50 GB + 75 GB) – 100 GB = 25 GB.

Limitations and Recommendations

The following limitations apply to retained automated backups:

- The maximum number of retained automated backups in one AWS Region is 40. It's not included in the DB instances limit. You can have 40 running DB instances and an additional 40 retained automated backups at the same time.
- Retained automated backups don't contain information about parameters or option groups.
- You can restore a deleted instance to a point in time that is within the retention period at the time of delete.
- A retained automated backup can't be modified because it consists of system backups, transaction logs, and the DB instance properties that existed at the time you deleted the source instance.

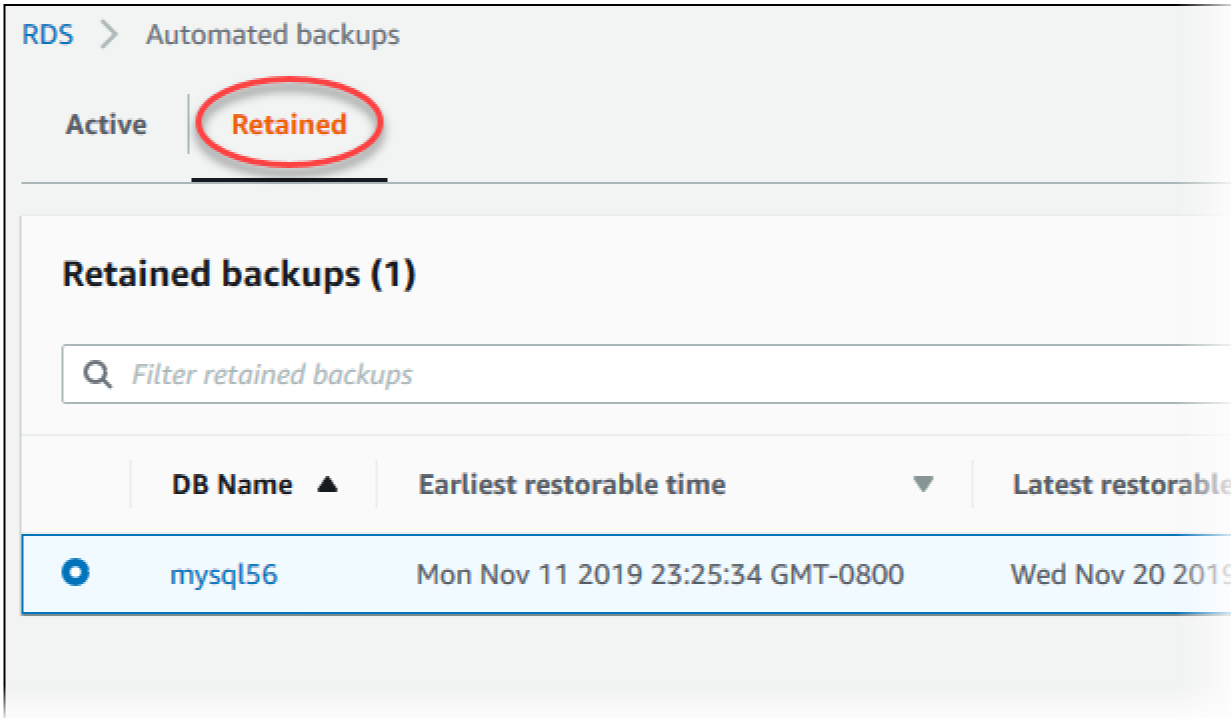
Deleting Retained Automated Backups

You can delete retained automated backups when they are no longer needed.

Console

To delete a retained automated backup

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Automated backups**.
3. Choose **Retained**.



4. Choose the retained automated backup that you want to delete.
5. For **Actions**, choose **Delete**.
6. On the confirmation page, enter **`delete me`** and choose **Delete**.

AWS CLI

You can delete a retained automated backup by using the AWS CLI command delete-db-instance-automated-backup.

The following options are used to delete a retained automated backup:

- `--dbi-resource-id` – The resource identifier for the source DB instance.

  You can find the resource identifier for the source DB instance of a retained automated backup by running the AWS CLI command describe-db-instance-automated-backups.

Example

The following example deletes the retained automated backup with source DB instance resource identifier `db-123ABCEXAMPLE`.

For Linux, macOS, or Unix:

```
aws rds delete-db-instance-automated-backup \
    --dbi-resource-id db-123ABCEXAMPLE
```

For Windows:

```
aws rds delete-db-instance-automated-backup ^
    --dbi-resource-id db-123ABCEXAMPLE
```

RDS API

You can delete a retained automated backup by using the Amazon RDS API operation DeleteDBInstanceAutomatedBackup.

The following parameters are used to delete a retained automated backup:

- `DbiResourceId` – The resource identifier for the source DB instance.

  You can find the resource identifier for the source DB instance of a retained automated backup using the Amazon RDS API operation DescribeDBInstanceAutomatedBackups.

Automated Backups with Unsupported MySQL Storage Engines

For the MySQL DB engine, automated backups are only supported for the InnoDB storage engine. Use of these features with other MySQL storage engines, including MyISAM, can lead to unreliable behavior while restoring from backups. Specifically, since storage engines like MyISAM don't support reliable crash recovery, your tables can be corrupted in the event of a crash. For this reason, we encourage you to use the InnoDB storage engine.

- To convert existing MyISAM tables to InnoDB tables, you can use the `ALTER TABLE` command, for example: `ALTER TABLE table_name ENGINE=innodb, ALGORITHM=COPY;`
- If you choose to use MyISAM, you can attempt to manually repair tables that become damaged after a crash by using the `REPAIR` command. For more information, see REPAIR TABLE Syntax in the MySQL documentation. However, as noted in the MySQL documentation, there is a good chance that you might not be able to recover all your data.
- If you want to take a snapshot of your MyISAM tables before restoring, follow these steps:
  1. Stop all activity to your MyISAM tables (that is, close all sessions).

     You can close all sessions by calling the mysql.rds_kill command for each process that is returned from the `SHOW FULL PROCESSLIST` command.
  2. Lock and flush each of your MyISAM tables. For example, the following commands lock and flush two tables named `myisam_table1` and `myisam_table2`:

     ```
     mysql> FLUSH TABLES myisam_table, myisam_table2 WITH READ LOCK;
     ```
  3. Create a snapshot of your DB instance. When the snapshot has completed, release the locks and resume activity on the MyISAM tables. You can release the locks on your tables using the following command:

     ```
     mysql> UNLOCK TABLES;
     ```

These steps force MyISAM to flush data stored in memory to disk, which ensures a clean start when you restore from a DB snapshot. For more information on creating a DB snapshot, see Creating a DB Snapshot (p. 301).

Automated Backups with Unsupported MariaDB Storage Engines

For the MariaDB DB engine, automated backups are only supported with the InnoDB storage engine (version 10.2 and later) and XtraDB storage engine (versions 10.0 and 10.1). Use of these features with other MariaDB storage engines, including Aria, might lead to unreliable behavior while restoring from backups. Even though Aria is a crash-resistant alternative to MyISAM, your tables can still be corrupted in the event of a crash. For this reason, we encourage you to use the XtraDB storage engine.

- To convert existing Aria tables to InnoDB tables, you can use the `ALTER TABLE` command. For example: `ALTER TABLE table_name ENGINE=innodb, ALGORITHM=COPY;`
- To convert existing Aria tables to XtraDB tables, you can use the `ALTER TABLE` command. For example: `ALTER TABLE table_name ENGINE=xtradb, ALGORITHM=COPY;`
- If you choose to use Aria, you can attempt to manually repair tables that become damaged after a crash by using the `REPAIR TABLE` command. For more information, see http://mariadb.com/kb/en/mariadb/repair-table/.
- If you want to take a snapshot of your Aria tables before restoring, follow these steps:
  1. Stop all activity to your Aria tables (that is, close all sessions).
  2. Lock and flush each of your Aria tables.
  3. Create a snapshot of your DB instance. When the snapshot has completed, release the locks and resume activity on the Aria tables. These steps force Aria to flush data stored in memory to disk, thereby ensuring a clean start when you restore from a DB snapshot.

Creating a DB Snapshot

Amazon RDS creates a storage volume snapshot of your DB instance, backing up the entire DB instance and not just individual databases. Creating this DB snapshot on a Single-AZ DB instance results in a brief I/O suspension that can last from a few seconds to a few minutes, depending on the size and class of your DB instance. For MariaDB, MySQL, Oracle, and PostgreSQL, I/O activity is not suspended on your primary during backup for Multi-AZ deployments, because the backup is taken from the standby. For SQL Server, I/O activity is suspended briefly during backup for Multi-AZ deployments.

When you create a DB snapshot, you need to identify which DB instance you are going to back up, and then give your DB snapshot a name so you can restore from it later. The amount of time it takes to create a snapshot varies with the size your databases. Since the snapshot includes the entire storage volume, the size of files, such as temporary files, also affects the amount of time it takes to create the snapshot.

Unlike automated backups, manual snapshots aren't subject to the backup retention period. Snapshots don't expire.

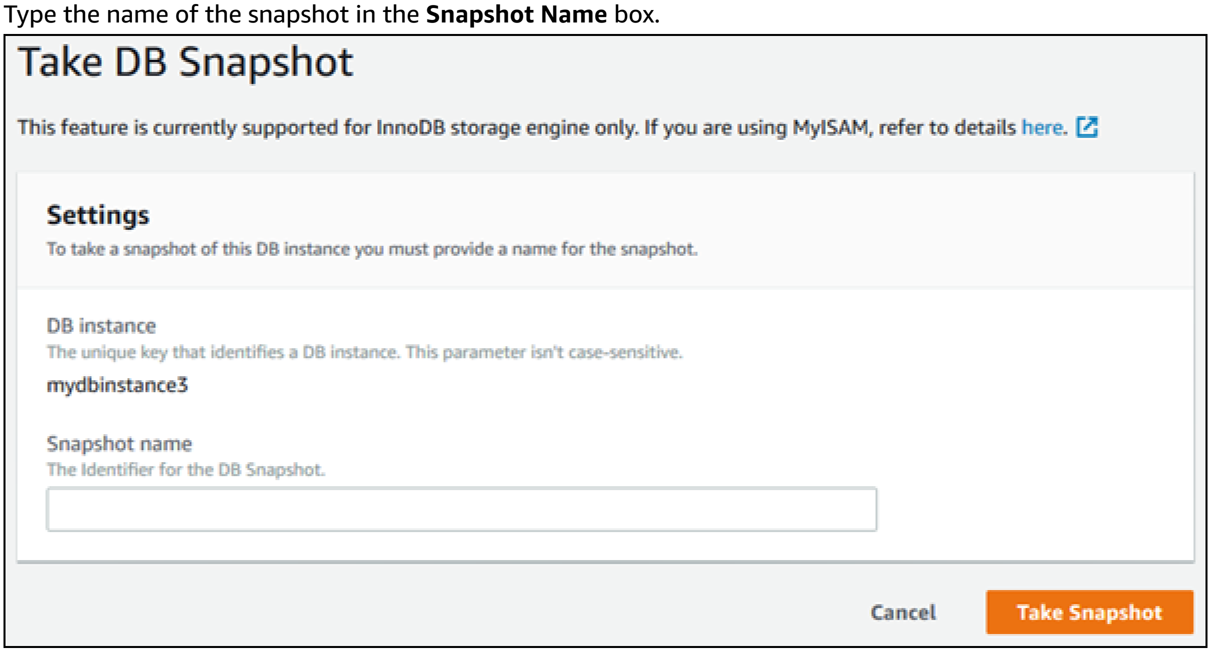
You can create a DB snapshot using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To create a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. In the list of DB instances, choose the DB instance for which you want to take a snapshot.
4. For **Actions**, choose **Take snapshot**.

   The **Take DB Snapshot** window appears.
5. Type the name of the snapshot in the **Snapshot Name** box.



6. Choose **Take Snapshot**.

AWS CLI

When you create a DB snapshot using the AWS CLI, you need to identify which DB instance you are going to back up, and then give your DB snapshot a name so you can restore from it later. You can do this by using the AWS CLI `create-db-snapshot` command with the following parameters:

- `--db-instance-identifier`
- `--db-snapshot-identifier`

In this example, you create a DB snapshot called *mydbsnapshot* for a DB instance called *mydbinstance*.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-snapshot \
    --db-instance-identifier mydbinstance \
    --db-snapshot-identifier mydbsnapshot
```

For Windows:

```
aws rds create-db-snapshot ^
    --db-instance-identifier mydbinstance ^
    --db-snapshot-identifier mydbsnapshot
```

RDS API

When you create a DB snapshot using the Amazon RDS API, you need to identify which DB instance you are going to back up, and then give your DB snapshot a name so you can restore from it later. You can do this by using the Amazon RDS API `CreateDBSnapshot` command with the following parameters:

- `DBInstanceIdentifier`
- `DBSnapshotIdentifier`

Restoring from a DB Snapshot

Amazon RDS creates a storage volume snapshot of your DB instance, backing up the entire DB instance and not just individual databases. You can create a DB instance by restoring from this DB snapshot. When you restore the DB instance, you provide the name of the DB snapshot to restore from, and then provide a name for the new DB instance that is created from the restore. You can't restore from a DB snapshot to an existing DB instance; a new DB instance is created when you restore.

You can restore a DB instance and use a different storage type than the source DB snapshot. In this case, the restoration process is slower because of the additional work required to migrate the data to the new storage type. If you restore to or from magnetic storage, the migration process is the slowest. That's because magnetic storage doesn't have the IOPS capability of Provisioned IOPS or General Purpose (SSD) storage.

> **Note**
> You can't restore a DB instance from a DB snapshot that is both shared and encrypted. Instead, you can make a copy of the DB snapshot and restore the DB instance from the copy.

Parameter Group Considerations

We recommend that you retain the parameter group for any DB snapshots you create, so that you can associate your restored DB instance with the correct parameter group. You can specify the parameter group when you restore the DB instance.

Security Group Considerations

When you restore a DB instance, the default security group is associated with the restored instance by default.

> **Note**
>
> - If you're using the Amazon RDS console, you can specify a custom security group to associate with the instance or create a new VPC security group.
> - If you're using the AWS CLI, you can specify a custom security group to associate with the instance by including the `--vpc-security-group-ids` option in the `restore-db-instance-from-db-snapshot` command.
> - If you're using the Amazon RDS API, you can include the `VpcSecurityGroupIds.VpcSecurityGroupId.N` parameter in the `RestoreDBInstanceFromDBSnapshot` action.

As soon as the restore is complete and your new DB instance is available, you can associate any custom security groups used by the snapshot you restored from. You must apply these changes by modifying the DB instance with the RDS console, the AWS CLI `modify-db-instance` command, or the `ModifyDBInstance` Amazon RDS API operation. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Option Group Considerations

When you restore a DB instance, the option group associated with the DB snapshot is associated with the restored DB instance after it is created. For example, if the DB snapshot you are restoring from uses Oracle Transparent Data Encryption, the restored DB instance will use the same option group.

When you assign an option group to a DB instance, the option group is also linked to the supported platform the DB instance is on, either VPC or EC2-Classic (non-VPC). If a DB instance is in a VPC, the option group associated with the DB instance is linked to that VPC. This means that you can't use the option group assigned to a DB instance if you attempt to restore the instance into a different VPC or onto a different platform. If you restore a DB instance into a different VPC or onto a different platform, you must either assign the default option group to the instance, assign an option group that is linked to that VPC or platform, or create a new option group and assign it to the DB instance. For persistent or permanent options, when restoring a DB instance into a different VPC you must create a new option group that includes the persistent or permanent option.

Microsoft SQL Server Considerations

When you restore a Microsoft SQL Server DB snapshot to a new instance, you can always restore to the same edition as your snapshot. In some cases, you can also change the edition of the DB instance. The following are the limitations when you change editions:

- The DB snapshot must have enough storage allocated for the new edition.
- Only the following edition changes are supported:
  - From Standard Edition to Enterprise Edition
  - From Web Edition to Standard Edition or Enterprise Edition
  - From Express Edition to Web Edition, Standard Edition or Enterprise Edition

If you want to change from one edition to a new edition that is not supported by restoring a snapshot, you can try using the native backup and restore feature. SQL Server verifies whether or not your database is compatible with the new edition based on what SQL Server features you have enabled on the database. For more information, see Importing and Exporting SQL Server Databases (p. 576).

Oracle Considerations

If you use Oracle GoldenGate, always retain the parameter group with the `compatible` parameter. When you restore a DB instance from a DB snapshot, you must specify the parameter group that has a matching or greater `compatible` parameter value.

You can upgrade a DB snapshot while it is still a DB snapshot, before you restore it. For more information, see Upgrading an Oracle DB Snapshot (p. 893).

Restoring from a Snapshot

You can restore a DB instance from a DB snapshot using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To restore a DB instance from a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the DB snapshot that you want to restore from.
4. For **Actions**, choose **Restore Snapshot**.
5. On the **Restore DB Instance** page, for **DB Instance Identifier**, enter the name for your restored DB instance.
6. Choose **Restore DB Instance**.

AWS CLI

To restore a DB instance from a DB snapshot, use the AWS CLI command restore-db-instance-from-db-snapshot.

In this example, you restore from a previously created DB snapshot named *mydbsnapshot*. You restore to a new DB instance named *mynewdbinstance*.

Example

For Linux, macOS, or Unix:

```
aws rds restore-db-instance-from-db-snapshot \
    --db-instance-identifier mynewdbinstance \
    --db-snapshot-identifier mydbsnapshot
```

For Windows:

```
aws rds restore-db-instance-from-db-snapshot ^
    --db-instance-identifier mynewdbinstance ^
    --db-snapshot-identifier mydbsnapshot
```

This command returns output similar to the following:

```
DBINSTANCE  mynewdbinstance  db.m3.large  MySQL     50       sa               creating  3  n
  5.6.40  general-public-license
```

RDS API

To restore a DB instance from a DB snapshot, call the Amazon RDS API function RestoreDBInstanceFromDBSnapshot with the following parameters:

- `DBInstanceIdentifier`
- `DBSnapshotIdentifier`

Copying a Snapshot

With Amazon RDS, you can copy automated or manual DB snapshots. After you copy a snapshot, the copy is a manual snapshot.

You can copy a snapshot within the same AWS Region, you can copy a snapshot across AWS Regions, and you can copy shared snapshots.

Limitations

The following are some limitations when you copy snapshots:

- You can't copy a snapshot to or from the following AWS Regions: China (Beijing) or China (Ningxia).
- You can copy a snapshot between AWS GovCloud (US-East) and AWS GovCloud (US-West), but you can't copy a snapshot between these AWS GovCloud (US) Regions and other AWS Regions.
- If you delete a source snapshot before the target snapshot becomes available, the snapshot copy may fail. Verify that the target snapshot has a status of `AVAILABLE` before you delete a source snapshot.
- You can have up to five snapshot copy requests in progress to a single destination Region per account.
- Depending on the Regions involved and the amount of data to be copied, a cross-Region snapshot copy can take hours to complete. If there is a large number of cross-Region snapshot copy requests from a given source AWS Region, Amazon RDS might put new cross-Region copy requests from that source AWS Region into a queue until some in-progress copies complete. No progress information is displayed about copy requests while they are in the queue. Progress information is displayed when the copy starts.

Snapshot Retention

Amazon RDS deletes automated snapshots at the end of their retention period, when you disable automated snapshots for a DB instance, or when you delete a DB instance. If you want to keep an automated snapshot for a longer period, copy it to create a manual snapshot, which is retained until you delete it. Amazon RDS storage costs might apply to manual snapshots if they exceed your default storage space.

For more information about backup storage costs, see Amazon RDS Pricing.

Copying Shared Snapshots

You can copy snapshots shared to you by other AWS accounts. If you are copying an encrypted snapshot that has been shared from another AWS account, you must have access to the KMS encryption key that was used to encrypt the snapshot.

You can copy a shared DB snapshot across Regions, provided that the snapshot is unencrypted. However, if the shared DB snapshot is encrypted, you can only copy it in the same AWS Region.

Handling Encryption

You can copy a snapshot that has been encrypted using an AWS KMS encryption key. If you copy an encrypted snapshot, the copy of the snapshot must also be encrypted. If you copy an encrypted snapshot within the same AWS Region, you can encrypt the copy with the same KMS encryption key as the original snapshot, or you can specify a different KMS encryption key. If you copy an encrypted snapshot across Regions, you can't use the same KMS encryption key for the copy as used for the source snapshot, because KMS keys are Region-specific. Instead, you must specify a KMS key valid in the destination AWS Region.

The source snapshot remains encrypted throughout the copy process. For more information, see Limitations of Amazon RDS Encrypted DB Instances (p. 1360).

You can also encrypt a copy of an unencrypted snapshot. This way, you can quickly add encryption to a previously unencrypted DB instance. That is, you can create a snapshot of your DB instance when you are ready to encrypt it, and then create a copy of that snapshot and specify a KMS encryption key to encrypt that snapshot copy. You can then restore an encrypted DB instance from the encrypted snapshot.

Copying Snapshots Across AWS Regions

When you copy a snapshot to an AWS Region that is different from the source snapshot's AWS Region, the first copy is a full snapshot copy, even if you copy an incremental snapshot. A full snapshot copy contains all of the data and metadata required to restore the DB instance. After the first snapshot copy, you can copy incremental snapshots of the same DB instance to the same destination Region within the same AWS account.

An incremental snapshot contains only the data that has changed after the most recent snapshot of the same DB instance. Incremental snapshot copying is faster and results in lower storage costs than full snapshot copying. Incremental snapshot copying across AWS Regions is supported for both unencrypted and encrypted snapshots.

Important
For shared snapshots, copying incremental snapshots is not supported. For shared snapshots, all of the copies are full snapshots, even within the same Region.

Depending on the AWS Regions involved and the amount of data to be copied, a cross-Region snapshot copy can take hours to complete. In some cases, there might be a large number of cross-Region snapshot copy requests from a given source AWS Region. In these cases, Amazon RDS might put new cross-Region copy requests from that source AWS Region into a queue until some in-progress copies complete. No progress information is displayed about copy requests while they are in the queue. Progress information is displayed when the copy starts.

Cross-Region snapshot copy isn't supported in the following opt-in AWS Regions:

- Africa (Cape Town)
- Asia Pacific (Hong Kong)
- Europe (Milan)
- Middle East (Bahrain)

Note
When you copy a source snapshot that is a snapshot copy, the copy isn't incremental because the snapshot copy doesn't include the required metadata for incremental copies.

Option Group Considerations

Option groups are specific to the AWS Region that they are created in, and you can't use an option group from one AWS Region in another AWS Region.

When you copy a snapshot across Regions, you can specify a new option group for the snapshot. We recommend that you prepare the new option group before you copy the snapshot. In the destination AWS Region, create an option group with the same settings as the original DB instance . If one already exists in the new AWS Region, you can use that one.

If you copy a snapshot and you don't specify a new option group for the snapshot, when you restore it the DB instance gets the default option group. To give the new DB instance the same options as the original, you must do the following:

1. In the destination AWS Region, create an option group with the same settings as the original DB instance . If one already exists in the new AWS Region, you can use that one.
2. After you restore the snapshot in the destination AWS Region, modify the new DB instance and add the new or existing option group from the previous step.

Parameter Group Considerations

When you copy a snapshot across Regions, the copy doesn't include the parameter group used by the original DB instance . When you restore a snapshot to create a new DB instance , that DB instance gets the default parameter group for the AWS Region it is created in. To give the new DB instance the same parameters as the original, you must do the following:

1. In the destination AWS Region, create a DB parameter group with the same settings as the original DB instance . If one already exists in the new AWS Region, you can use that one.
2. After you restore the snapshot in the destination AWS Region, modify the new DB instance and add the new or existing parameter group from the previous step.

Copying a DB Snapshot

Use the procedures in this topic to copy a DB snapshot. For an overview of copying a snapshot, see Copying a Snapshot (p. 306)

For each AWS account, you can copy up to five DB snapshots at a time from one AWS Region to another. If you copy a DB snapshot to another AWS Region, you create a manual DB snapshot that is retained in that AWS Region. Copying a DB snapshot out of the source AWS Region incurs Amazon RDS data transfer charges.

For more information about data transfer pricing, see Amazon RDS Pricing.

After the DB snapshot copy has been created in the new AWS Region, the DB snapshot copy behaves the same as all other DB snapshots in that AWS Region.

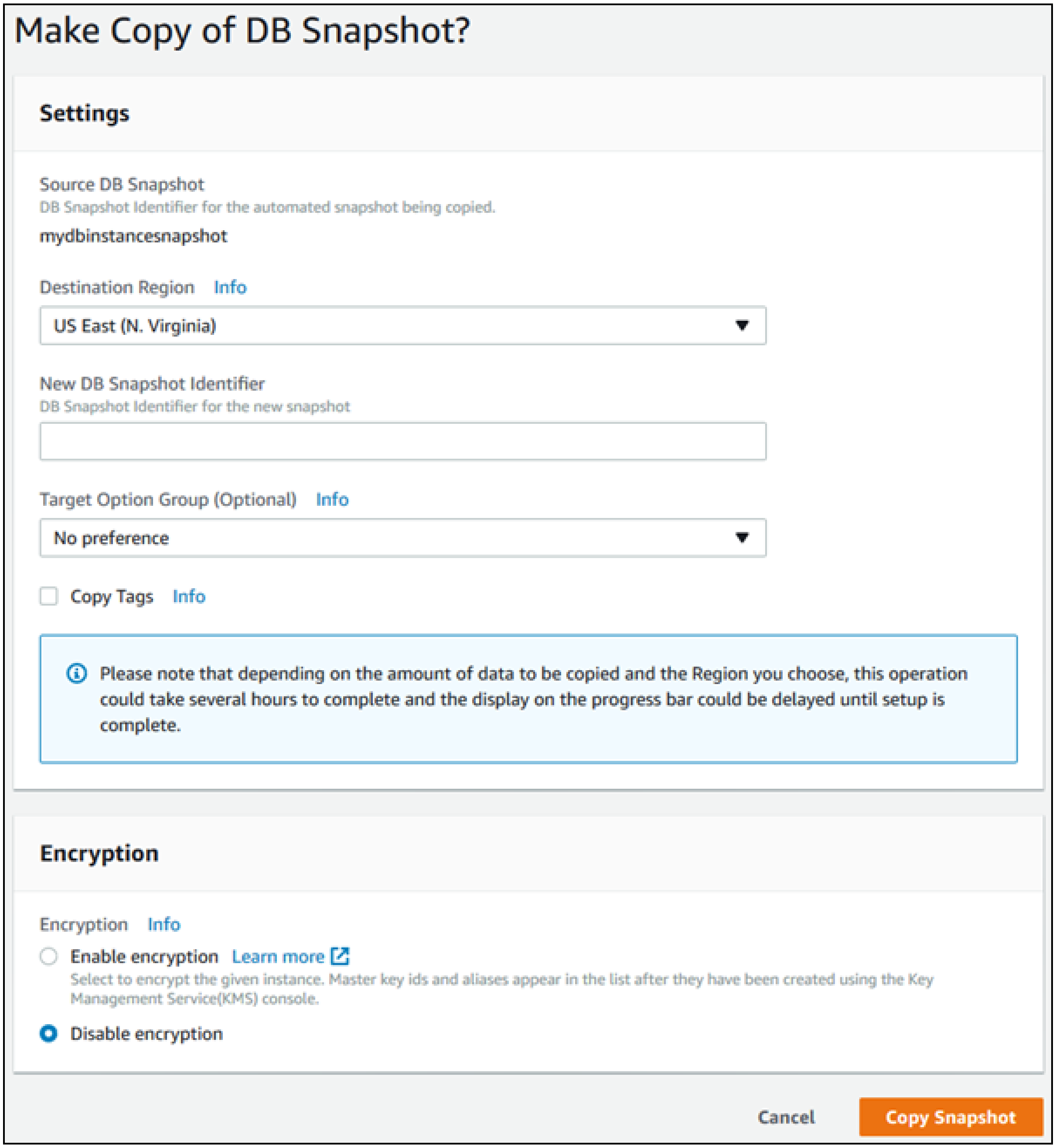
You can copy a DB snapshot using the AWS Management Console, the AWS CLI, or the RDS API.

Console

This procedure copies an encrypted or unencrypted DB snapshot, in the same AWS Region or across Regions, by using the AWS Management Console.

To copy a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Select the DB snapshot that you want to copy.
4. For **Actions**, choose **Copy Snapshot**. The **Make Copy of DB Snapshot** page appears.



5. (Optional) To copy the DB snapshot to a different AWS Region, for **Destination Region**, choose the new AWS Region.

   Note
   The destination AWS Region must have the same database engine version available as the source AWS Region.

6. For **New DB Snapshot Identifier**, type the name of the DB snapshot copy.
7. (Optional) For **Target Option Group**, choose a new option group.

   Specify this option if you are copying a snapshot from one AWS Region to another, and your DB instance uses a non-default option group.

If your source DB instance uses Transparent Data Encryption for Oracle or Microsoft SQL Server, you must specify this option when copying across Regions. For more information, see Option Group Considerations (p. 307).

8. (Optional) Select **Copy Tags** to copy tags and values from the snapshot to the copy of the snapshot.
9. (Optional) For **Enable Encryption**, choose one of the following options:
   - Choose **Disable encryption** if the DB snapshot isn't encrypted and you don't want to encrypt the copy.
   - Choose **Enable encryption** if the DB snapshot isn't encrypted but you want to encrypt the copy. In this case, for **Master Key**, specify the KMS key identifier to use to encrypt the DB snapshot copy.
   - Choose **Enable encryption** if the DB snapshot is encrypted. In this case, you must encrypt the copy, so **Yes** is already selected. For **Master Key**, specify the KMS key identifier to use to encrypt the DB snapshot copy.
10. Choose **Copy Snapshot**.

AWS CLI

You can copy a DB snapshot by using the AWS CLI command copy-db-snapshot. If you are copying the snapshot to a new AWS Region, run the command in the new AWS Region.

The following options are used to copy a DB snapshot. Not all options are required for all scenarios. Use the descriptions and the examples that follow to determine which options to use.

- `--source-db-snapshot-identifier` – The identifier for the source DB snapshot.
  - If the source snapshot is in the same AWS Region as the copy, specify a valid DB snapshot identifier. For example, `rds:mysql-instance1-snapshot-20130805`.
  - If the source snapshot is in a different AWS Region than the copy, specify a valid DB snapshot ARN. For example, `arn:aws:rds:us-west-2:123456789012:snapshot:mysql-instance1-snapshot-20130805`.
  - If you are copying from a shared manual DB snapshot, this parameter must be the Amazon Resource Name (ARN) of the shared DB snapshot.
  - If you are copying an encrypted snapshot this parameter must be in the ARN format for the source AWS Region, and must match the `SourceDBSnapshotIdentifier` in the `PreSignedUrl` parameter.
- `--target-db-snapshot-identifier` – The identifier for the new copy of the encrypted DB snapshot.
- `--copy-tags` – Include the copy tags option to copy tags and values from the snapshot to the copy of the snapshot.
- `--option-group-name` – The option group to associate with the copy of the snapshot.

  Specify this option if you are copying a snapshot from one AWS Region to another, and your DB instance uses a non-default option group.

  If your source DB instance uses Transparent Data Encryption for Oracle or Microsoft SQL Server, you must specify this option when copying across Regions. For more information, see Option Group Considerations (p. 307).
- `--kms-key-id` – The AWS KMS key ID for an encrypted DB snapshot. The KMS key ID is the Amazon Resource Name (ARN), KMS key identifier, or the KMS key alias for the KMS encryption key.
  - If you copy an encrypted DB snapshot from your AWS account, you can specify a value for this parameter to encrypt the copy with a new KMS encryption key. If you don't specify a value for this parameter, then the copy of the DB snapshot is encrypted with the same KMS key as the source DB snapshot.

  - If you copy an encrypted DB snapshot that is shared from another AWS account, then you must specify a value for this parameter.
  - If you specify this parameter when you copy an unencrypted snapshot, the copy is encrypted.
  - If you copy an encrypted snapshot to a different AWS Region, then you must specify a KMS key for the destination AWS Region. KMS encryption keys are specific to the AWS Region that they are created in, and you cannot use encryption keys from one AWS Region in another AWS Region.
- `--source-region` – The ID of the AWS Region of the source DB snapshot. If you copy an encrypted snapshot to a different AWS Region, then you must specify this option.

Example From Unencrypted, To Same Region

The following code creates a copy of a snapshot, with the new name `mydbsnapshotcopy`, in the same AWS Region as the source snapshot. When the copy is made, all tags on the original snapshot are copied to the snapshot copy.

For Linux, macOS, or Unix:

```
aws rds copy-db-snapshot \
    --source-db-snapshot-identifier mysql-instance1-snapshot-20130805 \
    --target-db-snapshot-identifier mydbsnapshotcopy \
    --copy-tags
```

For Windows:

```
aws rds copy-db-snapshot ^
    --source-db-snapshot-identifier mysql-instance1-snapshot-20130805 ^
    --target-db-snapshot-identifier mydbsnapshotcopy ^
    --copy-tags
```

Example From Unencrypted, Across Regions

The following code creates a copy of a snapshot, with the new name `mydbsnapshotcopy`, in the AWS Region in which the command is run.

For Linux, macOS, or Unix:

```
aws rds copy-db-snapshot \
    --source-db-snapshot-identifier arn:aws:rds:us-east-1:123456789012:snapshot:mysql-
instance1-snapshot-20130805 \
    --target-db-snapshot-identifier mydbsnapshotcopy
```

For Windows:

```
aws rds copy-db-snapshot ^
    --source-db-snapshot-identifier arn:aws:rds:us-east-1:123456789012:snapshot:mysql-
instance1-snapshot-20130805 ^
    --target-db-snapshot-identifier mydbsnapshotcopy
```

Example From Encrypted, Across Regions

The following code example copies an encrypted DB snapshot from the us-west-2 Region in the us-east-1 Region. Run the command in the us-east-1 Region.

For Linux, macOS, or Unix:

```
aws rds copy-db-snapshot \
```

```
 --source-db-snapshot-identifier arn:aws:rds:us-west-2:123456789012:snapshot:mysql-
instance1-snapshot-20161115 \
 --target-db-snapshot-identifier mydbsnapshotcopy \
 --source-region us-west-2 \
 --kms-key-id my-us-east-1-key \
    --option-group-name custom-option-group-name
```

For Windows:

```
aws rds copy-db-snapshot ^
 --source-db-snapshot-identifier arn:aws:rds:us-west-2:123456789012:snapshot:mysql-
instance1-snapshot-20161115 ^
 --target-db-snapshot-identifier mydbsnapshotcopy ^
 --source-region us-west-2 ^
 --kms-key-id my-us-east-1-key ^
    --option-group-name custom-option-group-name
```

RDS API

You can copy a DB snapshot by using the Amazon RDS API operation CopyDBSnapshot. If you are copying the snapshot to a new AWS Region, perform the action in the new AWS Region.

The following parameters are used to copy a DB snapshot. Not all parameters are required for all scenarios. Use the descriptions and the examples that follow to determine which parameters to use.

- `SourceDBSnapshotIdentifier` – The identifier for the source DB snapshot.
  - If the source snapshot is in the same AWS Region as the copy, specify a valid DB snapshot identifier. For example, `rds:mysql-instance1-snapshot-20130805`.
  - If the source snapshot is in a different AWS Region than the copy, specify a valid DB snapshot ARN. For example, `arn:aws:rds:us-west-2:123456789012:snapshot:mysql-instance1-snapshot-20130805`.
  - If you are copying from a shared manual DB snapshot, this parameter must be the Amazon Resource Name (ARN) of the shared DB snapshot.
  - If you are copying an encrypted snapshot this parameter must be in the ARN format for the source AWS Region, and must match the `SourceDBSnapshotIdentifier` in the `PreSignedUrl` parameter.
- `TargetDBSnapshotIdentifier` – The identifier for the new copy of the encrypted DB snapshot.
- `CopyTags` – Set this parameter to `true` to copy tags and values from the snapshot to the copy of the snapshot. The default is `false`.
- `OptionGroupName` – The option group to associate with the copy of the snapshot.

  Specify this parameter if you are copying a snapshot from one AWS Region to another, and your DB instance uses a non-default option group.

  If your source DB instance uses Transparent Data Encryption for Oracle or Microsoft SQL Server, you must specify this parameter when copying across Regions. For more information, see Option Group Considerations (p. 307).
- `KmsKeyId` – The AWS KMS key ID for an encrypted DB snapshot. The KMS key ID is the Amazon Resource Name (ARN), KMS key identifier, or the KMS key alias for the KMS encryption key.
  - If you copy an encrypted DB snapshot from your AWS account, you can specify a value for this parameter to encrypt the copy with a new KMS encryption key. If you don't specify a value for this parameter, then the copy of the DB snapshot is encrypted with the same KMS key as the source DB snapshot.
  - If you copy an encrypted DB snapshot that is shared from another AWS account, then you must specify a value for this parameter.

  - If you specify this parameter when you copy an unencrypted snapshot, the copy is encrypted.
  - If you copy an encrypted snapshot to a different AWS Region, then you must specify a KMS key for the destination AWS Region. KMS encryption keys are specific to the AWS Region that they are created in, and you cannot use encryption keys from one AWS Region in another AWS Region.
- `PreSignedUrl` – The URL that contains a Signature Version 4 signed request for the `CopyDBSnapshot` API operation in the source AWS Region that contains the source DB snapshot to copy.

  You must specify this parameter when you copy an encrypted DB snapshot from another AWS Region by using the Amazon RDS API. You can specify the source Region option instead of this parameter when you copy an encrypted DB snapshot from another AWS Region by using the AWS CLI.

  The presigned URL must be a valid request for the `CopyDBSnapshot` API operation that can be executed in the source AWS Region that contains the encrypted DB snapshot to be copied. The presigned URL request must contain the following parameter values:
  - `DestinationRegion` - The AWS Region that the encrypted DB snapshot will be copied to. This AWS Region is the same one where the `CopyDBSnapshot` action is called that contains this presigned URL.

    For example, if you copy an encrypted DB snapshot from the us-west-2 Region to the us-east-1 Region, then you call the `CopyDBSnapshot` action in the us-east-1 Region and provide a presigned URL that contains a call to the `CopyDBSnapshot` action in the us-west-2 Region. For this example, the `DestinationRegion` in the presigned URL must be set to the us-east-1 Region.
  - `KmsKeyId` - The KMS key identifier for the key to use to encrypt the copy of the DB snapshot in the destination AWS Region. This is the same identifier for both the `CopyDBSnapshot` action that is called in the destination AWS Region, and the action contained in the presigned URL.
  - `SourceDBSnapshotIdentifier` - The DB snapshot identifier for the encrypted snapshot to be copied. This identifier must be in the Amazon Resource Name (ARN) format for the source AWS Region. For example, if you are copying an encrypted DB snapshot from the us-west-2 Region, then your `SourceDBSnapshotIdentifier` looks like the following example: `arn:aws:rds:us-west-2:123456789012:snapshot:mysql-instance1-snapshot-20161115`.

  For more information on Signature Version 4 signed requests, see the following:
  - Authenticating Requests: Using Query Parameters (AWS Signature Version 4) in the Amazon Simple Storage Service API Reference
  - Signature Version 4 Signing Process in the AWS General Reference

Example From Unencrypted, To Same Region

The following code creates a copy of a snapshot, with the new name `mydbsnapshotcopy`, in the same AWS Region as the source snapshot. When the copy is made, all tags on the original snapshot are copied to the snapshot copy.

```
https://rds.us-west-1.amazonaws.com/
 ?Action=CopyDBSnapshot
 &CopyTags=true
 &SignatureMethod=HmacSHA256
 &SignatureVersion=4
 &SourceDBSnapshotIdentifier=mysql-instance1-snapshot-20130805
 &TargetDBSnapshotIdentifier=mydbsnapshotcopy
 &Version=2013-09-09
 &X-Amz-Algorithm=AWS4-HMAC-SHA256
 &X-Amz-Credential=AKIADQKE4SARGYLE/20140429/us-west-1/rds/aws4_request
 &X-Amz-Date=20140429T175351Z
 &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
 &X-Amz-Signature=9164337efa99caf850e874a1cb7ef62f3cea29d0b448b9e0e7c53b288ddffed2
```

Example From Unencrypted, Across Regions

The following code creates a copy of a snapshot, with the new name `mydbsnapshotcopy`, in the us-west-1 Region.

```
https://rds.us-west-1.amazonaws.com/
 ?Action=CopyDBSnapshot
 &SignatureMethod=HmacSHA256
 &SignatureVersion=4
 &SourceDBSnapshotIdentifier=arn%3Aaws%3Ards%3Aus-east-1%3A123456789012%3Asnapshot%3Amysql-
instance1-snapshot-20130805
 &TargetDBSnapshotIdentifier=mydbsnapshotcopy
 &Version=2013-09-09
 &X-Amz-Algorithm=AWS4-HMAC-SHA256
 &X-Amz-Credential=AKIADQKE4SARGYLE/20140429/us-west-1/rds/aws4_request
 &X-Amz-Date=20140429T175351Z
 &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
 &X-Amz-Signature=9164337efa99caf850e874a1cb7ef62f3cea29d0b448b9e0e7c53b288ddffed2
```

Example From Encrypted, Across Regions

The following code creates a copy of a snapshot, with the new name `mydbsnapshotcopy`, in the us-east-1 Region.

```
https://rds.us-east-1.amazonaws.com/
    ?Action=CopyDBSnapshot
    &KmsKeyId=my-us-east-1-key
    &OptionGroupName=custom-option-group-name
    &PreSignedUrl=https%253A%252F%252Frds.us-west-2.amazonaws.com%252F
         %253FAction%253DCopyDBSnapshot
         %2526DestinationRegion%253Dus-east-1
         %2526KmsKeyId%253Dmy-us-east-1-key
         %2526SourceDBSnapshotIdentifier%253Darn%25253Aaws%25253Ards%25253Aus-
west-2%25253A123456789012%25253Asnapshot%25253Amysql-instance1-snapshot-20161115
         %2526SignatureMethod%253DHmacSHA256
         %2526SignatureVersion%253D4
         %2526Version%253D2014-10-31
         %2526X-Amz-Algorithm%253DAWS4-HMAC-SHA256
         %2526X-Amz-Credential%253DAKIADQKE4SARGYLE%252F20161117%252Fus-west-2%252Frds
%252Faws4_request
         %2526X-Amz-Date%253D20161117T215409Z
         %2526X-Amz-Expires%253D3600
         %2526X-Amz-SignedHeaders%253Dcontent-type%253Bhost%253Buser-agent%253Bx-amz-
content-sha256%253Bx-amz-date
         %2526X-Amz-Signature
%253D255a0f17b4e717d3b67fad163c3ec26573b882c03a65523522cf890a67fca613
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &SourceDBSnapshotIdentifier=arn%3Aaws%3Ards%3Aus-west-2%3A123456789012%3Asnapshot
%3Amysql-instance1-snapshot-20161115
    &TargetDBSnapshotIdentifier=mydbsnapshotcopy
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20161117/us-east-1/rds/aws4_request
    &X-Amz-Date=20161117T221704Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=da4f2da66739d2e722c85fcfd225dc27bba7e2b8dbea8d8612434378e52adccf
```

Sharing a DB Snapshot

Using Amazon RDS, you can share a manual DB snapshot in the following ways:

- Sharing a manual DB snapshot, whether encrypted or unencrypted, enables authorized AWS accounts to copy the snapshot.
- Sharing an unencrypted manual DB snapshot enables authorized AWS accounts to directly restore a DB instance from the snapshot instead of taking a copy of it and restoring from that. However, you can't restore a DB instance from a DB snapshot that is both shared and encrypted. Instead, you can make a copy of the DB snapshot and restore the DB instance from the copy.

Note
To share an automated DB snapshot, create a manual DB snapshot by copying the automated snapshot, and then share that copy.

For more information on copying a snapshot, see Copying a Snapshot (p. 306). For more information on restoring a DB instance from a DB snapshot, see Restoring from a DB Snapshot (p. 303).

You can share a manual snapshot with up to 20 other AWS accounts. You can also share an unencrypted manual snapshot as public, which makes the snapshot available to all AWS accounts. Take care when sharing a snapshot as public so that none of your private information is included in any of your public snapshots.

The following limitations apply when sharing manual snapshots with other AWS accounts:

- When you restore a DB instance from a shared snapshot using the AWS Command Line Interface (AWS CLI) or Amazon RDS API, you must specify the Amazon Resource Name (ARN) of the shared snapshot as the snapshot identifier.
- You cannot share a DB snapshot that uses an option group with permanent or persistent options, except for Oracle DB instances that have the `Timezone` or `OLS` option (or both).

  A *permanent option* cannot be removed from an option group. Option groups with persistent options cannot be removed from a DB instance once the option group has been assigned to the DB instance.

  The following table lists permanent and persistent options and their related DB engines.

Option Name	Persistent	Permanent	DB Engine
TDE	Yes	No	Microsoft SQL Server Enterprise Edition
TDE	Yes	Yes	Oracle Enterprise Edition
Timezone	Yes	Yes	Oracle Enterprise Edition Oracle Standard Edition Oracle Standard Edition One Oracle Standard Edition Two

For Oracle DB instances, you can copy shared DB snapshots that have the `Timezone` or `OLS` option (or both). To do so, specify a target option group that includes these options when you copy the DB snapshot. The OLS option is permanent and persistent only for Oracle DB instances running Oracle version 12.2 or higher. For more information about these options, see Oracle Time Zone (p. 987) and Oracle Label Security (p. 954).

Sharing an Encrypted Snapshot

You can share DB snapshots that have been encrypted "at rest" using the AES-256 encryption algorithm, as described in Encrypting Amazon RDS Resources (p. 1358). To do this, you must take the following steps:

1. Share the AWS Key Management Service (AWS KMS) encryption key that was used to encrypt the snapshot with any accounts that you want to be able to access the snapshot.

   You can share AWS KMS encryption keys with another AWS account by adding the other account to the KMS key policy. For details on updating a key policy, see Key Policies in the *AWS KMS Developer Guide*. For an example of creating a key policy, see Allowing Access to an AWS KMS Encryption Key (p. 316) later in this topic.
2. Use the AWS Management Console, AWS CLI, or Amazon RDS API to share the encrypted snapshot with the other accounts.

These restrictions apply to sharing encrypted snapshots:

- You can't share encrypted snapshots as public.
- You can't share Oracle or Microsoft SQL Server snapshots that are encrypted using Transparent Data Encryption (TDE).
- You can't share a snapshot that has been encrypted using the default AWS KMS encryption key of the AWS account that shared the snapshot.

Allowing Access to an AWS KMS Encryption Key

For another AWS account to copy an encrypted DB snapshot shared from your account, the account that you share your snapshot with must have access to the KMS key that encrypted the snapshot. To allow another AWS account access to an AWS KMS key, update the key policy for the KMS key with the ARN of the AWS account that you are sharing to as a `Principal` in the KMS key policy, and then allow the `kms:CreateGrant` action.

After you have given an AWS account access to your KMS encryption key, to copy your encrypted snapshot, that AWS account must create an AWS Identity and Access Management (IAM) user if it doesn't already have one. In addition, that AWS account must also attach an IAM policy to that IAM user that allows the IAM user to copy an encrypted DB snapshot using your KMS key. The account must be an IAM user and cannot be a root AWS account identity due to KMS security restrictions.

In the following key policy example, user `111122223333` is the owner of the KMS encryption key, and user `444455556666` is the account that the key is being shared with. This updated key policy gives the AWS account access to the KMS key by including the ARN for the root AWS account identity for user `444455556666` as a `Principal` for the policy, and by allowing the `kms:CreateGrant` action.

```
{
  "Id": "key-policy-1",
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "Allow use of the key",
      "Effect": "Allow",
      "Principal": {"AWS": [
        "arn:aws:iam::111122223333:user/KeyUser",
        "arn:aws:iam::444455556666:root"
      ]},
      "Action": [
        "kms:CreateGrant",
        "kms:Encrypt",
```

```
        "kms:Decrypt",
        "kms:ReEncrypt*",
        "kms:GenerateDataKey*",
        "kms:DescribeKey"
      ],
      "Resource": "*"
    },
    {
      "Sid": "Allow attachment of persistent resources",
      "Effect": "Allow",
      "Principal": {"AWS": [
        "arn:aws:iam::111122223333:user/KeyUser",
        "arn:aws:iam::444455556666:root"
      ]},
      "Action": [
        "kms:CreateGrant",
        "kms:ListGrants",
        "kms:RevokeGrant"
      ],
      "Resource": "*",
      "Condition": {"Bool": {"kms:GrantIsForAWSResource": true}}
    }
  ]
}
```

Creating an IAM Policy to Enable Copying of the Encrypted Snapshot

Once the external AWS account has access to your KMS key, the owner of that AWS account can create a policy that allows an IAM user created for that account to copy an encrypted snapshot encrypted with that KMS key.

The following example shows a policy that can be attached to an IAM user for AWS account `444455556666` that enables the IAM user to copy a shared snapshot from AWS account `111122223333` that has been encrypted with the KMS key `c989c1dd-a3f2-4a5d-8d96-e793d082ab26` in the `us-west-2` region.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AllowUseOfTheKey",
            "Effect": "Allow",
            "Action": [
                "kms:Encrypt",
                "kms:Decrypt",
                "kms:ReEncrypt*",
                "kms:GenerateDataKey*",
                "kms:DescribeKey",
                "kms:CreateGrant",
                "kms:RetireGrant"
            ],
            "Resource": ["arn:aws:kms:us-west-2:111122223333:key/c989c1dd-a3f2-4a5d-8d96-
e793d082ab26"]
        },
        {
            "Sid": "AllowAttachmentOfPersistentResources",
            "Effect": "Allow",
            "Action": [
                "kms:CreateGrant",
                "kms:ListGrants",
                "kms:RevokeGrant"
            ],
```

```
            "Resource": ["arn:aws:kms:us-west-2:111122223333:key/c989c1dd-a3f2-4a5d-8d96-e793d082ab26"],
            "Condition": {
                "Bool": {
                    "kms:GrantIsForAWSResource": true
                }
            }
        }
    ]
}
```

For details on updating a key policy, see Key Policies in the *AWS KMS Developer Guide*.

Sharing a Snapshot

You can share a DB snapshot using the AWS Management Console, the AWS CLI, or the RDS API.

Console

Using the Amazon RDS console, you can share a manual DB snapshot with up to 20 AWS accounts. You can also use the console to stop sharing a manual snapshot with one or more accounts.

To share a manual DB snapshot by using the Amazon RDS console

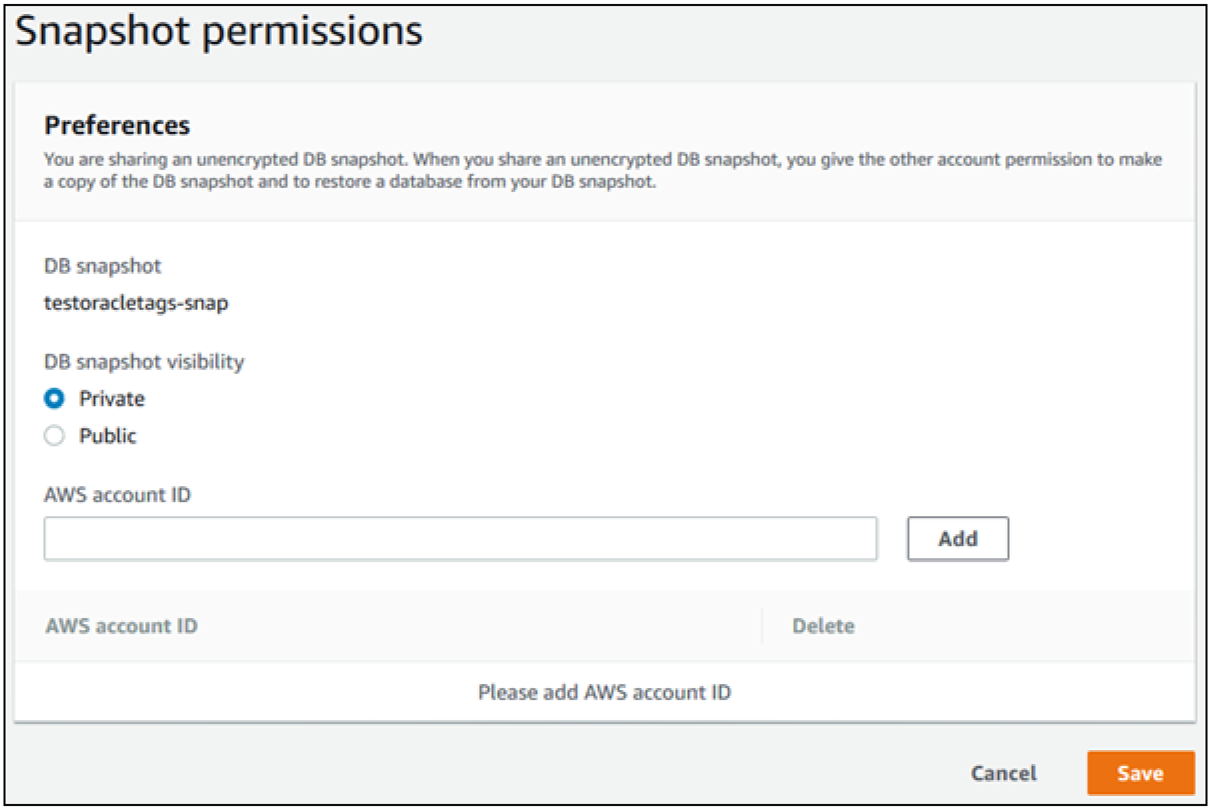
1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Select the manual snapshot that you want to share.
4. For **Actions**, choose **Share Snapshot**.
5. Choose one of the following options for **DB snapshot visibility**.

   - If the source is unencrypted, choose **Public** to permit all AWS accounts to restore a DB instance from your manual DB snapshot, or choose **Private** to permit only AWS accounts that you specify to restore a DB instance from your manual DB snapshot.

     Warning
     If you set **DB snapshot visibility** to **Public**, all AWS accounts can restore a DB instance from your manual DB snapshot and have access to your data. Do not share any manual DB snapshots that contain private information as **Public**.

   - If the source is encrypted, **DB snapshot visibility** is set as **Private** because encrypted snapshots can't be shared as public.
6. For **AWS Account ID**, type the AWS account identifier for an account that you want to permit to restore a DB instance from your manual snapshot, and then choose **Add**. Repeat to include additional AWS account identifiers, up to 20 AWS accounts.

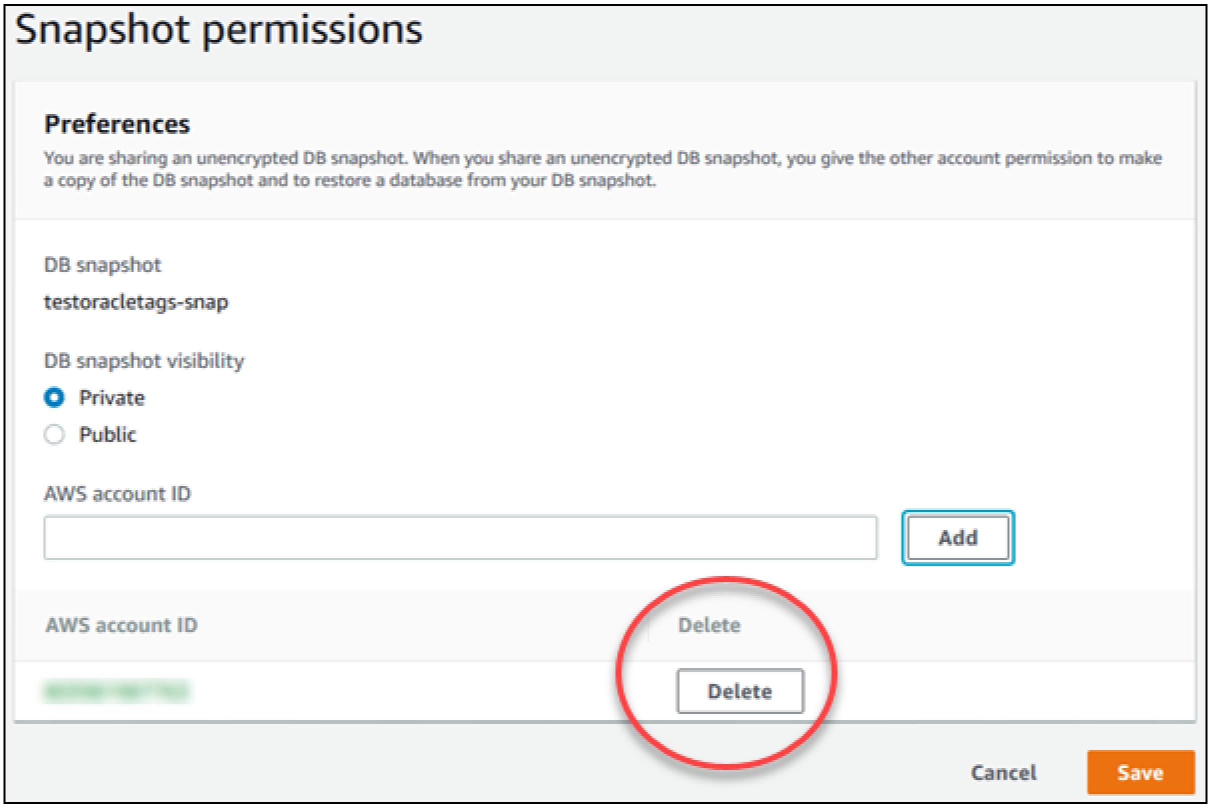
   If you make an error when adding an AWS account identifier to the list of permitted accounts, you can delete it from the list by choosing **Delete** at the right of the incorrect AWS account identifier.



7. After you have added identifiers for all of the AWS accounts that you want to permit to restore the manual snapshot, choose **Save** to save your changes.

To stop sharing a manual DB snapshot with an AWS account

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Select the manual snapshot that you want to stop sharing.
4. Choose **Actions**, and then choose **Share Snapshot**.
5. To remove permission for an AWS account, choose **Delete** for the AWS account identifier for that account from the list of authorized accounts.



6. Choose **Save** to save your changes.

AWS CLI

To share a DB snapshot, use the `aws rds modify-db-snapshot-attribute` command. Use the `--values-to-add` parameter to add a list of the IDs for the AWS accounts that are authorized to restore the manual snapshot.

The following example permits two AWS account identifiers, `123451234512` and `123456789012`, to restore the DB snapshot named `manual-snapshot1`, and removes the `all` attribute value to mark the snapshot as private.

```
aws rds modify-db-snapshot-attribute \
--db-snapshot-identifier manual-snapshot1 \
--attribute-name restore \
--values-to-add '["111122223333","444455556666"]'
```

To remove an AWS account identifier from the list, use the `-- values-to-remove` parameter. The following example prevents AWS account ID 444455556666 from restoring the snapshot.

```
aws rds modify-db-snapshot-attribute \
--db-snapshot-identifier manual-snapshot1 \
--attribute-name restore \
--values-to-remove '["444455556666 "]'
```

RDS API

You can also share a manual DB snapshot with other AWS accounts by using the Amazon RDS API. To do so, call the `ModifyDBSnapshotAttribute` operation. Specify `restore` for `AttributeName`, and use the `ValuesToAdd` parameter to add a list of the IDs for the AWS accounts that are authorized to restore the manual snapshot.

To make a manual snapshot public and restorable by all AWS accounts, use the value `all`. However, take care not to add the `all` value for any manual snapshots that contain private information that you don't want to be available to all AWS accounts. Also, don't specify `all` for encrypted snapshots, because making such snapshots public isn't supported.

To remove sharing permission for an AWS account, use the `ModifyDBSnapshotAttribute` operation with `AttributeName` set to `restore` and the `ValuesToRemove` parameter. To mark a manual snapshot as private, remove the value `all` from the values list for the `restore` attribute.

To list all of the AWS accounts permitted to restore a snapshot, use the `DescribeDBSnapshotAttributes` API operation.

Exporting DB Snapshot Data to Amazon S3

You can export DB snapshot data to an Amazon S3 bucket. After the data is exported, you can analyze the exported data directly through tools like Amazon Athena or Amazon Redshift Spectrum. The export process runs in the background and doesn't affect the performance of your active DB instance.

When you export a DB snapshot, Amazon RDS extracts data from the snapshot and stores it in an Amazon S3 bucket in your account. The data is stored in an Apache Parquet format that is compressed and consistent.

You can export all types of DB snapshots including manual snapshots, automated system snapshots, and snapshots created by the AWS Backup service. By default, all data in the snapshot is exported. However, you can choose to export specific sets of databases, schemas, or tables.

> **Note**
> Exporting snapshots from DB instances that use magnetic storage isn't supported.

Exporting snapshots is supported in the following AWS Regions:

- US East (N. Virginia)
- US East (Ohio)
- US West (Oregon)
- Europe (Ireland)
- Asia Pacific (Tokyo)

> **Note**
> You can copy a snapshot from an AWS Region where S3 export isn't supported to one where it is supported, then export the copy. The S3 bucket must be in the same AWS Region as the copy.

The following table shows the engine versions that are supported for exporting snapshot data to Amazon S3.

MariaDB	MySQL	PostgreSQL
10.3 10.2.12 and higher 10.1.26 and higher 10.0.32 and higher	8.0.13 and higher 5.7.24 and higher 5.6.40 and higher	11.2 and higher 10.7 and higher 9.6.12 and higher 9.5.16 and higher 9.4.21 and higher

For complete lists of engine versions supported by Amazon RDS, see the following:

- MariaDB on Amazon RDS Versions (p. 499)
- MySQL on Amazon RDS Versions (p. 713)
- Supported PostgreSQL Database Versions (p. 1310)

Topics

Overview of Exporting Snapshot Data

The following procedure provides a high-level view of how to export DB snapshot data to an Amazon S3 bucket. For more details, see the following sections.

To export DB snapshot data to Amazon S3

1. Identify the snapshot to export.

   Use an existing automated or manual snapshot, or create a manual snapshot of a DB instance.
2. Set up access to the Amazon S3 bucket.

   A *bucket* is a container for Amazon S3 objects or files. To provide the information to access a bucket, take the following steps:

   a. Identify the S3 bucket where the snapshot is to be exported to. The S3 bucket must be in the same AWS Region as the snapshot. For more information, see Identifying the Amazon S3 Bucket to Export to (p. 323).
   b. Create an AWS Key Management Service (AWS KMS) key for the server-side encryption. The KMS key is used by the snapshot export task to set up KMS server-side encryption when writing the export data to S3. For more information, see Encrypting Amazon RDS Resources (p. 1358).
   c. Create an AWS Identity and Access Management (IAM) role that grants the snapshot export task access to the S3 bucket. For more information, see Providing Access to an Amazon S3 Bucket Using an IAM Role (p. 324).
3. Export the snapshot to Amazon S3 using the console or the `start-export-task` CLI command. For more information, see Exporting a Snapshot to an Amazon S3 Bucket (p. 325).
4. To access your exported data in the Amazon S3 bucket, see Uploading, Downloading, and Managing Objects in the *Amazon Simple Storage Service Console User Guide*.

Setting Up Access to an Amazon S3 Bucket

To export DB snapshot data to an Amazon S3 file, you first give the snapshot permission to access the Amazon S3 bucket. You then create an IAM role to allow the Amazon RDS service to write to the Amazon S3 bucket.

Topics

Identifying the Amazon S3 Bucket to Export to

Identify the Amazon S3 bucket to export the DB snapshot to. Use an existing S3 bucket or create a new S3 bucket.

> **Note**
> The S3 bucket to export to must be in the same AWS Region as the snapshot.

For more information about working with Amazon S3 buckets, see How Do I View the Properties for an S3 Bucket?, How Do I Enable Default Encryption for an Amazon S3 Bucket?, and How Do I Create an S3 Bucket? in the *Amazon Simple Storage Service Console User Guide*.

Providing Access to an Amazon S3 Bucket Using an IAM Role

Before you export DB snapshot data to Amazon S3, give the snapshot export tasks write-access permission to the Amazon S3 bucket.

To do this, create an IAM policy that provides access to the bucket. Then create an IAM role and attach the policy to the role. You later assign the IAM role to your snapshot export task.

To give DB snapshot tasks access to Amazon S3

1. Create an IAM policy. This policy provides the bucket and object permissions that allow your snapshot export task to access Amazon S3.

   Include in the policy the following required actions to allow the transfer of files from Amazon RDS to an S3 bucket:

   - `s3:PutObject*`
   - `s3:GetObject*`
   - `s3:ListBucket`
   - `s3:DeleteObject*`
   - `s3:GetBucketLocation`

   Include in the policy the following resources to identify the S3 bucket and objects in the bucket. The following list of resources shows the Amazon Resource Name (ARN) format for accessing Amazon S3.

   - `arn:aws:s3:::your-s3-bucket`
   - `arn:aws:s3:::your-s3-bucket/*`

   For more information on creating an IAM policy for Amazon RDS, see Creating and Using an IAM Policy for IAM Database Access (p. 1390). See also Tutorial: Create and Attach Your First Customer Managed Policy in the *IAM User Guide*.

   The following AWS CLI command creates an IAM policy named `ExportPolicy` with these options. It grants access to a bucket named `your-s3-bucket`.

   > **Note**
   > After you create the policy, note the ARN of the policy. You need the ARN for a subsequent step when you attach the policy to an IAM role.

```
aws iam create-policy  --policy-name ExportPolicy --policy-document '{
     "Version": "2012-10-17",
     "Statement": [
         {
             "Effect": "Allow",
             "Action": [
                 "s3:ListBucket",
                 "s3:GetBucketLocation"
             ],
             "Resource": [
                 "arn:aws:s3:::*"
             ]
         },
         {
```

```
                "Effect": "Allow",
                "Action": [
                    "s3:PutObject*",
                    "s3:GetObject*",
                    "s3:DeleteObject*"
                ],
                "Resource": [
                    "arn:aws:s3:::your-s3-bucket",
                    "arn:aws:s3:::your-s3-bucket/*"
                ]
            }
        ]
}'
```

2. Create an IAM role. You do this so that Amazon RDS can assume this IAM role on your behalf to access your Amazon S3 buckets. For more information, see Creating a Role to Delegate Permissions to an IAM User in the *IAM User Guide*.

   The following example shows using the AWS CLI command to create a role named `rds-s3-export-role`.

```
aws iam create-role  --role-name rds-s3-export-role  --assume-role-policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Principal": {
            "Service": "export.rds.amazonaws.com"
          },
         "Action": "sts:AssumeRole"
       }
     ]
   }'
```

3. Attach the IAM policy that you created to the IAM role that you created.

   The following AWS CLI command attaches the policy created earlier to the role named `rds-s3-export-role`. Replace *`your-policy-arn`* with the policy ARN that you noted in an earlier step.

```
aws iam attach-role-policy  --policy-arn your-policy-arn  --role-name rds-s3-export-
role
```

Exporting a Snapshot to an Amazon S3 Bucket

You can have up to five concurrent DB snapshot export tasks in progress per account.

Note
Exporting RDS Snapshots can take a while depending on your database type and size. The export task first restores and scales the entire database before extracting the data to Amazon S3. The task's progress during this phase displays as **STARTING**. When the task switches to exporting data to Amazon S3, progress displays as **IN_PROGRESS**.
The time it takes for the export to complete depends on the data stored in the database. For example, tables with well distributed numeric primary key or index columns will export the fastest. Tables that don't contain a column suitable for partitioning and tables with only one index on a string-based column will take longer because the export uses a slower single threaded process.

You can export a DB snapshot to Amazon S3 using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To export a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. From the tabs, choose the type of snapshot that you want to export.
4. In the list of snapshots, choose the snapshot that you want to export.
5. For **Actions**, choose **Export to Amazon S3**.

   The **Export to Amazon S3** window appears.
6. For **Export identifier**, enter a name to identify the export task. This value is also used for the name of the file created in the S3 bucket.
7. Choose the amount of data to be exported:
   - Choose **All** to export all data in the snapshot.
   - Choose **Partial** to export specific parts of the snapshot. To identify which parts of the snapshot to export, enter one or more tables for **Identifiers**.
8. For **S3 bucket**, choose the bucket to export to.

   To assign the exported data to a folder path in the S3 bucket, enter the optional path for **S3 prefix**.
9. For **IAM role**, choose a role that grants you write access to your chosen S3 bucket. If you created a role by following the steps in Providing Access to an Amazon S3 Bucket Using an IAM Role (p. 324), choose that role.
10. For **Master key**, enter the ARN for the key to use for encrypting the exported data.
11. Choose **Export to Amazon S3**.

AWS CLI

To export a DB snapshot to Amazon S3 using the AWS CLI, use the start-export-task command with the following required options:

- `--export-task-identifier`
- `--source-arn`
- `--s3-bucket-name`
- `--iam-role-arn`
- `--kms-key-id`

In the following examples, the snapshot export task is named *my_snapshot_export*, which exports a snapshot to an S3 bucket named *my_export_bucket*.

Example

For Linux, macOS, or Unix:

```
aws rds start-export-task \
    --export-task-identifier my_snapshot_export \
    --source-arn arn:aws:rds:AWS_Region:123456789012:snapshot:snapshot_name \
    --s3-bucket-name my_export_bucket \
    --iam-role-arn iam_role \
```

```
    --kms-key-id master_key
```

For Windows:

```
aws rds start-export-task ^
    --export-task-identifier my_snapshot_export ^
    --source-arn arn:aws:rds:AWS_Region:123456789012:snapshot:snapshot_name ^
    --s3-bucket-name my_export_bucket ^
    --iam-role-arn iam_role ^
    --kms-key-id master_key
```

Sample output follows.

```
{
    "Status": "STARTING",
    "IamRoleArn": "iam_role",
    "ExportTime": "2019-08-12T01:23:53.109Z",
    "S3Bucket": "my_export_bucket",
    "PercentProgress": 0,
    "KmsKeyId": "master_key",
    "ExportTaskIdentifier": "my_snapshot_export",
    "TotalExtractedDataInGB": 0,
    "TaskStartTime": "2019-11-13T19:46:00.173Z",
    "SourceArn": "arn:aws:rds:AWS_Region:123456789012:snapshot:snapshot_name"
}
```

To provide a folder path in the S3 bucket for the snapshot export, include the `--s3-prefix` option in the start-export-task command.

RDS API

To export a DB snapshot to Amazon S3 using the Amazon RDS API, use the StartExportTask operation with the following required parameters:

- `ExportTaskIdentifier`
- `SourceArn`
- `S3BucketName`
- `IamRoleArn`
- `KmsKeyId`

Monitoring Snapshot Exports

You can monitor DB snapshot exports using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To monitor DB snapshot exports

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. To monitor the list of snapshot exports, choose the **Exports in Amazon S3** tab.
4. To view information about a specific snapshot export, choose the export task.

AWS CLI

To monitor DB snapshot exports using the AWS CLI, use the describe-export-tasks command.

The following example shows how to display current information about all of your snapshot exports.

Example

```
aws rds describe-export-tasks

{
    "ExportTasks": [
        {
            "Status": "CANCELED",
            "TaskEndTime": "2019-11-01T17:36:46.961Z",
            "S3Prefix": "something",
            "ExportTime": "2019-10-24T20:23:48.364Z",
            "S3Bucket": "awsexamplebucket",
            "PercentProgress": 0,
            "KmsKeyId": "arn:aws:kms:AWS_Region:123456789012:key/K7MDENG/
bPxRfiCYEXAMPLEKEY",
            "ExportTaskIdentifier": "anewtest",
            "IamRoleArn": "arn:aws:iam::123456789012:role/export-to-s3",
            "TotalExtractedDataInGB": 0,
            "TaskStartTime": "2019-10-25T19:10:58.885Z",
            "SourceArn": "arn:aws:rds:AWS_Region:123456789012:snapshot:parameter-groups-
test"
        },
{
            "Status": "COMPLETE",
            "TaskEndTime": "2019-10-31T21:37:28.312Z",
            "WarningMessage": "{\"skippedTables\":[],\"skippedObjectives\":[],\"general\":
[{\"reason\":\"FAILED_TO_EXTRACT_TABLES_LIST_FOR_DATABASE\"}]}",
            "S3Prefix": "",
            "ExportTime": "2019-10-31T06:44:53.452Z",
            "S3Bucket": "awsexamplebucket1",
            "PercentProgress": 100,
            "KmsKeyId": "arn:aws:kms:AWS_Region:123456789012:key/2Zp9Utk/
h3yCo8nvbEXAMPLEKEY",
            "ExportTaskIdentifier": "thursday-events-test",
            "IamRoleArn": "arn:aws:iam::123456789012:role/export-to-s3",
            "TotalExtractedDataInGB": 263,
            "TaskStartTime": "2019-10-31T20:58:06.998Z",
            "SourceArn":
 "arn:aws:rds:AWS_Region:123456789012:snapshot:rds:example-1-2019-10-31-06-44"
        },
        {
            "Status": "FAILED",
            "TaskEndTime": "2019-10-31T02:12:36.409Z",
            "FailureCause": "The S3 bucket edgcuc-export isn't located in the current AWS
 Region. Please, review your S3 bucket name and retry the export.",
            "S3Prefix": "",
            "ExportTime": "2019-10-30T06:45:04.526Z",
            "S3Bucket": "awsexamplebucket2",
            "PercentProgress": 0,
            "KmsKeyId": "arn:aws:kms:AWS_Region:123456789012:key/2Zp9Utk/
h3yCo8nvbEXAMPLEKEY",
            "ExportTaskIdentifier": "wednesday-afternoon-test",
            "IamRoleArn": "arn:aws:iam::123456789012:role/export-to-s3",
            "TotalExtractedDataInGB": 0,
            "TaskStartTime": "2019-10-30T22:43:40.034Z",
            "SourceArn":
 "arn:aws:rds:AWS_Region:123456789012:snapshot:rds:example-1-2019-10-30-06-45"
        }
```

```
    ]
}
```

To display information about a specific snapshot export, include the `--export-task-identifier` option with the `describe-export-tasks` command. To filter the output, include the `--Filters` option. For more options, see the describe-export-tasks command.

RDS API

To display information about DB snapshot exports using the Amazon RDS API, use the DescribeExportTasks operation.

Canceling a Snapshot Export Task

You can cancel a DB snapshot export task using the AWS Management Console, the AWS CLI, or the RDS API.

> **Note**
> Canceling a snapshot export task doesn't remove any data that was exported to Amazon S3. For information about how to delete the data using the console, see How Do I Delete Objects from an S3 Bucket? To delete the data using the CLI, use the delete-object command.

Console

To cancel a snapshot export task

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the **Exports in Amazon S3** tab.
4. Choose the snapshot export task that you want to cancel.
5. Choose **Cancel**.
6. Choose **Cancel export task** on the confirmation page.

AWS CLI

To cancel a snapshot export task using the AWS CLI, use the cancel-export-task command. The command requires the `--export-task-identifier` option.

Example

```
aws rds cancel-export-task --export-task-identifier my_export
{
    "Status": "CANCELING",
    "S3Prefix": "",
    "ExportTime": "2019-08-12T01:23:53.109Z",
    "S3Bucket": "awsexamplebucket",
    "PercentProgress": 0,
    "KmsKeyId": "arn:aws:kms:AWS_Region:123456789012:key/K7MDENG/bPxRfiCYEXAMPLEKEY",
    "ExportTaskIdentifier": "my_export",
    "IamRoleArn": "arn:aws:iam::123456789012:role/export-to-s3",
    "TotalExtractedDataInGB": 0,
    "TaskStartTime": "2019-11-13T19:46:00.173Z",
    "SourceArn": "arn:aws:rds:AWS_Region:123456789012:snapshot:export-example-1"
```

```
}
```

RDS API

To cancel a snapshot export task using the Amazon RDS API, use the CancelExportTask operation with the `ExportTaskIdentifier` parameter.

Data Conversion When Exporting to an Amazon S3 Bucket

When you export a DB snapshot to an Amazon S3 bucket, Amazon RDS converts data to, exports data in, and stores data in the Parquet format. For more information about Parquet, see the Apache Parquet website.

Parquet stores all data as one of the following primitive types:

- BOOLEAN
- INT32
- INT64
- INT96
- FLOAT
- DOUBLE
- BYTE_ARRAY – A variable-length byte array, also known as binary
- FIXED_LEN_BYTE_ARRAY – A fixed-length byte array used when the values have a constant size

The Parquet data types are few to reduce the complexity of reading and writing the format. Parquet provides logical types for extending primitive types. A *logical type* is implemented as an annotation with the data in a `LogicalType` metadata field. The logical type annotation explains how to interpret the primitive type.

When the `STRING` logical type annotates a `BYTE_ARRAY` type, it indicates that the byte array should be interpreted as a UTF-8 encoded character string. After an export task completes, Amazon RDS notifies you if any string conversion occurred. The underlying data exported is always the same as the data from the source. However, due to the encoding difference in UTF-8, some characters might appear different from the source when read in tools such as Athena.

For more information, see Parquet Logical Type Definitions in the Parquet documentation.

Note

- Some characters aren't supported in database table column names. Tables with the following characters in column names are skipped during export.

```
,;{}()\n\t=
```

- If the data contains a huge value close to or greater than 500 MB, the export fails.
- If the database, schema, or table name contains spaces, partial export isn't supported. However, you can export the entire DB snapshot.

Topics

MySQL and MariaDB Data Type Mapping to Parquet

The following table shows the mapping from MySQL and MariaDB data types to Parquet data types when data is converted and exported to Amazon S3.

Source Data Type	Parquet Primitive Type	Logical Type Annotation	Conversion Notes
Numeric Data Types			
BIGINT	INT64		
BIGINT UNSIGNED	FIXED_LEN_BYTE_ARRAY(9)	DECIMAL(20,0)	Parquet supports only signed types, so the mapping requires an additional byte (8 plus 1) to store the BIGINT_UNSIGNED type.
BIT	BYTE_ARRAY		
DECIMAL	INT32	DECIMAL(p,s)	If the source value is less thanm 2^{31}, it's stored as INT32.
	INT64	DECIMAL(p,s)	If the source value is 2^{31} or greater, but less than 2^{63}, it's stored as INT64.
	FIXED_LEN_BYTE_ARRAY(N)	DECIMAL(p,s)	If the source value is 2^{63} or greater, it's stored as FIXED_LEN_BYTE_ARRAY(N).
	BYTE_ARRAY	STRING	Parquet doesn't support Decimal precision greater than 38. The Decimal value is converted to a string in a BYTE_ARRAY type and encoded as UTF8.
DOUBLE	DOUBLE		
FLOAT	DOUBLE		
INT	INT32		
INT UNSIGNED	INT64		
MEDIUMINT	INT32		
MEDIUMINT UNSIGNED	INT64		
NUMERIC	INT32	DECIMAL(p,s)	If the source value is less than 2^{31}, it's stored as INT32.

Source Data Type	Parquet Primitive Type	Logical Type Annotation	Conversion Notes
	INT64	DECIMAL(p,s)	If the source value is 2^{31} or greater, but less than 2^{63}, it's stored as INT64.
	FIXED_LEN_ARRAY(N)	DECIMAL(p,s)	If the source value is 2^{63} or greater, it's stored as FIXED_LEN_BYTE_ARRAY(N).
	BYTE_ARRAY	STRING	Parquet doesn't support Numeric precision greater than 38. This Numeric value is converted to a string in a BYTE_ARRAY type and encoded as UTF8.
SMALLINT	INT32		
SMALLINT UNSIGNED	INT32		
TINYINT	INT32		
TINYINT UNSIGNED	INT32		
String Data Types			
BINARY	BYTE_ARRAY		
BLOB	BYTE_ARRAY		
CHAR	BYTE_ARRAY		
ENUM	BYTE_ARRAY	STRING	
LINESTRING	BYTE_ARRAY		
LONGBLOB	BYTE_ARRAY		
LONGTEXT	BYTE_ARRAY	STRING	
MEDIUMBLOB	BYTE_ARRAY		
MEDIUMTEXT	BYTE_ARRAY	STRING	
MULTILINESTRING	BYTE_ARRAY		
SET	BYTE_ARRAY	STRING	
TEXT	BYTE_ARRAY	STRING	
TINYBLOB	BYTE_ARRAY		
TINYTEXT	BYTE_ARRAY	STRING	
VARBINARY	BYTE_ARRAY		
VARCHAR	BYTE_ARRAY	STRING	
Date and Time Data Types			

Source Data Type	Parquet Primitive Type	Logical Type Annotation	Conversion Notes
DATE	BYTE_ARRAY	STRING	A date is converted to a string in a BYTE_ARRAY type and encoded as UTF8.
DATETIME	INT64	TIMESTAMP_MICROS	
TIME	BYTE_ARRAY	STRING	A TIME type is converted to a string in a BYTE_ARRAY and encoded as UTF8.
TIMESTAMP	INT64	TIMESTAMP_MICROS	
YEAR	INT32		
Geometric Data Types			
GEOMETRY	BYTE_ARRAY		
GEOMETRYCOLLECTION	BYTE_ARRAY		
MULTIPOINT	BYTE_ARRAY		
MULTIPOLYGON	BYTE_ARRAY		
POINT	BYTE_ARRAY		
POLYGON	BYTE_ARRAY		
JSON Data Type			
JSON	BYTE_ARRAY	STRING	

PostgreSQL Data Type Mapping to Parquet

The following table shows the mapping from PostgreSQL data types to Parquet data types when data is converted and exported to Amazon S3.

PostgreSQL Data Type	Parquet Primitive Type	Logical Type Annotation	Mapping Notes
Numeric Data Types			
BIGINT	INT64		
BIGSERIAL	INT64		
DECIMAL	BYTE_ARRAY	STRING	A DECIMAL type is converted to a string in a BYTE_ARRAY type and encoded as UTF8. This conversion is to avoid complications due to data precision and

PostgreSQL Data Type	Parquet Primitive Type	Logical Type Annotation	Mapping Notes
			data values that are not a number (NaN).
DOUBLE PRECISION	DOUBLE		
INTEGER	INT32		
MONEY	BYTE_ARRAY	STRING	
REAL	FLOAT		
SERIAL	INT32		
SMALLINT	INT32	INT_16	
SMALLSERIAL	INT32	INT_16	
String and Related Data Types			
ARRAY	BYTE_ARRAY	STRING	An array is converted to a string and encoded as BINARY (UTF8). This conversion is to avoid complications due to data precision, data values that are not a number (NaN), and time data values.
BIT	BYTE_ARRAY	STRING	
BIT VARYING	BYTE_ARRAY	STRING	
BYTEA	BINARY		
CHAR	BYTE_ARRAY	STRING	
CHAR(N)	BYTE_ARRAY	STRING	
ENUM	BYTE_ARRAY	STRING	
NAME	BYTE_ARRAY	STRING	
TEXT	BYTE_ARRAY	STRING	
TEXT SEARCH	BYTE_ARRAY	STRING	
VARCHAR(N)	BYTE_ARRAY	STRING	
XML	BYTE_ARRAY	STRING	
Date and Time Data Types			
DATE	BYTE_ARRAY	STRING	
INTERVAL	BYTE_ARRAY	STRING	
TIME	BYTE_ARRAY	STRING	

PostgreSQL Data Type	Parquet Primitive Type	Logical Type Annotation	Mapping Notes
TIME WITH TIME ZONE	BYTE_ARRAY	STRING	
TIMESTAMP	BYTE_ARRAY	STRING	
TIMESTAMP WITH TIME ZONE	BYTE_ARRAY	STRING	
Geometric Data Types			
BOX	BYTE_ARRAY	STRING	
CIRCLE	BYTE_ARRAY	STRING	
LINE	BYTE_ARRAY	STRING	
LINESEGMENT	BYTE_ARRAY	STRING	
PATH	BYTE_ARRAY	STRING	
POINT	BYTE_ARRAY	STRING	
POLYGON	BYTE_ARRAY	STRING	
JSON Data Types			
JSON	BYTE_ARRAY	STRING	
JSONB	BYTE_ARRAY	STRING	
Other Data Types			
BOOLEAN	BOOLEAN		
CIDR	BYTE_ARRAY	STRING	Network data type
COMPOSITE	BYTE_ARRAY	STRING	
DOMAIN	BYTE_ARRAY	STRING	
INET	BYTE_ARRAY	STRING	Network data type
MACADDR	BYTE_ARRAY	STRING	
OBJECT IDENTIFIER	N/A		
PG_LSN	BYTE_ARRAY	STRING	
RANGE	BYTE_ARRAY	STRING	
UUID	BYTE_ARRAY	STRING	

Restoring a DB Instance to a Specified Time

You can restore a DB instance to a specific point in time, creating a new DB instance. When you restore a DB instance to a point in time, the default DB security group is applied to the new DB instance. If you need custom DB security groups applied to your DB instance, you must apply them explicitly using the AWS Management Console, the AWS CLI `modify-db-instance` command, or the Amazon RDS API `ModifyDBInstance` operation after the DB instance is available.

RDS uploads transaction logs for DB instances to Amazon S3 every 5 minutes. To determine the latest restorable time for a DB instance, use the AWS CLI describe-db-instances command and look at the value returned in the `LatestRestorableTime` field for the DB instance. In the AWS Management Console, this property is visible as the **Latest restore time** for the DB instance. You can restore to any point in time during your backup retention period.

Several of the database engines used by Amazon RDS have special considerations when restoring from a point in time. When you restore an Oracle DB instance to a point in time, you can specify a different Oracle DB engine, license model, and DBName (SID) to be used by the new DB instance. When you restore a SQL Server DB instance to a point in time, each database within that instance is restored to a point in time within 1 second of each other database within the instance. Transactions that span multiple databases within the instance may be restored inconsistently. Also, for a SQL Server DB instance, the `OFFLINE`, `EMERGENCY`, and `SINGLE_USER` modes are not currently supported. Setting any database into one of these modes will cause the latest restorable time to stop moving ahead for the whole instance.

Some actions, such as changing the recovery model of a SQL Server database, can break the sequence of logs that are used for point-in-time recovery. In some cases, Amazon RDS can detect this issue and the latest restorable time is prevented from moving forward; in other cases, such as when a SQL Server database uses the `BULK_LOGGED` recovery model, the break in log sequence is not detected. It may not be possible to restore a SQL Server DB instance to a point in time if there is a break in the log sequence. For these reasons, Amazon RDS does not support changing the recovery model of SQL Server databases.

You can restore a DB instance to a point in time using the AWS Management Console, the AWS CLI, or the RDS API.

Console

To restore a DB instance to a specified time

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to restore.
4. For **Actions**, choose **Restore to point in time**.

   The **Launch DB Instance** window appears.
5. Choose **Latest restorable time** to restore to the latest possible time, or choose **Custom** to choose a time.

   If you chose **Custom**, enter the date and time that you want to restore the instance to.

   > **Note**
   > Times are shown in your local time zone, which is indicated by an offset from Coordinated Universal Time (UTC). For example, UTC-5 is Eastern Standard Time/Central Daylight Time.
6. For **DB instance identifier**, enter the name of the restored DB instance, and then complete the other options.
7. Choose **Launch DB Instance**.

AWS CLI

To restore a DB instance to a specified time, use the AWS CLI command `restore-db-instance-to-point-in-time` to create a new DB instance.

Example

For Linux, macOS, or Unix:

```
aws rds restore-db-instance-to-point-in-time \
    --source-db-instance-identifier mysourcedbinstance \
    --target-db-instance-identifier mytargetdbinstance \
    --restore-time 2017-10-14T23:45:00.000Z
```

For Windows:

```
aws rds restore-db-instance-to-point-in-time ^
    --source-db-instance-identifier mysourcedbinstance ^
    --target-db-instance-identifier mytargetdbinstance ^
    --restore-time 2017-10-14T23:45:00.000Z
```

RDS API

To restore a DB instance to a specified time, call the Amazon RDS API `RestoreDBInstanceToPointInTime` operation with the following parameters:

- `SourceDBInstanceIdentifier`
- `TargetDBInstanceIdentifier`
- `RestoreTime`

Deleting a Snapshot

You can delete DB snapshots managed by Amazon RDS when you no longer need them.

> **Note**
> To delete backups managed by AWS Backup, use the AWS Backup console. For information about AWS Backup, see the *AWS Backup Developer Guide*.

Deleting a DB Snapshot

You can delete a manual, shared, or public DB snapshot using the AWS Management Console, the AWS CLI, or the RDS API.

To delete a shared or public snapshot, you must sign in to the AWS account that owns the snapshot.

If you have automated DB snapshots that you want to delete without deleting the DB instance, change the backup retention period for the DB instance to 0. The automated snapshots are deleted when the change is applied. You can apply the change immediately if you don't want to wait until the next maintenance period. After the change is complete, you can then re-enable automatic backups by setting the backup retention period to a number greater than 0. For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

If you deleted a DB instance, you can delete its automated DB snapshots by removing the automated backups for the DB instance. For information about automated backups, see Working With Backups (p. 291).

Console

To delete a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the DB snapshot that you want to delete.
4. For **Actions**, choose **Delete Snapshot**.
5. Choose **Delete** on the confirmation page.

AWS CLI

You can delete a DB snapshot by using the AWS CLI command delete-db-snapshot.

The following options are used to delete a DB snapshot.

- `--db-snapshot-identifier` – The identifier for the DB snapshot.

Example

The following code deletes the `mydbsnapshot` DB snapshot.

For Linux, macOS, or Unix:

```
aws rds delete-db-snapshot \
    --db-snapshot-identifier mydbsnapshot
```

For Windows:

```
aws rds delete-db-snapshot ^
    --db-snapshot-identifier mydbsnapshot
```

RDS API

You can delete a DB snapshot by using the Amazon RDS API operation DeleteDBSnapshot.

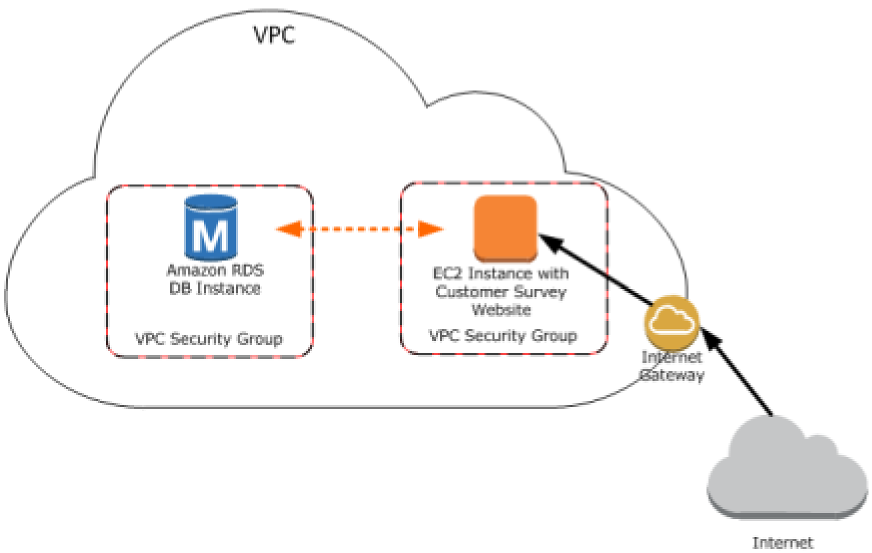
The following parameters are used to delete a DB snapshot.

- `DBSnapshotIdentifier` – The identifier for the DB snapshot.

Tutorial: Restore a DB Instance from a DB Snapshot

A common scenario when working with Amazon RDS is to have a DB instance that you work with occasionally but that you don't need full time. For example, you might have a quarterly customer survey that uses an Amazon Elastic Compute Cloud (Amazon EC2) instance to host a customer survey website and a DB instance that is used to store the survey results. One way to save money on such a scenario is to take a DB snapshot of the DB instance after the survey is completed, delete the DB instance, and then restore the DB instance when you need to conduct the survey again.

In the following illustration, you can see a possible scenario where an EC2 instance hosting a customer survey website is in the same Amazon Virtual Private Cloud (Amazon VPC) as a DB instance that retains the customer survey data. Note that each instance has its own security group; the EC2 instance security group allows access from the internet while the DB instance security group allows access only to and from the EC2 instance. When the survey is done, the EC2 instance can be stopped and the DB instance can be deleted after a final DB snapshot is created. When you need to conduct another survey, you can restart the EC2 instance and restore the DB instance from the DB snapshot.



For information about how to set up the needed VPC security groups for this scenario that allows the EC2 instance to connect with the DB instance, see A DB Instance in a VPC Accessed by an EC2 Instance in the Same VPC (p. 1435).

You must create a DB snapshot before you can restore a DB instance from one. When you restore the DB instance, you provide the name of the DB snapshot to restore from, and then provide a name for the new DB instance that is created from the restore operation. You cannot restore from a DB snapshot to an existing DB instance; a new DB instance is created when you restore.

Prerequisites for Restoring a DB Instance from a DB Snapshot

Some settings on the restored DB instance are reset when the instance is restored, so you must retain the original resources to be able to restore the DB instance to its previous settings. For example, when you restore a DB instance from a DB snapshot, the default DB parameter and a default security group are associated with the restored instance. That association means that the default security group does not allow access to the DB instance, and no custom parameter settings are available in the default parameter group. You need to retain the DB parameter group and security group associated with the DB instance that was used to create the DB snapshot.

The following are required before you can restore a DB instance from a DB snapshot:

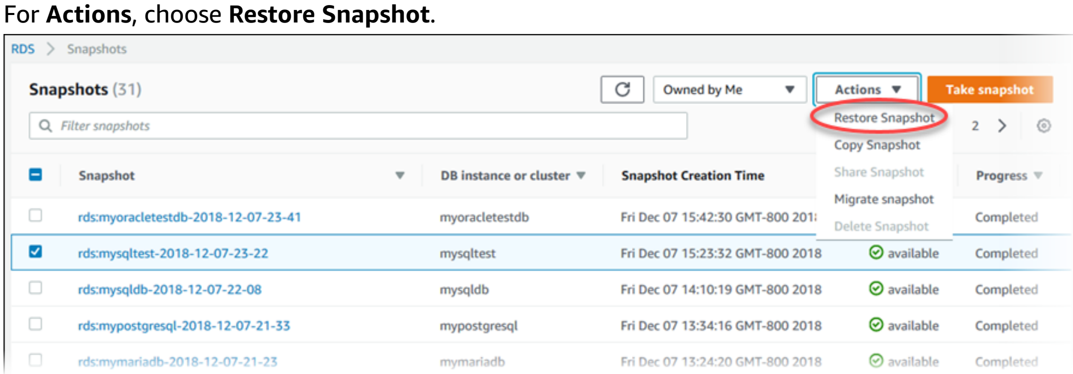
- You must have created a DB snapshot of a DB instance before you can restore a DB instance from that DB snapshot. For more information about creating a DB snapshot, see Creating a DB Snapshot (p. 301).
- You must retain the parameter group and security group associated with the DB instance you created the DB snapshot from.
- You need to determine the correct option group for the restored DB instance:
  - The option group associated with the DB snapshot that you restore from is associated with the restored DB instance once it is created. For example, if the DB snapshot you restore from uses Oracle Transparent Data Encryption (TDE), the restored DB instance uses the same option group, which had the TDE option.
  - You cannot use the option group associated with the original DB instance if you attempt to restore that instance into a different VPC or into a different platform. This restriction occurs because when an option group is assigned to a DB instance, it is also linked to the platform that the DB instance is on, either VPC or EC2-Classic (non-VPC). If a DB instance is in a VPC, the option group associated with the instance is linked to that VPC.
  - If you restore a DB instance into a different VPC or onto a different platform, you must either assign the default option group to the instance, assign an option group that is linked to that VPC or platform, or create a new option group and assign it to the DB instance. Note that with persistent or permanent options, such as Oracle TDE, you must create a new option group that includes the persistent or permanent option when restoring a DB instance into a different VPC. For more information about working with option groups, see Working with Option Groups (p. 186).

Restoring a DB Instance from a DB Snapshot

You can use the procedure following to restore from a snapshot in the AWS Management Console.

To restore a DB instance from a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the DB snapshot that you want to restore from.
4. For **Actions**, choose **Restore Snapshot**.



The **Restore DB Instance** page appears.

5. For **DB Instance Identifier** under **Settings**, enter the name that you want to use for the restored DB instance. If you are restoring from a DB instance that you deleted after you made the DB snapshot, you can use the name of that DB instance.
6. Choose **Restore DB Instance**.

Modifying a Restored DB Instance

As soon as the restore operation is complete, you should associate the custom security group used by the instance you restored from with any applicable custom DB parameter group that you might have. Only the default DB parameter and security groups are associated with the restored instance. If you want to restore the functionality of the DB instance to that of the DB instance that the snapshot was created from, you must modify the DB instance to use the security group and parameter group used by the previous DB instance.

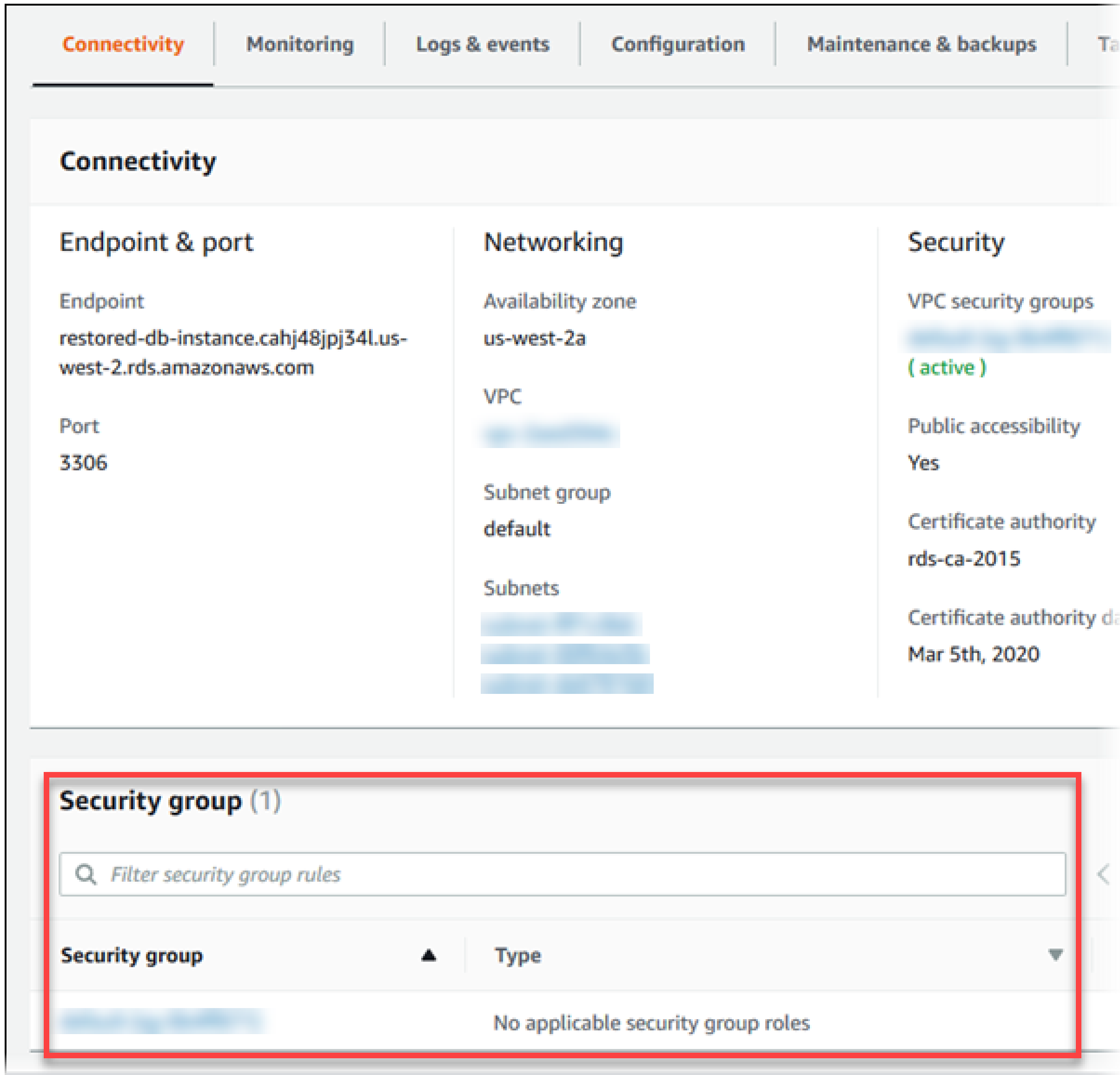
You must apply any changes explicitly using the RDS console's **Modify** command, the `ModifyDBInstance` API, or the `aws rds modify-db-instance` command line tool, once the DB instance is available. We recommend that you retain parameter groups for any DB snapshots you have so that you can associate a restored instance with the correct parameter file.

You can modify other settings on the restored DB instance. For example, you can use a different storage type than the source DB snapshot. In this case the restoration process is slower because of the additional work required to migrate the data to the new storage type. In the case of restoring to or from Magnetic (Standard) storage, the migration process is the slowest, because Magnetic storage does not have the IOPS capability of Provisioned IOPS or General Purpose (SSD) storage.

The next steps assume that your DB instance is in a VPC. If your DB instance is not in a VPC, use the AWS Management Console to locate the DB security group you need for the DB instance.

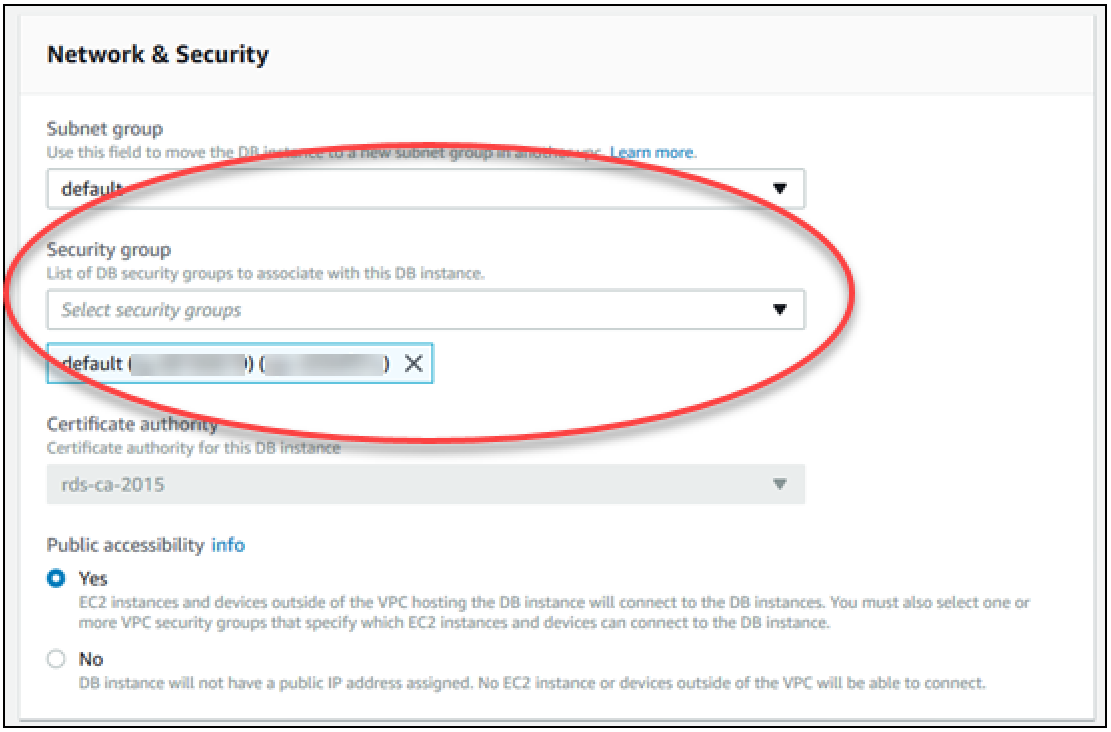
To modify a restored DB instance to have the settings of the original DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the name of the DB instance created when you restored from the DB snapshot to display its details. Choose the **Connectivity** tab. The security group assigned to the DB instance might not allow access. If there are no inbound rules, no permissions exist that allow inbound access.



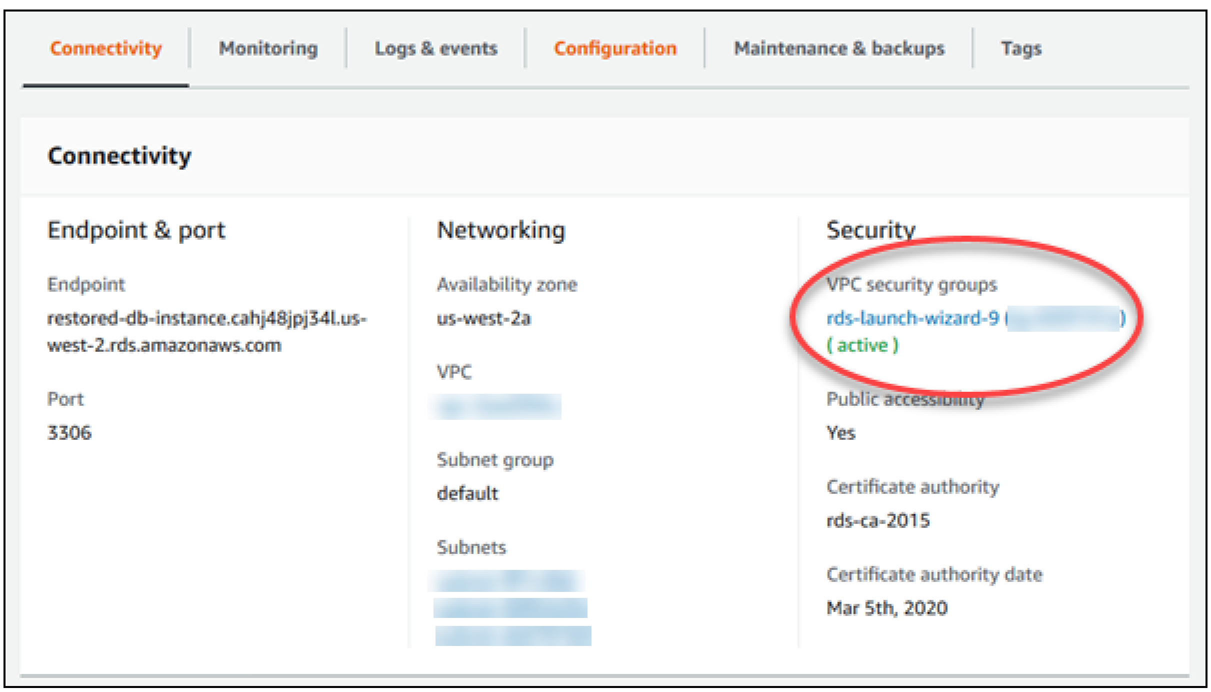
4. Choose **Modify**.
5. In the **Network & Security** section, choose the security group that you want to use for your DB instance. If you need to add rules to create a new security group to use with an EC2 instance, see A DB Instance in a VPC Accessed by an EC2 Instance in the Same VPC (p. 1435) for more information.

   You can also remove a security group by choosing the **X** associated with it.



6. Choose **Continue**, and then choose **Apply immediately**.
7. Choose **Modify DB Instance**.

   After the instance status is available, choose the DB instance name to display its details. Choose the **Connectivity** tab, and confirm that the new security group has been applied, making the DB instance authorized for access.



Monitoring an Amazon RDS DB Instance

This section shows you how to monitor Amazon RDS.

Topics

Overview of Monitoring Amazon RDS

Monitoring is an important part of maintaining the reliability, availability, and performance of Amazon RDS and your AWS solutions. You should collect monitoring data from all of the parts of your AWS solution so that you can more easily debug a multi-point failure if one occurs. Before you start monitoring Amazon RDS, we recommend that you create a monitoring plan that includes answers to the following questions:

- What are your monitoring goals?
- What resources will you monitor?
- How often will you monitor these resources?
- What monitoring tools will you use?
- Who will perform the monitoring tasks?
- Who should be notified when something goes wrong?

The next step is to establish a baseline for normal Amazon RDS performance in your environment. To do this, you measure performance at various times and under different load conditions. As you monitor Amazon RDS, consider storing historical monitoring data. This stored data gives you a baseline to compare against with current performance data, identify normal performance patterns and performance anomalies, and devise methods to address issues.

For example, with Amazon RDS, you can monitor network throughput, client connections, I/O for read, write, or metadata operations, and burst credit balances for your DB instances. When performance falls outside your established baseline, you might need to make changes to optimize your database availability for your workload. For example, you might need to change the instance class of your DB instance. Or you might need to change the number of DB instances and read replicas that are available for clients.

In general, acceptable values for performance metrics depend on what your baseline looks like and what your application is doing. Investigate consistent or trending variances from your baseline. Advice about specific types of metrics follows:

- **High CPU or RAM consumption** – High values for CPU or RAM consumption might be appropriate, if they're in keeping with your goals for your application (like throughput or concurrency) and are expected.
- **Disk space consumption** – Investigate disk space consumption if space used is consistently at or above 85 percent of the total disk space. See if it is possible to delete data from the instance or archive data to a different system to free up space.
- **Network traffic** – For network traffic, talk with your system administrator to understand what expected throughput is for your domain network and internet connection. Investigate network traffic if throughput is consistently lower than expected.
- **Database connections** – If you see high numbers of user connections and also decreases in instance performance and response time, consider constraining database connections. The best number of user connections for your DB instance varies based on your instance class and the complexity of the operations being performed. To determine the number of database connections, associate your DB instance with a parameter group where the `User Connections` parameter is set to a value other than 0 (unlimited). You can either use an existing parameter group or create a new one. For more information, see Working with DB Parameter Groups (p. 202).
- **IOPS metrics** – The expected values for IOPS metrics depend on disk specification and server configuration, so use your baseline to know what is typical. Investigate if values are consistently different than your baseline. For best IOPS performance, make sure that your typical working set fits into memory to minimize read and write operations.

Monitoring Tools

AWS provides various tools that you can use to monitor Amazon RDS. You can configure some of these tools to do the monitoring for you, and other tools require manual intervention. We recommend that you automate monitoring tasks as much as possible.

Automated Monitoring Tools

You can use the following automated monitoring tools to watch Amazon RDS and report when something is wrong:

- **Amazon RDS Events** – Subscribe to Amazon RDS events to be notified when changes occur with a DB instance, DB snapshot, DB parameter group, or DB security group. For more information, see Using Amazon RDS Event Notification (p. 429).
- **Database log files** – View, download, or watch database log files using the Amazon RDS console or Amazon RDS API operations. You can also query some database log files that are loaded into database tables. For more information, see Amazon RDS Database Log Files (p. 453).
- **Amazon RDS Enhanced Monitoring** — Look at metrics in real time for the operating system. For more information, see Enhanced Monitoring (p. 362).
- **Amazon RDS Performance Insights** — Assess the load on your database, and determine when and where to take action. For more information, see Using Amazon RDS Performance Insights (p. 376).
- **Amazon RDS Recommendations** — Look at automated recommendations for database resources, such as DB instances, read replicas, and DB parameter groups. For more information, see Using Amazon RDS Recommendations (p. 424).

In addition, Amazon RDS integrates with Amazon CloudWatch, Amazon EventBridge, and AWS CloudTrail for additional monitoring capabilities:

- **Amazon CloudWatch Metrics** – Amazon RDS automatically sends metrics to CloudWatch every minute for each active database. You don't get additional charges for Amazon RDS metrics in CloudWatch. For more information, see the section called “Viewing DB Instance Metrics” (p. 356).
- **Amazon CloudWatch Alarms** – You can watch a single Amazon RDS metric over a specific time period. You can then perform one or more actions based on the value of the metric relative to a threshold that you set. For more information, see Monitoring with Amazon CloudWatch (p. 348).
- **Amazon CloudWatch Logs** – Most DB engines enable you to monitor, store, and access your database log files in CloudWatch Logs. For more information, see Amazon CloudWatch Logs User Guide.
- **Amazon CloudWatch Events and Amazon EventBridge** – You can automate AWS services and respond to system events such as application availability issues or resource changes. Events from AWS services are delivered to CloudWatch Events and EventBridge nearly in real time. You can write simple rules to indicate which events interest you and what automated actions to take when an event matches a rule. For more information, see Getting CloudWatch Events and Amazon EventBridge Events for Amazon RDS (p. 450).
- **AWS CloudTrail** – You can view a record of actions taken by a user, role, or an AWS service in Amazon RDS. CloudTrail captures all API calls for Amazon RDS as events. These captures include calls from the Amazon RDS console and from code calls to the Amazon RDS API operations. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for Amazon RDS. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. For more information, see Logging Amazon RDS API Calls with AWS CloudTrail (p. 487).

Manual Monitoring Tools

Another important part of monitoring Amazon RDS involves manually monitoring those items that the CloudWatch alarms don't cover. The Amazon RDS, CloudWatch, AWS Trusted Advisor and other AWS console dashboards provide an at-a-glance view of the state of your AWS environment. We recommend that you also check the log files on your DB instance.

- From the Amazon RDS console, you can monitor the following items for your resources:
  - The number of connections to a DB instance
  - The amount of read and write operations to a DB instance
  - The amount of storage that a DB instance is currently using
  - The amount of memory and CPU being used for a DB instance
  - The amount of network traffic to and from a DB instance
- From the Trusted Advisor dashboard, you can review the following cost optimization, security, fault tolerance, and performance improvement checks:
  - Amazon RDS Idle DB Instances
  - Amazon RDS Security Group Access Risk
  - Amazon RDS Backups
  - Amazon RDS Multi-AZ

  For more information on these checks, see Trusted Advisor Best Practices (Checks).
- CloudWatch home page shows:
  - Current alarms and status
  - Graphs of alarms and resources
  - Service health status

  In addition, you can use CloudWatch to do the following:
  - Create customized dashboards to monitor the services that you care about.
  - Graph metric data to troubleshoot issues and discover trends.
  - Search and browse all your AWS resource metrics.
  - Create and edit alarms to be notified of problems.

Monitoring with Amazon CloudWatch

You can monitor DB instances using Amazon CloudWatch, which collects and processes raw data from Amazon RDS into readable, near real-time metrics. By default, Amazon RDS metric data is automatically sent to CloudWatch in 1-minute periods. For more information about CloudWatch, see What Is Amazon CloudWatch? in the *Amazon CloudWatch User Guide*.

Data points with a period of 60 seconds (1 minute) are available for 15 days. This means that you can access historical information and gain a better perspective on how your web application or service is performing. For more information about CloudWatch metrics retention, see Metrics Retention in the *Amazon CloudWatch User Guide*.

> **Note**
> If you are using Amazon RDS Performance Insights, additional metrics are available. For more information, see Performance Insights Metrics Published to Amazon CloudWatch (p. 410).

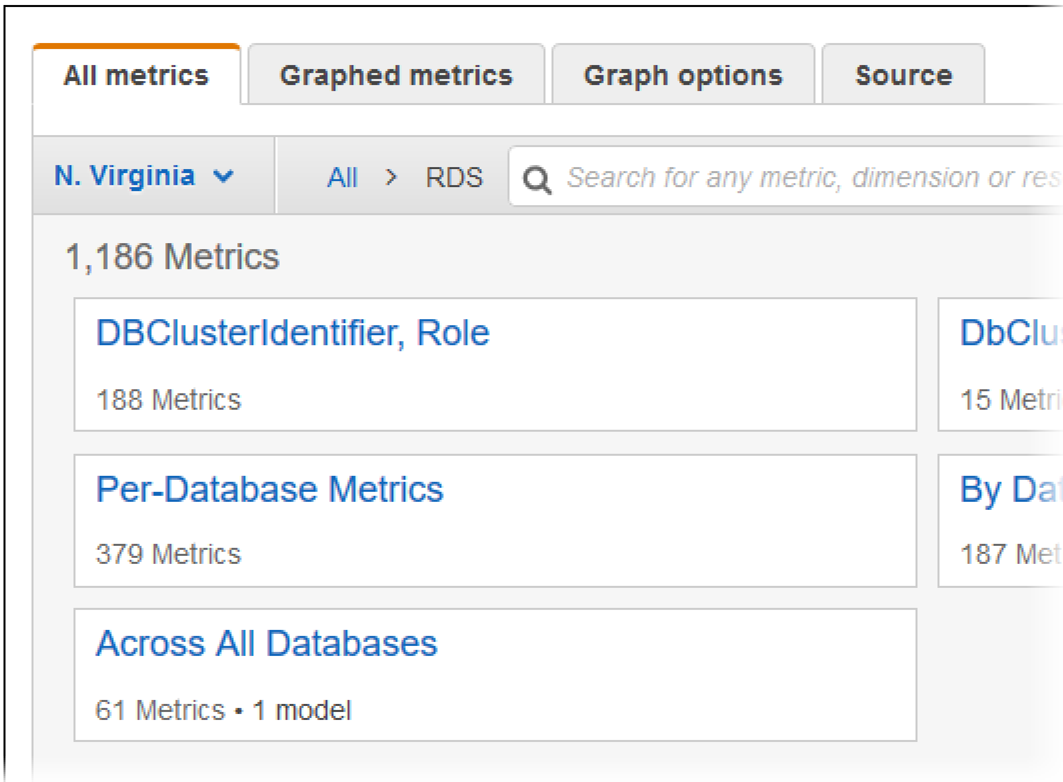
Amazon RDS Metrics and Dimensions

When you use Amazon RDS resources, Amazon RDS sends metrics and dimensions to Amazon CloudWatch every minute. You can use the following procedures to view the metrics for Amazon RDS.

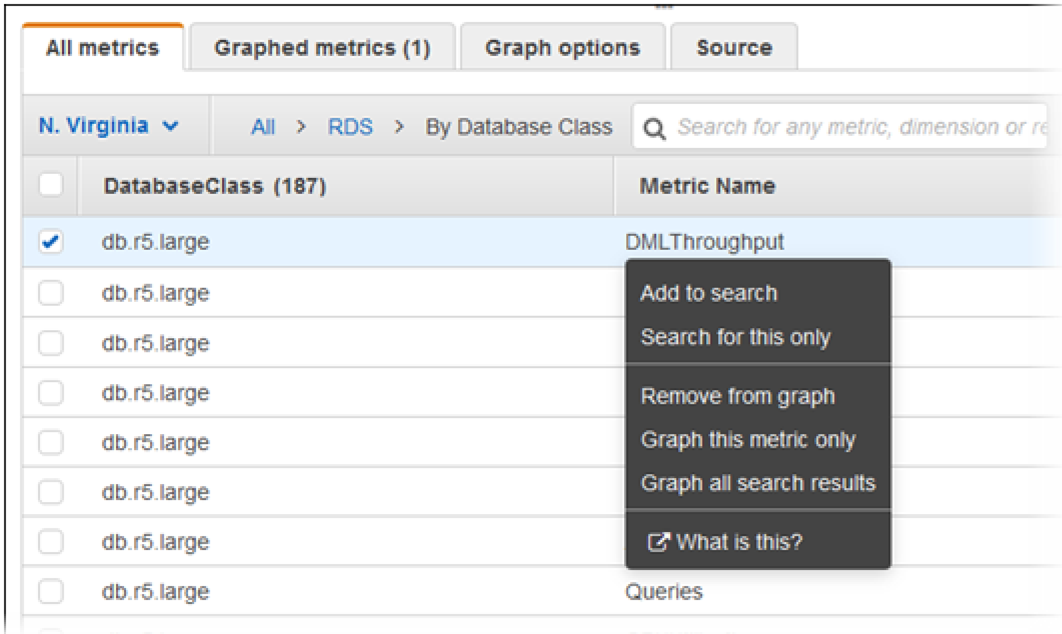
To view metrics using the Amazon CloudWatch console

Metrics are grouped first by the service namespace, and then by the various dimension combinations within each namespace.

1. Open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. If necessary, change the AWS Region. From the navigation bar, choose the AWS Region where your AWS resources are. For more information, see Regions and Endpoints.
3. In the navigation pane, choose **Metrics**. Choose the **RDS** metric namespace.



4. Choose a metric dimension, for example **By Database Class**.
5. To sort the metrics, use the column heading. To graph a metric, select the check box next to the metric. To filter by resource, choose the resource ID, and then choose **Add to search**. To filter by metric, choose the metric name, and then choose **Add to search**.



To view metrics using the AWS CLI

- At a command prompt, use the following command.

```
aws cloudwatch list-metrics --namespace AWS/RDS
```

Amazon RDS Metrics

The `AWS/RDS` namespace includes the following metrics.

> **Note**
> The Amazon RDS console might display metrics in units that are different from the units sent to Amazon CloudWatch. For example, the Amazon RDS console might display a metric in megabytes (MB), while the metric is sent to Amazon CloudWatch in bytes.

Metric	Console Name	Description
`BinLogDiskUsage`	**Binary Log Disk Usage (MB)**	The amount of disk space occupied by binary logs on the master. Applies to MySQL read replicas. Units: Bytes
`BurstBalance`	**Burst Balance (Percent)**	The percent of General Purpose SSD (gp2) burst-bucket I/O credits available. Units: Percent
`CPUUtilization`	**CPU Utilization (Percent)**	The percentage of CPU utilization. Units: Percent
`CPUCreditUsage`	**CPU Credit Usage (Count)**	(T2 instances) The number of CPU credits spent by the instance for CPU utilization. One CPU credit

Metric	Console Name	Description
		equals one vCPU running at 100 percent utilization for one minute or an equivalent combination of vCPUs, utilization, and time. For example, you might have one vCPU running at 50 percent utilization for two minutes or two vCPUs running at 25 percent utilization for two minutes. CPU credit metrics are available at a five-minute frequency only. If you specify a period greater than five minutes, use the `Sum` statistic instead of the `Average` statistic. Units: Credits (vCPU-minutes)
`CPUCreditBalance`	**CPU Credit Balance (Count)**	(T2 instances) The number of earned CPU credits that an instance has accrued since it was launched or started. For T2 Standard, the `CPUCreditBalance` also includes the number of launch credits that have been accrued. Credits are accrued in the credit balance after they are earned, and removed from the credit balance when they are spent. The credit balance has a maximum limit, determined by the instance size. After the limit is reached, any new credits that are earned are discarded. For T2 Standard, launch credits don't count towards the limit. The credits in the `CPUCreditBalance` are available for the instance to spend to burst beyond its baseline CPU utilization. When an instance is running, credits in the `CPUCreditBalance` don't expire. When the instance stops, the `CPUCreditBalance` does not persist, and all accrued credits are lost. CPU credit metrics are available at a five-minute frequency only. Units: Credits (vCPU-minutes)
`DatabaseConnections`	**DB Connections (Count)**	The number of database connections in use. The metric value might not include broken database connections that haven't been cleaned up by your database yet. So, the number of database connections recorded by your database might be higher than the metric value. Units: Count
`DiskQueueDepth`	**Queue Depth (Count)**	The number of outstanding I/Os (read/write requests) waiting to access the disk. Units: Count

Metric	Console Name	Description
`FailedSQLServerAgentJobsCount`	**Failed SQL Server Agent Jobs Count (Count/Minute)**	The number of failed Microsoft SQL Server Agent jobs during the last minute. Unit: Count/Minute
`FreeableMemory`	**Freeable Memory (MB)**	The amount of available random access memory. For MariaDB, MySQL, Oracle, and PostgreSQL DB instances, this metric reports the value of the `MemAvailable` field of `/proc/meminfo`. Units: Bytes
`FreeStorageSpace`	**Free Storage Space (MB)**	The amount of available storage space. Units: Bytes
`MaximumUsedTransactionIDs`	**Maximum Used Transaction IDs (Count)**	The maximum transaction IDs that have been used. Applies to PostgreSQL. Units: Count
`NetworkReceiveThroughput`	**Network Receive Throughput (MB/Second)**	The incoming (receive) network traffic on the DB instance, including both customer database traffic and Amazon RDS traffic used for monitoring and replication. Units: Bytes/Second
`NetworkTransmitThroughput`	**Network Transmit Throughput (MB/Second)**	The outgoing (transmit) network traffic on the DB instance, including both customer database traffic and Amazon RDS traffic used for monitoring and replication. Units: Bytes/Second
`OldestReplicationSlotLag`	**Oldest Replication Slot Lag (MB)**	The lagging size of the replica lagging the most in terms of write-ahead log (WAL) data received. Applies to PostgreSQL. Units: Megabytes
`ReadIOPS`	**Read IOPS (Count/Second)**	The average number of disk read I/O operations per second. Units: Count/Second
`ReadLatency`	**Read Latency (Milliseconds)**	The average amount of time taken per disk I/O operation. Units: Seconds
`ReadThroughput`	**Read Throughput (MB/Second)**	The average number of bytes read from disk per second. Units: Bytes/Second

Metric	Console Name	Description
`ReplicaLag`	**Replica Lag (Milliseconds)**	The amount of time a read replica DB instance lags behind the source DB instance. Applies to MySQL, MariaDB, Oracle, PostgreSQL, and SQL Server read replicas. Units: Seconds
`ReplicationSlotDiskUsage`	**Replica Slot Disk Usage (MB)**	The disk space used by replication slot files. Applies to PostgreSQL. Units: Megabytes
`SwapUsage`	**Swap Usage (MB)**	The amount of swap space used on the DB instance. This metric is not available for SQL Server. Units: Bytes
`TransactionLogsDiskUsage`	**Transaction Logs Disk Usage (MB)**	The disk space used by transaction logs. Applies to PostgreSQL. Units: Megabytes
`TransactionLogsGeneration`	**Transaction Logs Generation (MB/Second)**	The size of transaction logs generated per second. Applies to PostgreSQL. Units: Bytes/Second
`WriteIOPS`	**Write IOPS (Count/Second)**	The average number of disk write I/O operations per second. Units: Count/Second
`WriteLatency`	**Write Latency (Milliseconds)**	The average amount of time taken per disk I/O operation. Units: Seconds
`WriteThroughput`	**Write Throughput (MB/Second)**	The average number of bytes written to disk per second. Units: Bytes/Second

Amazon RDS Dimensions

Amazon RDS metrics data can be filtered by using any of the dimensions in the following table:

Dimension	Description
`DBInstanceIdentifier`	This dimension filters the data that you request for a specific DB instance.
`DBClusterIdentifier`	This dimension filters the data that you request for a specific Amazon Aurora DB cluster.
`DBClusterIdentifier, Role`	This dimension filters the data that you request for a specific Aurora DB cluster, aggregating the metric by instance role (WRITER/

Dimension	Description
	READER). For example, you can aggregate metrics for all READER instances that belong to a cluster.
`DatabaseClass`	This dimension filters the data that you request for all instances in a database class. For example, you can aggregate metrics for all instances that belong to the database class `db.r5.large`.
`EngineName`	This dimension filters the data that you request for the identified engine name only. For example, you can aggregate metrics for all instances that have the engine name `mysql`.
`SourceRegion`	This dimension filters the data that you request for the specified region only. For example, you can aggregate metrics for all instances in the `us-east-1` Region.

Creating CloudWatch Alarms to Monitor Amazon RDS

You can create a CloudWatch alarm that sends an Amazon SNS message when the alarm changes state. An alarm watches a single metric over a time period that you specify. The alarm can also perform one or more actions based on the value of the metric relative to a given threshold over a number of time periods. The action is a notification sent to an Amazon SNS topic or Amazon EC2 Auto Scaling policy.

Alarms invoke actions for sustained state changes only. CloudWatch alarms don't invoke actions simply because they are in a particular state. The state must have changed and have been maintained for a specified number of time periods. The following procedures show how to create alarms for Amazon RDS.

To set alarms using the CloudWatch console

1. Sign in to the AWS Management Console and open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. Choose **Alarms** and then choose **Create Alarm**. Doing this launches the Create Alarm Wizard.
3. Choose **RDS Metrics** and scroll through the Amazon RDS metrics to find the metric that you want to place an alarm on. To display just Amazon RDS metrics, search for the identifier of your resource. Choose the metric to create an alarm on and then choose **Next**.
4. Enter **Name**, **Description**, and **Whenever** values for the metric.
5. If you want CloudWatch to send you an email when the alarm state is reached, for **Whenever this alarm**, choose **State is ALARM**. For **Send notification to**, choose an existing SNS topic. If you choose **Create topic**, you can set the name and email addresses for a new email subscription list. This list is saved and appears in the field for future alarms.

   Note
   If you use **Create topic** to create a new Amazon SNS topic, the email addresses must be verified before they receive notifications. Emails are only sent when the alarm enters an alarm state. If this alarm state change happens before the email addresses are verified, the addresses don't receive a notification.
6. Preview the alarm that you're about to create in the **Alarm Preview** area, and then choose **Create Alarm**.

To set an alarm using the AWS CLI

- Call `put-metric-alarm`. For more information, see *AWS CLI Command Reference*.

To set an alarm using the CloudWatch API

- Call `PutMetricAlarm`. For more information, see *Amazon CloudWatch API Reference*

Publishing Database Engine Logs to Amazon CloudWatch Logs

You can configure your Amazon RDS database engine to publish log data to a log group in Amazon CloudWatch Logs. With CloudWatch Logs, you can perform real-time analysis of the log data, and use CloudWatch to create alarms and view metrics. You can use CloudWatch Logs to store your log records in highly durable storage, which you can manage with the CloudWatch Logs Agent. For example, you can determine when to rotate log records from a host to the log service, so you can access the raw logs when you need to.

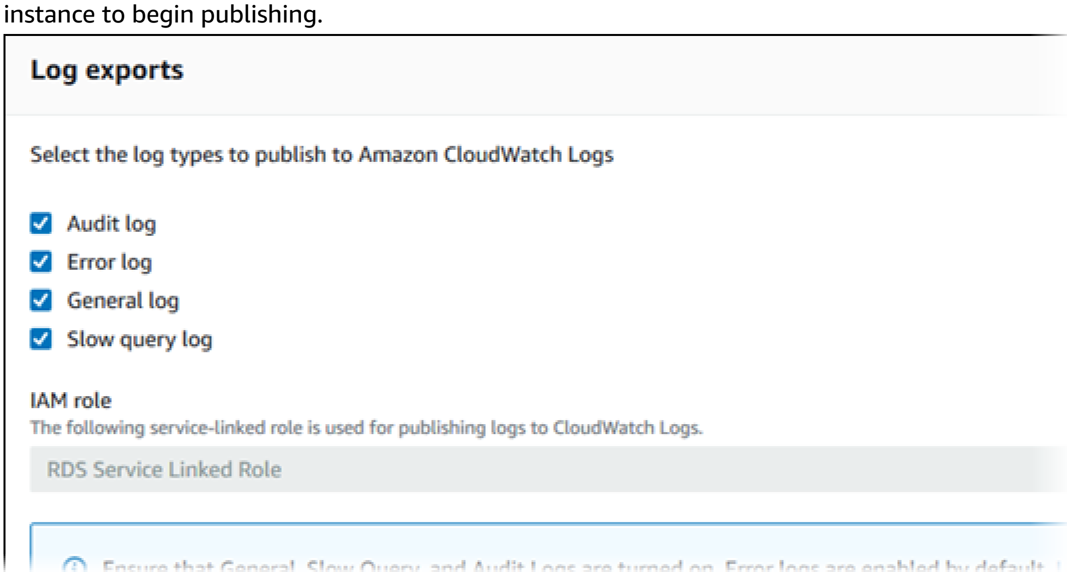
For engine-specific information, see the following topics:

- the section called “Publishing MariaDB Logs to Amazon CloudWatch Logs” (p. 458)
- the section called “Publishing MySQL Logs to CloudWatch Logs” (p. 470)
- the section called “Publishing Oracle Logs to Amazon CloudWatch Logs” (p. 478)
- the section called “Publishing PostgreSQL Logs to CloudWatch Logs” (p. 483)
- the section called “Publishing SQL Server Logs to Amazon CloudWatch Logs” (p. 465)

Note
Before you enable log data publishing, make sure that you have a service-linked role in AWS Identity and Access Management (IAM). For more information about service-linked roles, see Using Service-Linked Roles for Amazon RDS (p. 1429).

Configuring CloudWatch Log Integration

To publish your database log files to CloudWatch Logs, choose which logs to publish. Make this choice in the **Advanced Settings** section when you create a new DB instance. You can also modify an existing DB instance to begin publishing.



After you have enabled publishing, Amazon RDS continuously streams all of the DB instance log records to a log group. For example, you have a log group `/aws/rds/instance/log type` for each type of log that you publish. This log group is in the same AWS Region as the database instance that generates the log.

After you have published log records, you can use CloudWatch Logs to search and filter the records. For more information about searching and filtering logs, see Searching and Filtering Log Data.

Viewing DB Instance Metrics

Amazon RDS provides metrics so that you can monitor the health of your DB instances. You can monitor both DB instance metrics and operating system (OS) metrics.

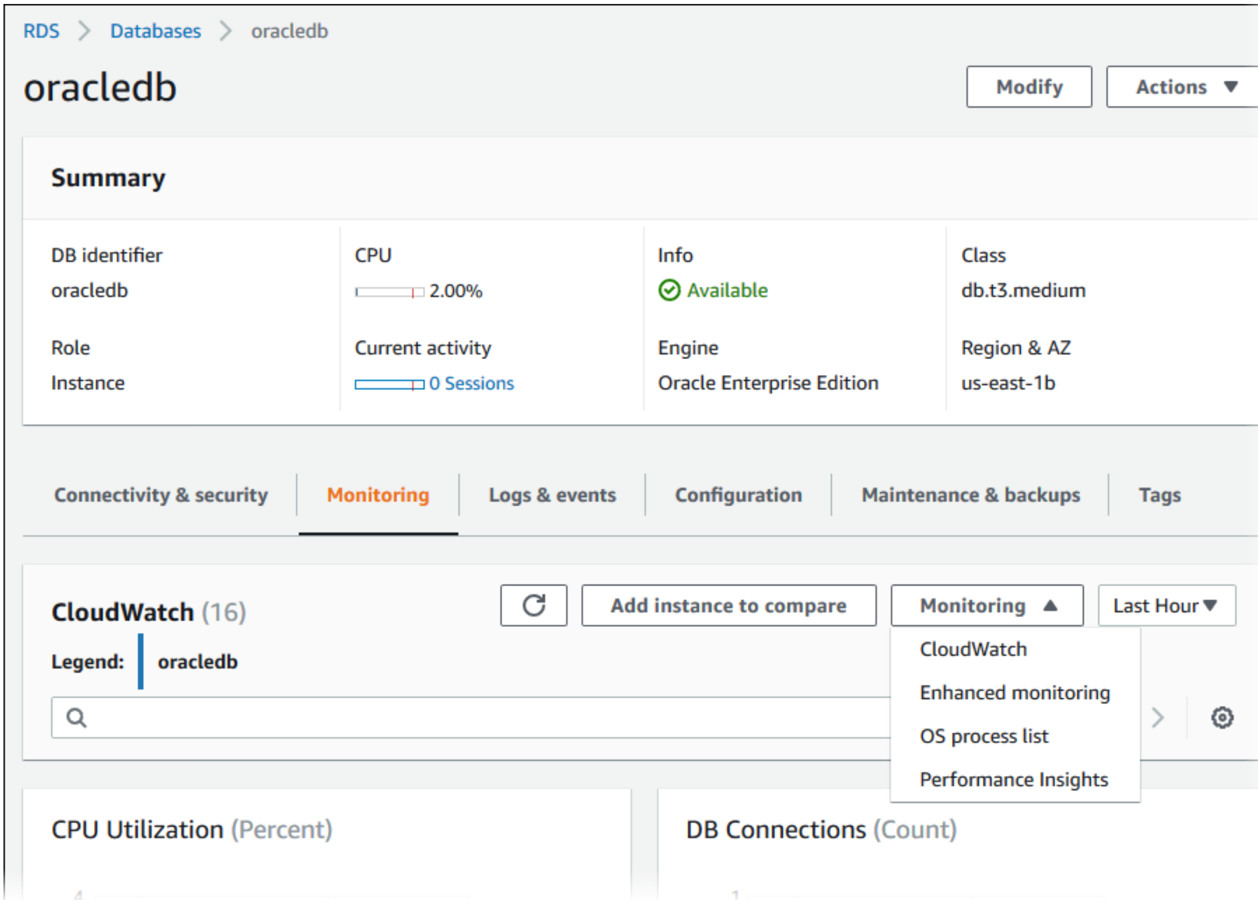
Following, you can find details about how to view metrics for your DB instance using the RDS console and CloudWatch. For information on monitoring metrics for your DB instance's operating system in real time using CloudWatch Logs, see Enhanced Monitoring (p. 362).

Viewing Metrics by Using the Console

To view DB and OS metrics for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the name of the DB instance that you need information about to show its details.
4. Choose the **Monitoring** tab.
5. For **Monitoring**, choose the option for how you want to view your metrics from these:

   - **CloudWatch** – Shows a summary of DB instance metrics available from Amazon CloudWatch. Each metric includes a graph showing the metric monitored over a specific time span.
   - **Enhanced monitoring** – Shows a summary of OS metrics available for a DB instance with Enhanced Monitoring enabled. Each metric includes a graph showing the metric monitored over a specific time span.
   - **OS Process list** – Shows details for each process running in the selected instance.
   - **Performance Insights** – Opens the Amazon RDS Performance Insights console for your DB instance.



Tip
To choose the time range of the metrics represented by the graphs, you can use the time range list.
To bring up a more detailed view, you can choose any graph. You can also apply metric-specific filters to the data.

Viewing DB Instance Metrics with the CLI or API

Amazon RDS integrates with CloudWatch metrics to provide a variety of DB instance metrics. You can view CloudWatch metrics using the RDS console, AWS CLI, or API.

For a complete list of Amazon RDS metrics, go to Amazon RDS Dimensions and Metrics in the *Amazon CloudWatch User Guide*.

Viewing DB Metrics by Using the CloudWatch CLI

Note
The following CLI example requires the CloudWatch command line tools. For more information on CloudWatch and to download the developer tools, see Amazon CloudWatch on the AWS website. The `StartTime` and `EndTime` values supplied in this example are for illustration only. Substitute appropriate start and end time values for your DB instance.

To view usage and performance statistics for a DB instance

- Use the CloudWatch command `mon-get-stats` with the following parameters.

```
PROMPT>mon-get-stats FreeStorageSpace --dimensions="DBInstanceIdentifier=mydbinstance"
 --statistics= Average
  --namespace="AWS/RDS" --start-time 2009-10-16T00:00:00 --end-time 2009-10-16T00:02:00
```

Viewing DB Metrics by Using the CloudWatch API

The `StartTime` and `EndTime` values supplied in this example are for illustration only. Substitute appropriate start and end time values for your DB instance.

To view usage and performance statistics for a DB instance

- Call the CloudWatch API `GetMetricStatistics` with the following parameters:
  - `Statistics.member.1` = `Average`
  - `Namespace` = `AWS/RDS`
  - `StartTime` = `2009-10-16T00:00:00`
  - `EndTime` = `2009-10-16T00:02:00`
  - `Period` = `60`
  - `MeasureName` = `FreeStorageSpace`

DB Instance Status

The status of a DB instance indicates the health of the DB instance. You can view the status of a DB instance by using the Amazon RDS console, the AWS CLI command describe-db-instances, or the API operation DescribeDBInstances.

> **Note**
> Amazon RDS also uses another status called *maintenance status*, which is shown in the **Maintenance** column of the Amazon RDS console. This value indicates the status of any maintenance patches that need to be applied to a DB instance. Maintenance status is independent of DB instance status. For more information on *maintenance status*, see Applying Updates for a DB Instance (p. 236).

Find the possible status values for DB instances in the following table, which also shows how you are billed for each status. It shows if you will be billed for the DB instance and storage, billed only for storage, or not billed. For all DB instance statuses, you are always billed for backup usage.

DB Instance Status	Billed	Description
available	Billed	The DB instance is healthy and available.
backing-up	Billed	The DB instance is currently being backed up.
backtracking	Billed	The DB instance is currently being backtracked. This status only applies to Aurora MySQL.
configuring-enhanced-monitoring	Billed	Enhanced Monitoring is being enabled or disabled for this DB instance.
configuring-iam-database-auth	Billed	AWS Identity and Access Management (IAM) database authentication is being enabled or disabled for this DB instance.
configuring-log-exports	Billed	Publishing log files to Amazon CloudWatch Logs is being enabled or disabled for this DB instance.
converting-to-vpc	Billed	The DB instance is being converted from a DB instance that is not in an Amazon Virtual Private Cloud (Amazon VPC) to a DB instance that is in an Amazon VPC.
creating	Not billed	The DB instance is being created. The DB instance is inaccessible while it is being created.
deleting	Not billed	The DB instance is being deleted.
failed	Not billed	The DB instance has failed and Amazon RDS can't recover it. Perform a point-in-time restore to the latest restorable time of the DB instance to recover the data.
inaccessible-encryption-credentials	Not billed	The AWS KMS key used to encrypt or decrypt the DB instance can't be accessed.
incompatible-network	Not billed	Amazon RDS is attempting to perform a recovery action on a DB instance but can't do so because the VPC is in a state that prevents the action from being completed. This status can occur if, for example, all available IP addresses in a subnet are in use and Amazon RDS can't get an IP address for the DB instance.

DB Instance Status	Billed	Description
incompatible-option-group	Billed	Amazon RDS attempted to apply an option group change but can't do so, and Amazon RDS can't roll back to the previous option group state. For more information, check the **Recent Events** list for the DB instance. This status can occur if, for example, the option group contains an option such as TDE and the DB instance doesn't contain encrypted information.
incompatible-parameters	Billed	Amazon RDS can't start the DB instance because the parameters specified in the DB instance's DB parameter group aren't compatible with the DB instance. Revert the parameter changes or make them compatible with the DB instance to regain access to your DB instance. For more information about the incompatible parameters, check the **Recent Events** list for the DB instance.
incompatible-restore	Not billed	Amazon RDS can't do a point-in-time restore. Common causes for this status include using temp tables, using MyISAM tables with MySQL, or using Aria tables with MariaDB.
maintenance	Billed	Amazon RDS is applying a maintenance update to the DB instance. This status is used for instance-level maintenance that RDS schedules well in advance.
modifying	Billed	The DB instance is being modified because of a customer request to modify the DB instance.
moving-to-vpc	Billed	The DB instance is being moved to a new Amazon Virtual Private Cloud (Amazon VPC).
rebooting	Billed	The DB instance is being rebooted because of a customer request or an Amazon RDS process that requires the rebooting of the DB instance.
renaming	Billed	The DB instance is being renamed because of a customer request to rename it.
resetting-master-credentials	Billed	The master credentials for the DB instance are being reset because of a customer request to reset them.
restore-error	Billed	The DB instance encountered an error attempting to restore to a point-in-time or from a snapshot.
starting	Billed for storage	The DB instance is starting.
stopped	Billed for storage	The DB instance is stopped.
stopping	Billed for storage	The DB instance is being stopped.

DB Instance Status	Billed	Description
storage-full	Billed	The DB instance has reached its storage capacity allocation. This is a critical status, and we recommend that you fix this issue immediately. To do so, scale up your storage by modifying the DB instance. To avoid this situation, set Amazon CloudWatch alarms to warn you when storage space is getting low.
storage-optimization	Billed	Your DB instance is being modified to change the storage size or type. The DB instance is fully operational. However, while the status of your DB instance is **storage-optimization**, you can't request any changes to the storage of your DB instance. The storage optimization process is usually short, but can sometimes take up to and even beyond 24 hours.
upgrading	Billed	The database engine version is being upgraded.

Enhanced Monitoring

Amazon RDS provides metrics in real time for the operating system (OS) that your DB instance runs on. You can view the metrics for your DB instance using the console, or consume the Enhanced Monitoring JSON output from Amazon CloudWatch Logs in a monitoring system of your choice.

By default, Enhanced Monitoring metrics are stored in the CloudWatch Logs for 30 days. To modify the amount of time the metrics are stored in the CloudWatch Logs, change the retention for the `RDSOSMetrics` log group in the CloudWatch console. For more information, see Change Log Data Retention in CloudWatch Logs in the *Amazon CloudWatch Logs User Guide*.

The cost for using Enhanced Monitoring depends on several factors:

- You are only charged for Enhanced Monitoring that exceeds the free tier provided by Amazon CloudWatch Logs.

  For more information about pricing, see Amazon CloudWatch Pricing.
- A smaller monitoring interval results in more frequent reporting of OS metrics and increases your monitoring cost.
- Usage costs for Enhanced Monitoring are applied for each DB instance that Enhanced Monitoring is enabled for. Monitoring a large number of DB instances is more expensive than monitoring only a few.
- DB instances that support a more compute-intensive workload have more OS process activity to report and higher costs for Enhanced Monitoring.

Enhanced Monitoring Availability

Enhanced Monitoring is available for the following database engines:

- MariaDB
- Microsoft SQL Server
- MySQL version 5.5 or later
- Oracle
- PostgreSQL

Enhanced Monitoring is available for all DB instance classes except for db.m1.small.

Differences Between CloudWatch and Enhanced Monitoring Metrics

CloudWatch gathers metrics about CPU utilization from the hypervisor for a DB instance, and Enhanced Monitoring gathers its metrics from an agent on the instance. As a result, you might find differences between the measurements, because the hypervisor layer performs a small amount of work. The differences can be greater if your DB instances use smaller instance classes, because then there are likely more virtual machines (VMs) that are managed by the hypervisor layer on a single physical instance. Enhanced Monitoring metrics are useful when you want to see how different processes or threads on a DB instance use the CPU.

Setting Up for and Enabling Enhanced Monitoring

To set up for and enable Enhanced Monitoring, take the steps listed following.

Before You Begin

Enhanced Monitoring requires permission to act on your behalf to send OS metric information to CloudWatch Logs. You grant Enhanced Monitoring the required permissions using an AWS Identity and Access Management (IAM) role.

The first time that you enable Enhanced Monitoring in the console, you can select the **Default** option for the **Monitoring Role** property to have RDS create the required IAM role. RDS then automatically creates a role named `rds-monitoring-role` for you, and uses it for the specified DB instance or read replica.

You can also create the required role before you enable Enhanced Monitoring, and then specify your new role's name when you enable Enhanced Monitoring. You must create this required role if you enable Enhanced Monitoring using the AWS CLI or the RDS API.

To create the appropriate IAM role to permit Amazon RDS to communicate with the Amazon CloudWatch Logs service on your behalf, take the following steps.

The user that enables Enhanced Monitoring must be granted the `PassRole` permission. For more information, see Example 2 in Granting a User Permissions to Pass a Role to an AWS Service in the *IAM User Guide*.

To create an IAM role for Amazon RDS Enhanced Monitoring

1. Open the IAM Console at https://console.aws.amazon.com.
2. In the navigation pane, choose **Roles**.
3. Choose **Create role**.
4. Choose the **AWS service** tab, and then choose **RDS** from the list of services.
5. Choose **RDS - Enhanced Monitoring**, and then choose **Next: Permissions**.
6. Ensure that the **Attached permissions policy** page shows **AmazonRDSEnhancedMonitoringRole**, and then choose **Next: Tags**.
7. On the **Add tags** page, choose **Next: Review**.
8. For **Role Name**, enter a name for your role, for example **`emaccess`**, and then choose **Create role**.

Enabling and Disabling Enhanced Monitoring

You can enable and disable Enhanced Monitoring using the AWS Management Console, AWS CLI, or RDS API.

Console

You can enable Enhanced Monitoring when you create a DB instance or read replica, or when you modify a DB instance. If you modify a DB instance to enable Enhanced Monitoring, you don't need to reboot your DB instance for the change to take effect.

You can enable Enhanced Monitoring in the RDS console when you do one of the following actions:

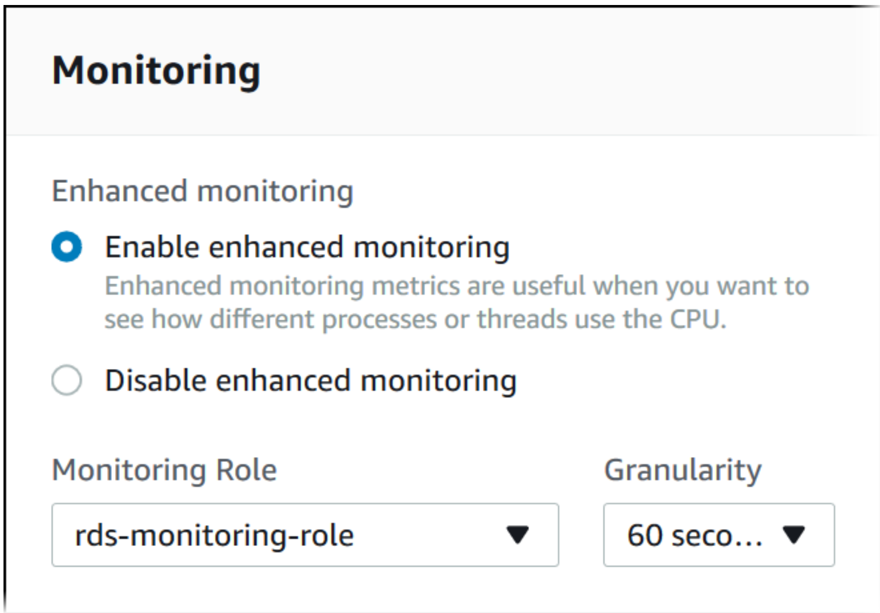
- **Create a DB instance** – You can enable Enhanced Monitoring in the **Monitoring** section under **Additional configuration**.
- **Create a read replica** – You can enable Enhanced Monitoring in the **Monitoring** section.
- **Modify a DB instance** – You can enable Enhanced Monitoring in the **Monitoring** section.

To enable Enhanced Monitoring by using the RDS console, scroll to the **Monitoring** section and do the following:

1. Choose **Enable enhanced monitoring** for your DB instance or read replica.

2. Set the **Monitoring Role** property to the IAM role that you created to permit Amazon RDS to communicate with Amazon CloudWatch Logs for you, or choose **Default** to have RDS create a role for you named `rds-monitoring-role`.
3. Set the **Granularity** property to the interval, in seconds, between points when metrics are collected for your DB instance or read replica. The **Granularity** property can be set to one of the following values: `1`, `5`, `10`, `15`, `30`, or `60`.

To disable Enhanced Monitoring, choose **Disable enhanced monitoring**.



Enabling Enhanced Monitoring doesn't require your DB instance to restart.

> **Note**
> The fastest that the RDS console refreshes is every 5 seconds. If you set the granularity to 1 second in the RDS console, you still see updated metrics only every 5 seconds. You can retrieve 1-second metric updates by using CloudWatch Logs.

AWS CLI

To enable Enhanced Monitoring using the AWS CLI, in the following commands, set the `--monitoring-interval` option to a value other than `0` and set the `--monitoring-role-arn` option to the role you created in Before You Begin (p. 363).

- create-db-instance
- create-db-instance-read-replica
- modify-db-instance

The `--monitoring-interval` option specifies the interval, in seconds, between points when Enhanced Monitoring metrics are collected. Valid values for the option are `0`, `1`, `5`, `10`, `15`, `30`, and `60`.

To disable Enhanced Monitoring using the AWS CLI, set the `--monitoring-interval` option to `0` in the these commands.

Example

The following example enables Enhanced Monitoring for a DB instance:

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --monitoring-interval 30 \
    --monitoring-role-arn arn:aws:iam::123456789012:role/emaccess
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --monitoring-interval 30 ^
    --monitoring-role-arn arn:aws:iam::123456789012:role/emaccess
```

RDS API

To enable Enhanced Monitoring using the RDS API, in the following operations, set the `MonitoringInterval` parameter to a value other than `0` and set the `MonitoringRoleArn` parameter to the role you created in Before You Begin (p. 363).

- CreateDBInstance
- CreateDBInstanceReadReplica
- ModifyDBInstance

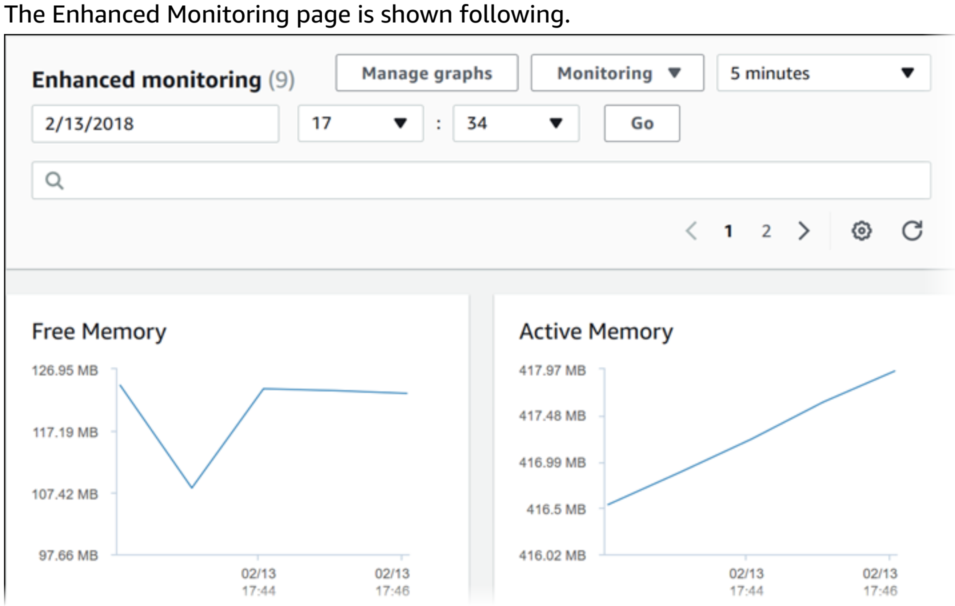
The `MonitoringInterval` parameter specifies the interval, in seconds, between points when Enhanced Monitoring metrics are collected. Valid values for the parameter are `0`, `1`, `5`, `10`, `15`, `30`, and `60`.

To disable Enhanced Monitoring using the RDS API, set the `MonitoringInterval` parameter to `0` in the these operations.

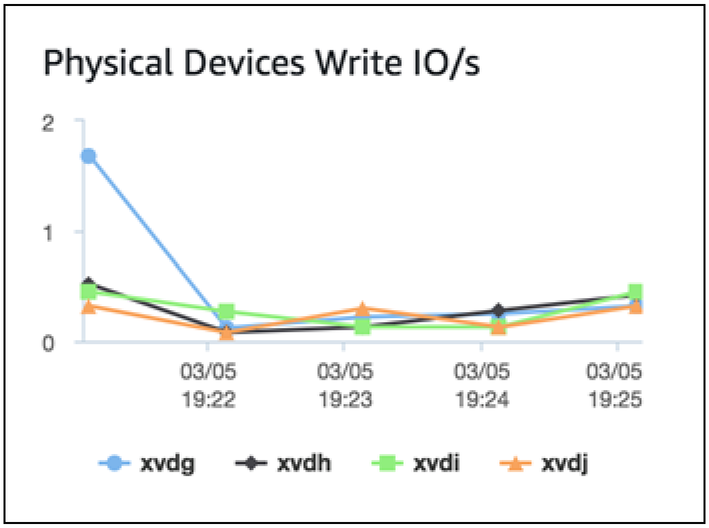
Viewing Enhanced Monitoring

You can view OS metrics reported by Enhanced Monitoring in the RDS console by choosing **Enhanced monitoring** for **Monitoring**.

The Enhanced Monitoring page is shown following.

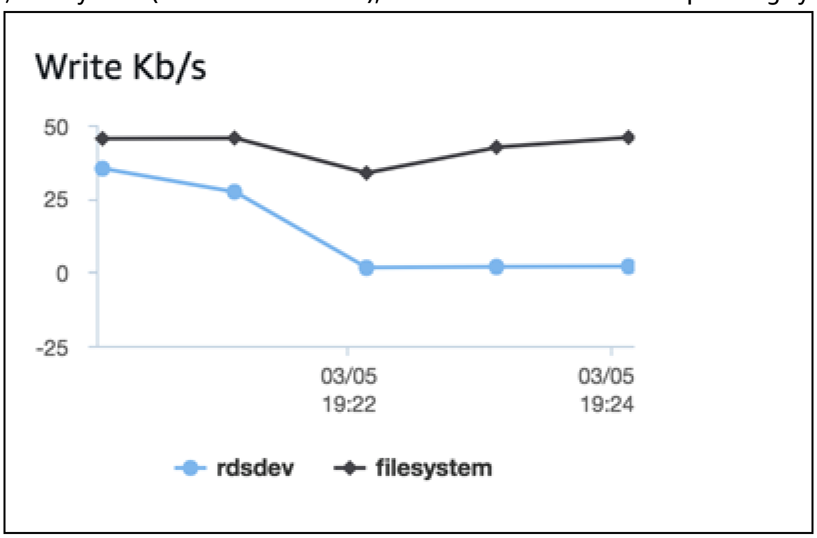


Some DB instances use more than one disk for the DB instance's data storage volume. On those DB instances, the **Physical Devices** graphs show metrics for each one of the disks. For example, the following graph shows metrics for four disks.

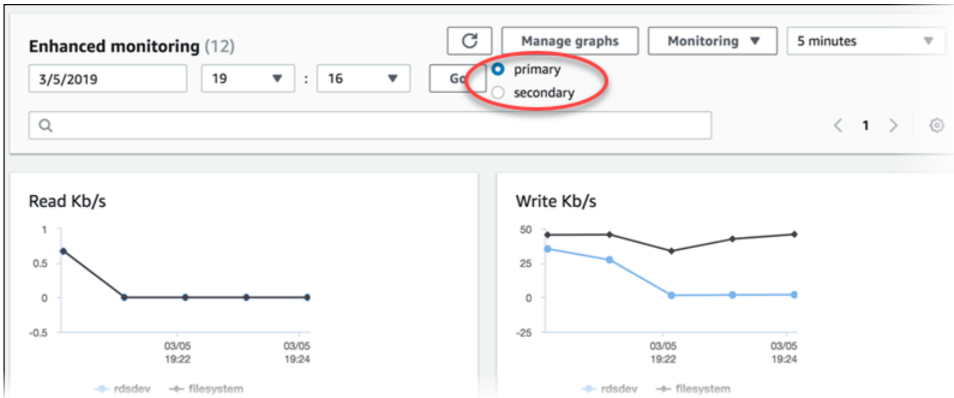


Note
Currently, **Physical Devices** graphs are not available for Microsoft SQL Server DB instances.

When you are viewing aggregated **Disk I/O** and **File system** graphs, the **rdsdev** device relates to the `/rdsdbdata` file system, where all database files and logs are stored. The **filesystem** device relates to the `/` file system (also known as root), where files related to the operating system are stored.



If the DB instance is a Multi-AZ deployment, you can view the OS metrics for the primary DB instance and its Multi-AZ standby replica. In the **Enhanced monitoring** view, choose **primary** to view the OS metrics for the primary DB instance, or choose **secondary** to view the OS metrics for the standby replica.

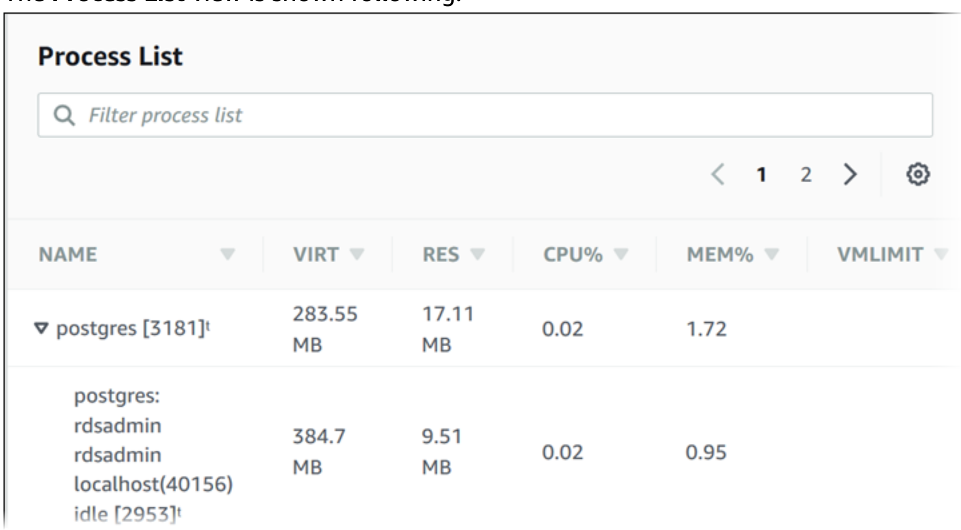


For more information about Multi-AZ deployments, see [High Availability (Multi-AZ) for Amazon RDS (p. 41)](#).

> **Note**
> Currently, viewing OS metrics for a Multi-AZ standby replica is not supported for MariaDB or Microsoft SQL Server DB instances.

If you want to see details for the processes running on your DB instance, choose **OS process list** for **Monitoring**.

The **Process List** view is shown following.



The Enhanced Monitoring metrics shown in the **Process list** view are organized as follows:

- **RDS child processes** – Shows a summary of the RDS processes that support the DB instance, for example `mysqld` for MySQL DB instances. Process threads appear nested beneath the parent process. Process threads show CPU utilization only as other metrics are the same for all threads for the process. The console displays a maximum of 100 processes and threads. The results are a combination of the top CPU consuming and memory consuming processes and threads. If there are more than 50 processes and more than 50 threads, the console displays the top 50 consumers in each category. This display helps you identify which processes are having the greatest impact on performance.
- **RDS processes** – Shows a summary of the resources used by the RDS management agent, diagnostics monitoring processes, and other AWS processes that are required to support RDS DB instances.
- **OS processes** – Shows a summary of the kernel and system processes, which generally have minimal impact on performance.

The items listed for each process are:

- **VIRT** – Displays the virtual size of the process.
- **RES** – Displays the actual physical memory being used by the process.
- **CPU%** – Displays the percentage of the total CPU bandwidth being used by the process.
- **MEM%** – Displays the percentage of the total memory being used by the process.

The monitoring data that is shown in the RDS console is retrieved from Amazon CloudWatch Logs. You can also retrieve the metrics for a DB instance as a log stream from CloudWatch Logs. For more information, see Viewing Enhanced Monitoring by Using CloudWatch Logs (p. 368).

Enhanced Monitoring metrics are not returned during the following:

- A failover of the DB instance.
- Changing the instance class of the DB instance (scale compute).

Enhanced Monitoring metrics are returned during a reboot of a DB instance because only the database engine is rebooted. Metrics for the operating system are still reported.

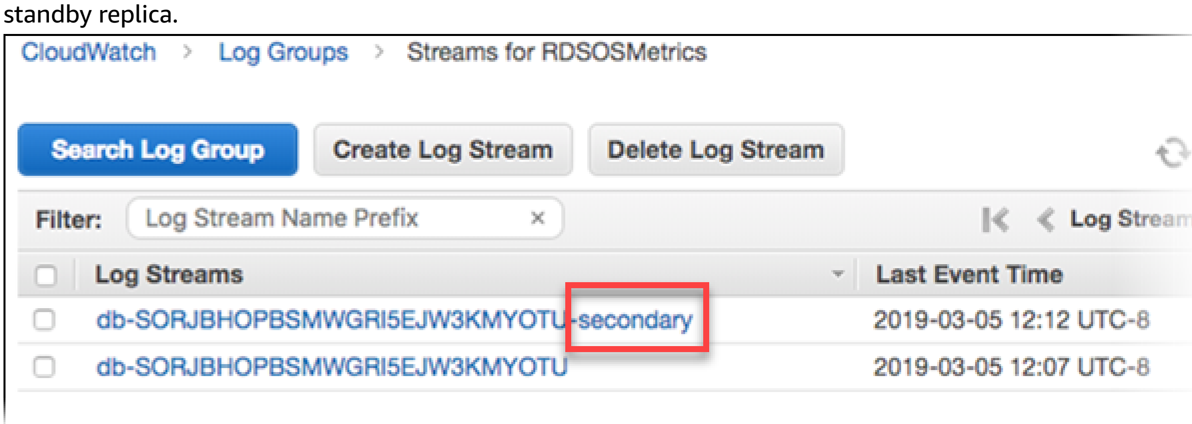
Viewing Enhanced Monitoring by Using CloudWatch Logs

After you have enabled Enhanced Monitoring for your DB instance, you can view the metrics for your DB instance using CloudWatch Logs, with each log stream representing a single DB instance being monitored. The log stream identifier is the resource identifier (`DbiResourceId`) for the DB instance.

To view Enhanced Monitoring log data

1. Open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. If necessary, choose the region that your DB instance is in. For more information, see Regions and Endpoints in the *Amazon Web Services General Reference*.
3. Choose **Logs** in the navigation pane.
4. Choose **RDSOSMetrics** from the list of log groups.

   In a Multi-AZ deployment, log files with `-secondary` appended to the name are for the Multi-AZ standby replica.



5. Choose the log stream that you want to view from the list of log streams.

Available OS Metrics

The following tables list the OS metrics available using Amazon CloudWatch Logs.

Metrics for MariaDB, MySQL, Oracle, and PostgreSQL DB instances

Group	Metric	Console Name	Description
`General`	`engine`	Not applicable	The database engine for the DB instance.
	`instanceID`	Not applicable	The DB instance identifier.
	`instanceResourceID`	Not applicable	An immutable identifier for the DB instance that is unique to an AWS Region, also used as the log stream identifier.
	`numVCPUs`	Not applicable	The number of virtual CPUs for the DB instance.
	`timestamp`	Not applicable	The time at which the metrics were taken.
	`uptime`	Not applicable	The amount of time that the DB instance has been active.
	`version`	Not applicable	The version of the OS metrics' stream JSON format.
`cpuUtilization`	`guest`	**CPU Guest**	The percentage of CPU in use by guest programs.
	`idle`	**CPU Idle**	The percentage of CPU that is idle.
	`irq`	**CPU IRQ**	The percentage of CPU in use by software interrupts.
	`nice`	**CPU Nice**	The percentage of CPU in use by programs running at lowest priority.
	`steal`	**CPU Steal**	The percentage of CPU in use by other virtual machines.
	`system`	**CPU System**	The percentage of CPU in use by the kernel.
	`total`	**CPU Total**	The total percentage of the CPU in use. This value includes the `nice` value.
	`user`	**CPU User**	The percentage of CPU in use by user programs.
	`wait`	**CPU Wait**	The percentage of CPU unused while waiting for I/O access.
`diskIO`	`avgQueueLen`	**Avg Queue Size**	The number of requests waiting in the I/O device's queue.
	`avgReqSz`	**Ave Request Size**	The average request size, in kilobytes.
	`await`	**Disk I/O Await**	The number of milliseconds required to respond to requests, including queue time and service time.

Group	Metric	Console Name	Description
	`device`	**Not applicable**	The identifier of the disk device in use.
	`diskQueueDepth`	**Disk Queue Depth**	The number of pending input and output (I/O) requests waiting to access the disk.
	`readIOsPS`	**Read IO/s**	The number of read operations per second.
	`readKb`	**Read Total**	The total number of kilobytes read.
	`readKbPS`	**Read Kb/s**	The number of kilobytes read per second.
	`readLatency`	**Read Latency**	The elapsed time between the submission of a read I/O request and its completion, in milliseconds. This metric is only available for Amazon Aurora.
	`readThroughput`	**Read Throughput**	The amount of network throughput used by requests to the DB cluster, in bytes per second. This metric is only available for Amazon Aurora.
	`rrqmPS`	**Rrqms**	The number of merged read requests queued per second.
	`tps`	**TPS**	The number of I/O transactions per second.
	`util`	**Disk I/O Util**	The percentage of CPU time during which requests were issued.
	`writeIOsPS`	**Write IO/s**	The number of write operations per second.
	`writeKb`	**Write Total**	The total number of kilobytes written.
	`writeKbPS`	**Write Kb/s**	The number of kilobytes written per second.
	`writeLatency`	**Write Latency**	The average elapsed time between the submission of a write I/O request and its completion, in milliseconds. This metric is only available for Amazon Aurora.
	`writeThroughput`	**Write Throughput**	The amount of network throughput used by responses from the DB cluster, in bytes per second. This metric is only available for Amazon Aurora.
	`wrqmPS`	**Wrqms**	The number of merged write requests queued per second.
`fileSys`	`maxFiles`	**Max Inodes**	The maximum number of files that can be created for the file system.
	`mountPoint`	Not applicable	The path to the file system.
	`name`	Not applicable	The name of the file system.
	`total`	**Total Filesystem**	The total number of disk space available for the file system, in kilobytes.

Group	Metric	Console Name	Description
	`used`	**Used Filesystem**	The amount of disk space used by files in the file system, in kilobytes.
	`usedFilePercent`	**Used %**	The percentage of available files in use.
	`usedFiles`	**Used Inodes**	The number of files in the file system.
	`usedPercent`	**Used Inodes %**	The percentage of the file-system disk space in use.
`loadAverageMinute`	`fifteen`	**Load Avg 15 min**	The number of processes requesting CPU time over the last 15 minutes.
	`five`	**Load Avg 5 min**	The number of processes requesting CPU time over the last 5 minutes.
	`one`	**Load Avg 1 min**	The number of processes requesting CPU time over the last minute.
`memory`	`active`	**Active Memory**	The amount of assigned memory, in kilobytes.
	`buffers`	**Buffered Memory**	The amount of memory used for buffering I/O requests prior to writing to the storage device, in kilobytes.
	`cached`	**Cached Memory**	The amount of memory used for caching file system–based I/O.
	`dirty`	**Dirty Memory**	The amount of memory pages in RAM that have been modified but not written to their related data block in storage, in kilobytes.
	`free`	**Free Memory**	The amount of unassigned memory, in kilobytes.
	`hugePagesFree`	**Huge Pages Free**	The number of free huge pages. Huge pages are a feature of the Linux kernel.
	`hugePagesRsvd`	**Huge Pages Rsvd**	The number of committed huge pages.
	`hugePagesSize`	**Huge Pages Size**	The size for each huge pages unit, in kilobytes.
	`hugePagesSurp`	**Huge Pages Surp**	The number of available surplus huge pages over the total.
	`hugePagesTotal`	**Huge Pages Total**	The total number of huge pages.
	`inactive`	**Inactive Memory**	The amount of least-frequently used memory pages, in kilobytes.
	`mapped`	**Mapped Memory**	The total amount of file-system contents that is memory mapped inside a process address space, in kilobytes.
	`pageTables`	**Page Tables**	The amount of memory used by page tables, in kilobytes.

Group	Metric	Console Name	Description
	slab	**Slab Memory**	The amount of reusable kernel data structures, in kilobytes.
	total	**Total Memory**	The total amount of memory, in kilobytes.
	writeback	**Writeback Memory**	The amount of dirty pages in RAM that are still being written to the backing storage, in kilobytes.
network	interface	Not applicable	The identifier for the network interface being used for the DB instance.
	rx	**RX**	The number of bytes received per second.
	tx	**TX**	The number of bytes uploaded per second.
processList	cpuUsedPc	**CPU %**	The percentage of CPU used by the process.
	id	Not applicable	The identifier of the process.
	memoryUsedPc	**MEM%**	The amount of memory used by the process, in kilobytes.
	name	Not applicable	The name of the process.
	parentID	Not applicable	The process identifier for the parent process of the process.
	rss	**RES**	The amount of RAM allocated to the process, in kilobytes.
	tgid	Not applicable	The thread group identifier, which is a number representing the process ID to which a thread belongs. This identifier is used to group threads from the same process.
	VIRT	**VIRT**	The amount of virtual memory allocated to the process, in kilobytes.
swap	swap	**Swap**	The amount of swap memory available, in kilobytes.
	swap in	**Swaps in**	The amount of memory, in kilobytes, swapped in from disk.
	swap out	**Swaps out**	The amount of memory, in kilobytes, swapped out to disk.
	free	**Free Swap**	The amount of swap memory free, in kilobytes.
	committed	**Committed Swap**	The amount of swap memory, in kilobytes, used as cache memory.
tasks	blocked	**Tasks Blocked**	The number of tasks that are blocked.
	running	**Tasks Running**	The number of tasks that are running.

Group	Metric	Console Name	Description
	sleeping	**Tasks Sleeping**	The number of tasks that are sleeping.
	stopped	**Tasks Stopped**	The number of tasks that are stopped.
	total	**Tasks Total**	The total number of tasks.
	zombie	**Tasks Zombie**	The number of child tasks that are inactive with an active parent task.

Metrics for Microsoft SQL Server DB instances

Group	Metric	Console Name	Description
General	engine	Not applicable	The database engine for the DB instance.
	instanceID	Not applicable	The DB instance identifier.
	instanceResourceID	Not applicable	An immutable identifier for the DB instance that is unique to an AWS Region, also used as the log stream identifier.
	numVCPUs	Not applicable	The number of virtual CPUs for the DB instance.
	timestamp	Not applicable	The time at which the metrics were taken.
	uptime	Not applicable	The amount of time that the DB instance has been active.
	version	Not applicable	The version of the OS metrics' stream JSON format.
cpuUtilization	idle	**CPU Idle**	The percentage of CPU that is idle.
	kern	**CPU Kernel**	The percentage of CPU in use by the kernel.
	user	**CPU User**	The percentage of CPU in use by user programs.
disks	name	Not applicable	The identifier for the disk.
	totalKb	**Total Disk Space**	The total space of the disk, in kilobytes.
	usedKb	**Used Disk Space**	The amount of space used on the disk, in kilobytes.
	usedPc	**Used Disk Space %**	The percentage of space used on the disk.
	availKb	**Available Disk Space**	The space available on the disk, in kilobytes.
	availPc	**Available Disk Space %**	The percentage of space available on the disk.

Group	Metric	Console Name	Description
	`rdCountPS`	**Reads/s**	The number of read operations per second
	`rdBytesPS`	**Read Kb/s**	The number of bytes read per second.
	`wrCountPS`	**Write IO/s**	The number of write operations per second.
	`wrBytesPS`	**Write Kb/s**	The amount of bytes written per second.
`memory`	`commitTotKb`	**Commit Total**	The amount of pagefile-backed virtual address space in use, that is, the current commit charge. This value is composed of main memory (RAM) and disk (pagefiles).
	`commitLimitKb`	**Maximum Commit**	The maximum possible value for the `commitTotKb` metric. This value is the sum of the current pagefile size plus the physical memory available for pageable contents, excluding RAM that is assigned to nonpageable areas.
	`commitPeakKb`	**Commit Peak**	The largest value of the `commitTotKb` metric since the operating system was last started.
	`kernTotKb`	**Total Kernel Memory**	The sum of the memory in the paged and nonpaged kernel pools, in kilobytes.
	`kernPagedKb`	**Paged Kernel Memory**	The amount of memory in the paged kernel pool, in kilobytes.
	`kernNonpagedKb`	**Nonpaged Kerenel Memory**	The amount of memory in the nonpaged kernel pool, in kilobytes.
	`pageSize`	**Page Size**	The size of a page, in bytes.
	`physTotKb`	**Total Memory**	The amount of physical memory, in kilobytes.
	`physAvailKb`	**Available Memory**	The amount of available physical memory, in kilobytes.
	`sqlServerTotKb`	**SQL Server Total Memory**	The amount of memory committed to SQL Server, in kilobytes.
	`sysCacheKb`	**System Cache**	The amount of system cache memory, in kilobytes.
`network`	`interface`	Not applicable	The identifier for the network interface being used for the DB instance.
	`rdBytesPS`	**Network Read Kb/s**	The number of bytes received per second.
	`wrBytesPS`	**Network Write Kb/s**	The number of bytes sent per second.
`processList`	`cpuUsedPc`	**Used %**	The percentage of CPU used by the process.
	`memUsedPc`	**MEM%**	The percentage of total memory used by the process.

Group	Metric	Console Name	Description
	`name`	Not applicable	The name of the process.
	`pid`	Not applicable	The identifier of the process. This value is not present for processes that are owned by Amazon RDS.
	`ppid`	Not applicable	The process identifier for the parent of this process. This value is only present for child processes.
	`tid`	Not applicable	The thread identifier. This value is only present for threads. The owning process can be identified by using the `pid` value.
	`workingSetKb`	Not applicable	The amount of memory in the private working set plus the amount of memory that is in use by the process and can be shared with other processes, in kilobytes.
	`workingSetPrivKb`	Not applicable	The amount of memory that is in use by a process, but can't be shared with other processes, in kilobytes.
	`workingSetShareableKb`	Not applicable	The amount of memory that is in use by a process and can be shared with other processes, in kilobytes.
	`virtKb`	Not applicable	The amount of virtual address space the process is using, in kilobytes. Use of virtual address space doesn't necessarily imply corresponding use of either disk or main memory pages.
`system`	`handles`	**Handles**	The number of handles that the system is using.
	`processes`	**Processes**	The number of processes running on the system.
	`threads`	**Threads**	The number of threads running on the system.

Using Amazon RDS Performance Insights

Amazon RDS Performance Insights monitors your Amazon RDS DB instance load so that you can analyze and troubleshoot your database performance. Amazon RDS Performance Insights is currently available for use with the following DB engines:

- Amazon Aurora with MySQL compatibility version 2.04.2 and higher 2.x versions (compatible with MySQL 5.7)
- Amazon Aurora with MySQL compatibility version 1.17.3 and higher 1.x versions (compatible with MySQL 5.6)
- Amazon Aurora with PostgreSQL compatibility
- Amazon RDS for MariaDB version 10.4.8 and higher 10.4 versions, version 10.3.13 and higher 10.3 versions, and version 10.2.21 and higher 10.2 versions
- Amazon RDS for MySQL version 8.0.17 and higher 8.0 versions, version 5.7.22 and higher 5.7 versions, and version 5.6.41 and higher 5.6 versions
- Amazon RDS for Microsoft SQL Server (all versions except SQL Server 2008)
- Amazon RDS for PostgreSQL version 10, 11, and 12
- Amazon RDS for Oracle (all versions)

Note

Amazon RDS Performance Insights is not supported for MariaDB version 10.0 or 10.1, or for MySQL version 5.5. Amazon RDS Performance Insights is not supported for MariaDB version 10.3.13 DB instances in the Europe (Frankfurt) and Europe (Stockholm) AWS Regions.
For Amazon RDS for MariaDB and MySQL, Performance Insights is not supported on the following DB instance classes: db.t2.micro, db.t2.small, db.t3.micro, and db.t3.small.
Amazon RDS Performance Insights is not supported in the Middle East (Bahrain) region.
On Aurora MySQL, Performance Insights is not supported on db.t2 or db.t3 DB instance classes.
Performance Insights is not supported for Aurora MySQL DB clusters enabled for parallel query.

Important

This guide describes using Amazon RDS Performance Insights with non-Aurora DB engines. For information about using Amazon RDS Performance Insights with Amazon Aurora, see the Using Amazon RDS Performance Insights in the *Amazon Aurora User Guide*.

Performance Insights expands on existing Amazon RDS monitoring features to illustrate your database's performance and help you analyze any issues that affect it. With the Performance Insights dashboard, you can visualize the database load and filter the load by waits, SQL statements, hosts, or users.

Performance Insights is on by default in the console create wizard for all DB engines that work with Amazon RDS. If you have more than one database on a DB instance, performance data for all of the databases is aggregated for the DB instance.

The central metric for Performance Insights is `DB Load`, which represents the average number of active sessions for the DB engine. The `DB Load` metric is collected every second. An *active session* is a connection that has submitted work to the DB engine and is waiting for a response from it. For example, if you submit a SQL query to the DB engine, the database session is active while the DB engine is processing that query.

By combining `DB Load` with wait event data, you can get a complete picture of the state for an active session. A *wait event* is a condition that causes the execution of a SQL statement to wait for a specific event to happen before it can continue. For example, SQL statement execution might wait until a locked resource is unlocked. Wait events vary by DB engine:

- For information about all MariaDB and MySQL wait events, see Wait Event Summary Tables in the MySQL documentation.

- For information about all PostgreSQL wait events, see PostgreSQL Wait Events in the PostgreSQL documentation.
- For information about all Oracle wait events, see Descriptions of Wait Events in the Oracle documentation.
- For information about all SQL Server wait events, see Types of Waits in the SQL Server documentation.

> **Note**
> For Oracle, background processes sometimes do work without an associated SQL statement. In these cases, Performance Insights reports the type of background process concatenated with a colon and the wait class associated with that background process. Types of background process include LGWR, ARC0, PMON, and so on.
> For example, when the archiver is performing I/O, the Performance Insights report for it is similar to `ARC1:System I/O`. Occasionally, the background process type is also missing, and Performance Insights only reports the wait class, for example `:System I/O`.

Session information is collected, aggregated, and displayed in the dashboard as the **Average Active Sessions** chart. The **Average Active Sessions** chart displays the **Max CPU** value as a line, so you can see if active sessions are exceeding it or not. The **Max CPU** value is determined by the number of **vCPU** (virtual CPU) cores for your DB instance.

If the load in the **Average Active Sessions** chart is often above the **Max CPU** line and the primary wait state is CPU, the system CPU is overloaded. In these cases, you might want to throttle connections to the instance, tune any SQL queries with a high CPU load, or consider a larger instance class. High and consistent instances of any wait state indicate that there might be bottlenecks or resource contention issues to resolve. This can be true even if the load doesn't cross the **Max CPU** line.

You can find an overview of Performance Insights in the following video.

Using Performance Insights to Analyze Performance of Amazon Aurora PostgreSQL

Topics

Enabling Performance Insights

To use Performance Insights, you must enable it on your DB instance.

The Performance Insights agent consumes limited CPU and memory on the DB host. When the DB load is high, the agent limits the performance impact by collecting data less frequently.

Console

You can use the console to enable Performance Insights when you create a new DB instance. You can also modify a DB instance to enable Performance Insights.

Topics

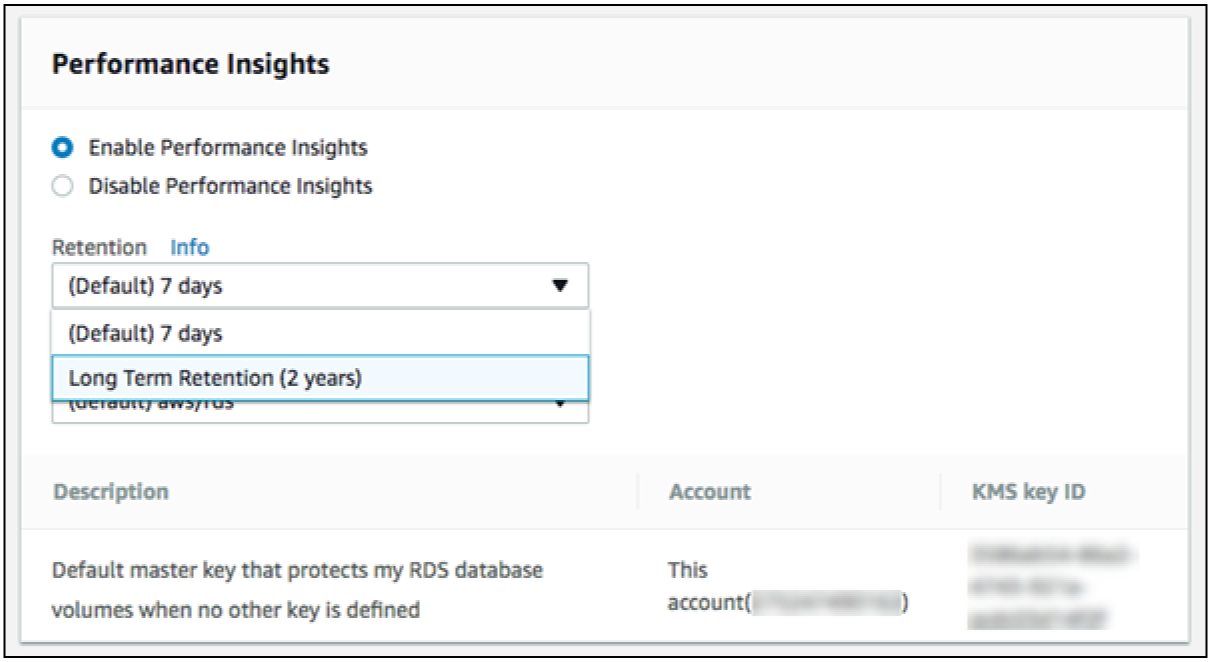
- Enabling Performance Insights with the Console When Creating a DB Instance (p. 378)
- Enabling Performance Insights with the Console When Modifying a DB Instance (p. 378)

Enabling Performance Insights with the Console When Creating a DB Instance

When you create a new DB instance, Performance Insights is enabled when you choose **Enable Performance Insights** in the **Performance Insights** section.

To create a DB instance, follow the instructions for your DB engine in Creating an Amazon RDS DB Instance (p. 136).

The following screenshot shows the **Performance Insights** section.



You have the following options when you choose **Enable Performance Insights**:

- **Retention** – The amount of time to retain Performance Insights data. Choose either 7 days (the default) or 2 years.
- **Master key** – Specify your AWS Key Management Service (AWS KMS) key. Performance Insights encrypts all potentially sensitive data using your AWS KMS key. Data is encrypted in flight and at rest. For more information, see Encrypting Amazon RDS Resources (p. 1358).

Enabling Performance Insights with the Console When Modifying a DB Instance

You can modify a DB instance to enable Performance Insights using the console.

To enable Performance Insights for a DB instance using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose **Databases**.
3. Choose the DB instance that you want to modify, and choose **Modify**.
4. In the **Performance Insights** section, choose **Enable Performance Insights**.

   You have the following options when you choose **Enable Performance Insights**:

- **Retention** – The amount of time to retain Performance Insights data. Choose either 7 days (the default) or 2 years.
- **Master key** – Specify your AWS Key Management Service (AWS KMS) key. Performance Insights encrypts all potentially sensitive data using your AWS KMS key. Data is encrypted in flight and at rest. For more information, see Encrypting Amazon RDS Resources (p. 1358).

5. Choose **Continue**.
6. For **Scheduling of Modifications**, choose one of the following:
   - **Apply during the next scheduled maintenance window** – Wait to apply the **Performance Insights** modification until the next maintenance window.
   - **Apply immediately** – Apply the **Performance Insights** modification as soon as possible.
7. Choose **Modify instance**.

AWS CLI

When you create a new DB instance using the create-db-instance AWS CLI command, Performance Insights is enabled when you specify `--enable-performance-insights`.

You can also specify the `--enable-performance-insights` value using the following AWS CLI commands:

- create-db-instance-read-replica
- modify-db-instance
- restore-db-instance-from-s3

The following procedure describes how to enable Performance Insights for a DB instance using the AWS CLI.

To enable Performance Insights for a DB instance using the AWS CLI

- Call the modify-db-instance AWS CLI command and supply the following values:
  - `--db-instance-identifier` – The name of the DB instance.
  - `--enable-performance-insights`

  The following example enables Performance Insights for `sample-db-instance`.

  For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier sample-db-instance \
    --enable-performance-insights
```

  For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier sample-db-instance ^
    --enable-performance-insights
```

When you enable Performance Insights, you can optionally specify the amount of time, in days, to retain Performance Insights data with the `--performance-insights-retention-period` option. Valid values are 7 (the default) or 731 (2 years).

The following example enables Performance Insights for `sample-db-instance` and specifies that Performance Insights data is retained for two years.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier sample-db-instance \
    --enable-performance-insights \
    --performance-insights-retention-period 731
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier sample-db-instance ^
    --enable-performance-insights ^
    --performance-insights-retention-period 731
```

RDS API

When you create a new DB instance using the CreateDBInstance operation Amazon RDS API operation, Performance Insights is enabled when you set `EnablePerformanceInsights` to `True`.

You can also specify the `EnablePerformanceInsights` value using the following API operations:

- ModifyDBInstance
- CreateDBInstanceReadReplica
- RestoreDBInstanceFromS3

When you enable Performance Insights, you can optionally specify the amount of time, in days, to retain Performance Insights data with the `PerformanceInsightsRetentionPeriod` parameter. Valid values are 7 (the default) or 731 (2 years).

Enabling the Performance Schema for Performance Insights on Amazon RDS for MariaDB or MySQL

For Amazon RDS for MariaDB or MySQL, Performance Insights provides more detailed information when the Performance Schema feature is enabled. The Performance Schema is enabled automatically when you create an Amazon RDS for MariaDB or MySQL DB instance with Performance Insights enabled. When you create the DB instance with Performance Insights enabled, the following subset of Performance Schema parameters is set to the specified values automatically:

Parameter Name	Parameter Value
`performance_schema`	`1`
`performance-schema-consumer-events-waits-current`	`ON`

Parameter Name	Parameter Value
performance-schema-instrument	wait/%=ON
performance-schema-consumer-global-instrumentation	ON
performance-schema-consumer-thread-instrumentation	ON

Performance Schema is enabled automatically only if your parameter group doesn't have an explicitly set value for the `performance_schema` parameter. You can examine the `performance_schema` parameter, and if the value of source is `user`, then you set a value. If you want the Performance Schema parameters to be set automatically, then reset the value for the `performance_schema` parameter. You can view the source of a parameter value by viewing the parameter in the AWS Management Console or by running the AWS CLI describe-db-parameters command.

Important
When Performance Insights enables the Performance Schema automatically, the parameter changes are made on the DB instance, but they aren't reflected in the parameter group associated with the DB instance.

When you change the value of the `performance_schema` parameter, a DB instance reboot is required. If you're creating a new DB instance with Performance Insights enabled, the `performance_schema` parameter is set to 1 (enabled) by default.

Without the Performance Schema enabled, Performance Insights displays database load broken down by the list state of the MySQL process. With Performance Schema enabled, Performance Insights displays database load broken down by detailed wait events.

For more information about the dashboard, see Using the Performance Insights Dashboard (p. 383). For more information about the MySQL performance schema, see MySQL 8.0 Reference Manual.

Access Control for Performance Insights

To access Performance Insights, you must have the appropriate permissions from AWS Identity and Access Management (IAM). There are two options available for granting access:

1. Attach the `AmazonRDSFullAccess` managed policy to an IAM user or role.
2. Create a custom IAM policy and attach it to an IAM user or role.

AmazonRDSFullAccess Managed Policy

`AmazonRDSFullAccess` is an AWS-managed policy that grants access to all of the Amazon RDS API operations. The policy also grants access to related services that are used by the Amazon RDS console—for example, event notifications using Amazon SNS.

In addition, `AmazonRDSFullAccess` contains all the permissions needed for using Performance Insights. If you attach this policy to an IAM user or role, the recipient can use Performance Insights. along with other console features.

Using a Custom IAM Policy

For users who don’t have full access with the `AmazonRDSFullAccess` policy, you can grant access to Performance Insights by creating or modifying a user-managed IAM policy. When you attach the policy to an IAM user or role, the recipient can use Performance Insights.

To create a custom policy

1. Open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Policies**.
3. Choose **Create policy**.
4. On the **Create Policy** page, choose the JSON tab.
5. Copy and paste the following.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "pi:*",
            "Resource": "arn:aws:pi:*:*:metrics/rds/*"
        }
    ]
}
```

6. Choose **Review policy**

   Note
   Currently, when you enter this policy, the **Visual editor** tab displays a warning that the `pi` resource is not recognized. You can ignore this warning.

7. Provide a name for the policy and optionally a description, and then choose **Create policy**.

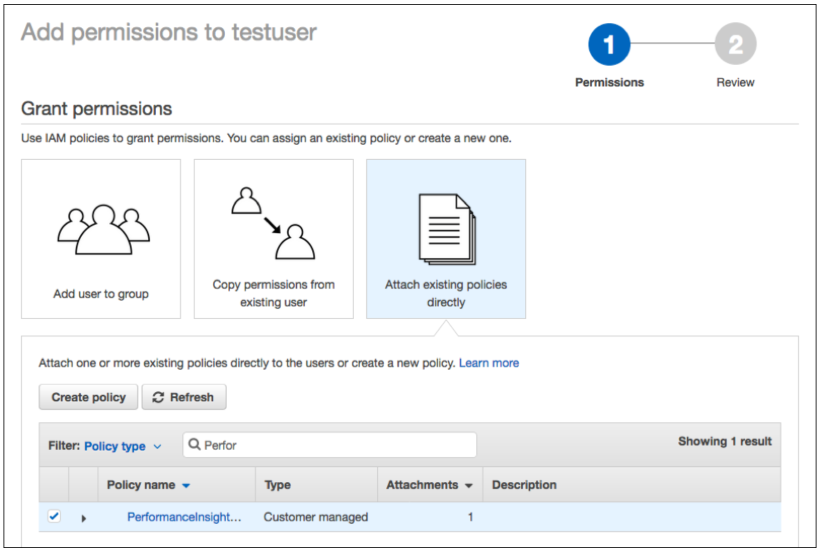
You can now attach the policy to an IAM user or role. The following procedure assumes that you already have an IAM user available for this purpose.

To attach the policy to an IAM user

1. Open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Users**.
3. Choose an existing user from the list.

   Important
   To use Performance Insights, the user must have access to Amazon RDS in addition to the custom policy. For example, the `AmazonRDSReadOnlyAccess` predefined policy provides read-only access to Amazon RDS. For more information, see Managing Access Using Policies (p. 1373).

4. On the **Summary** page, choose **Add permissions**.
5. Choose **Attach existing policies directly**. For **Search**, type the first few characters of your policy name, as shown following.



6. Choose your policy, and then choose **Next: Review**.
7. Choose **Add permissions**.

Using the Performance Insights Dashboard

The Performance Insights dashboard contains database performance information to help you analyze and troubleshoot performance issues. On the main dashboard page, you can view information about the database load. You can also drill into details for a particular wait state, SQL query, host, or user.

Topics

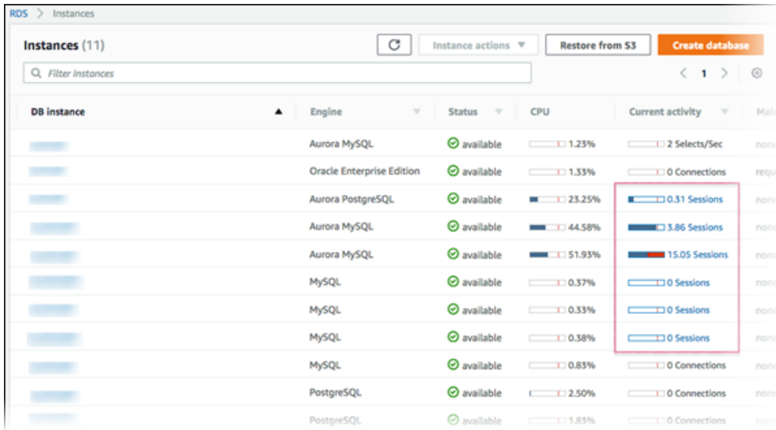
Opening the Performance Insights Dashboard

To see the Performance Insights dashboard, use the following procedure.

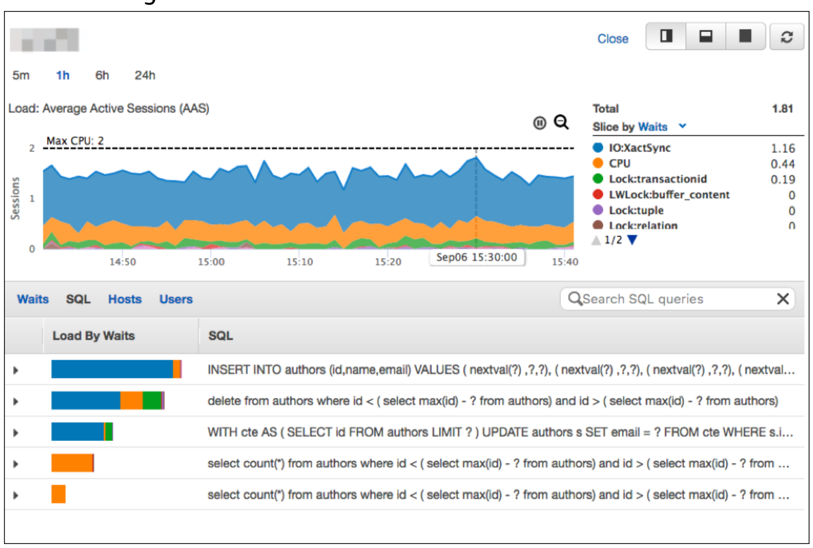
To view the Performance Insights dashboard in the AWS Management Console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Performance Insights**.
3. Choose a DB instance. The Performance Insights dashboard is displayed for that DB instance.

   For DB instances with Performance Insights enabled, you can also reach the dashboard by choosing the **Sessions** item in the list of DB instances. Under **Current activity**, the **Sessions** item shows the database load in average active sessions over the last five minutes. The bar graphically shows the load. When the bar is empty, the DB instance is idle. As the load increases, the bar fills with blue. When the load passes the number of virtual CPUs (vCPUs) on the DB instance class, the bar turns red, indicating a potential bottleneck.



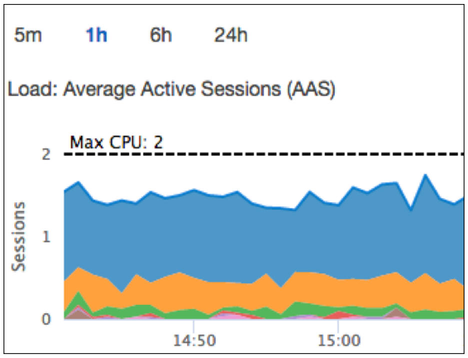
The following screenshot shows the dashboard for a DB instance.



By default, the Performance Insights dashboard shows data for the last 60 minutes. You can modify it to display data for the last 5 minutes, 60 minutes, 5 hours, 24 hours, or 1 week. You can also show all of the data available.

The Performance Insight dashboard automatically refreshes with new data. The refresh rate depends on the amount of data displayed:

- 5 minutes refreshes every 5 seconds.
- 1 hour and 5 hours both refresh every minute.
- 24 hours refreshes every 5 minutes.
- 1 week refreshes every hour.



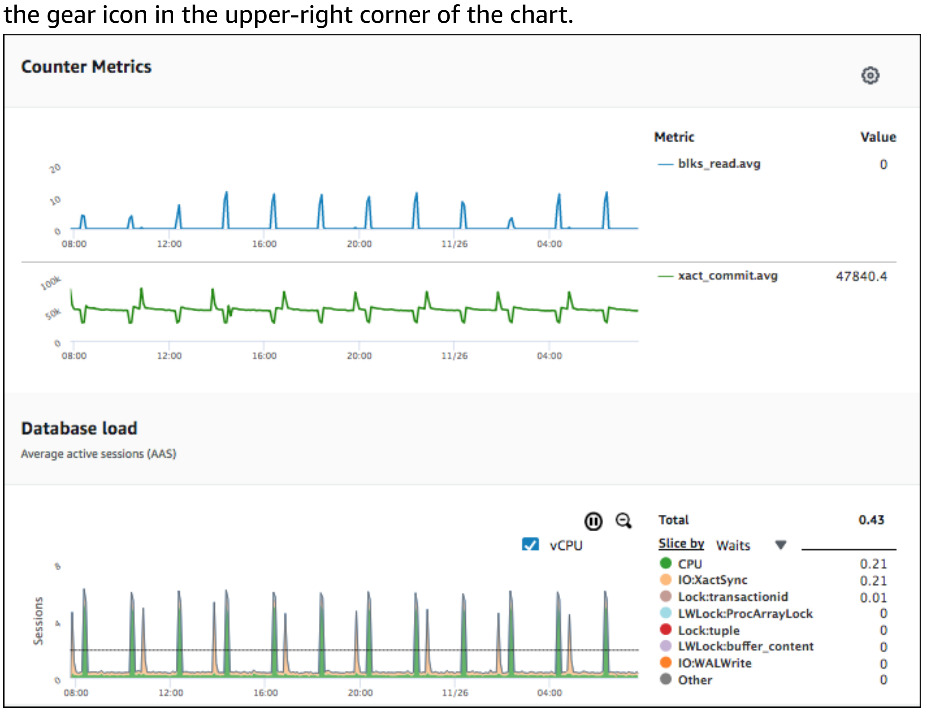
Performance Insights Dashboard Components

The dashboard is divided into three parts:

1. **Counter Metrics chart** – Shows data for specific performance counter metrics.
2. **Average Active Sessions chart** – Shows how the database load compares to DB instance capacity as represented by the **Max CPU** line.
3. **Top load items table** – Shows the top items contributing to database load.

Counter Metrics Chart

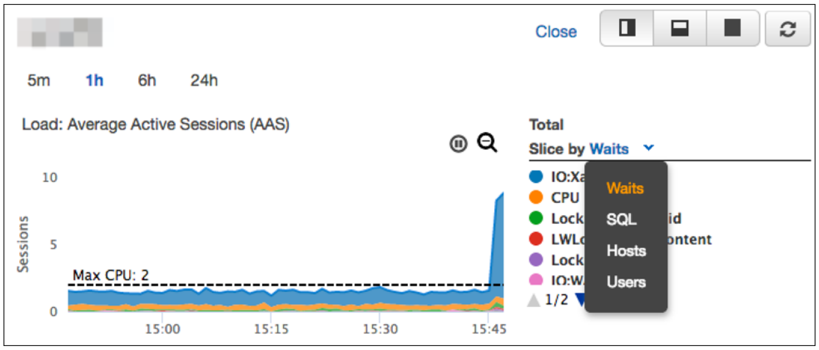
The **Counter Metrics** chart displays data for performance counters. The default metrics shown are `blks_read.avg` and `xact_commit.avg`. Choose which performance counters to display by selecting the gear icon in the upper-right corner of the chart.



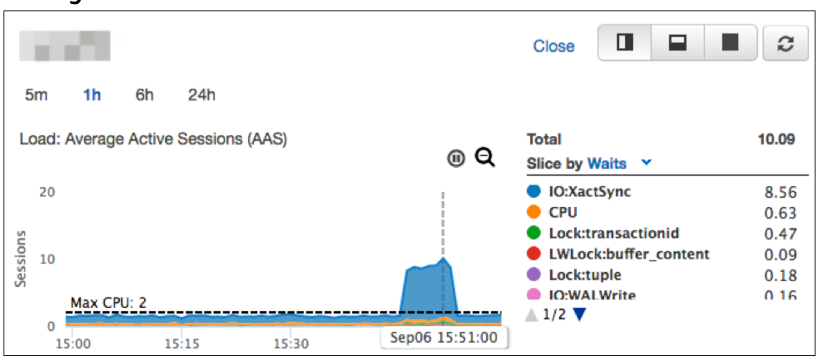
For more information, see Performance Insights Counters (p. 411).

Average Active Sessions Chart

The **Average Active Sessions** chart shows how the database load compares to DB instance capacity as represented by the **Max CPU** line. By default, load is shown as active sessions grouped by wait states. You can also choose instead to display load as active sessions grouped by SQL queries, hosts, or users.

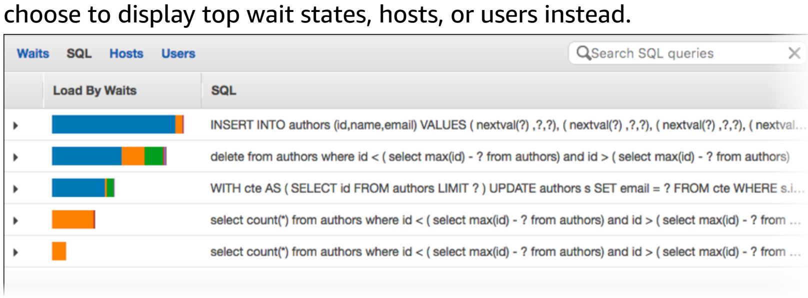


To see details for any item for the selected time period in the legend, hover over that item on the **Average Active Sessions** chart.



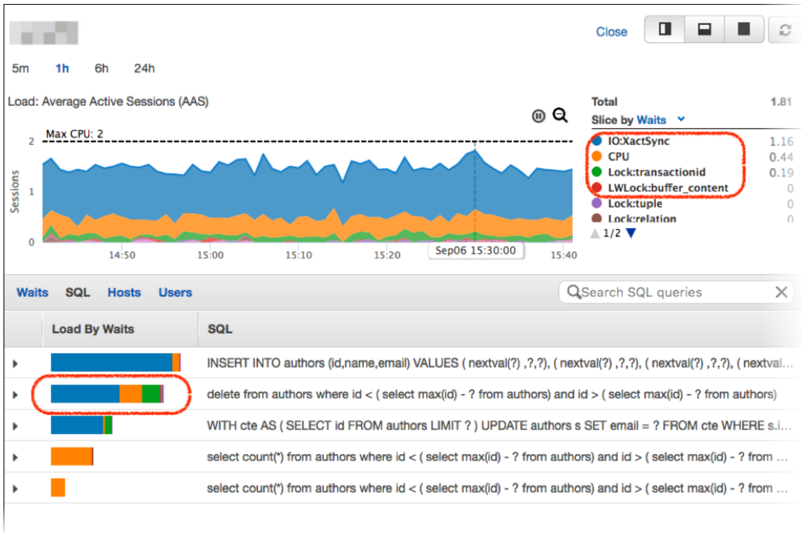
Top Load Items Table

The **Top Load Items** table shows the top items contributing to database load. By default, the top SQL queries that are contributing to the database load are shown. Queries are displayed as digests of multiple actual queries that are structurally similar but that possibly have different parameters. You can choose to display top wait states, hosts, or users instead.



The percentage of the database load associated with each top load item is illustrated in the **DB Load by Waits** column. This column reflects the load for that item by whatever grouping is currently selected in the **Average Active Sessions** chart. Take the case where the **Average Active Sessions** chart is grouping by hosts and you are looking at SQL queries in the top load items table. In this case, the **DB Load by Waits** bar reflects the load that query represents on the related host. Here it's colored-coded to map to the representation of that host in the **Average Active Sessions** chart.

For another example, suppose that the **Average Active Sessions** chart is grouping by wait states and you are looking at SQL queries in the top load items table. In this case, the **DB Load by Waits** bar is sized, segmented, and color-coded to show how much of a given wait state that query is contributing to. It also shows what wait states are affecting that query.



In the **Top Load Items** table, you can view the following types of identifiers (IDs) that are associated with SQL statements:

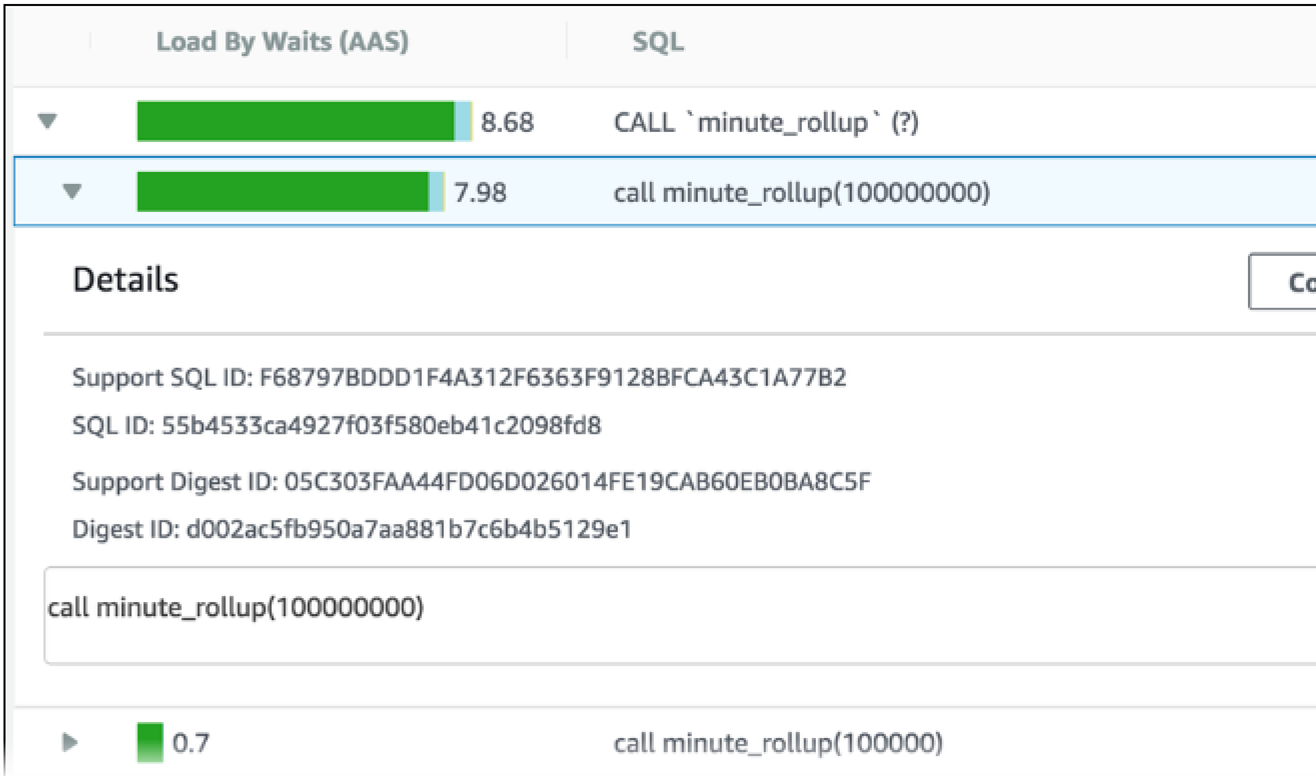
- **SQL ID** – An ID that the database uses to uniquely identify a SQL statement.

  For Oracle and SQL Server DB instances, you can use a SQL ID to find a specific SQL statement.
- **Support SQL ID** – A hash value of the SQL ID. This value is only for referencing a SQL ID when you are working with AWS Support. AWS Support doesn't have access to your actual SQL IDs and SQL text.
- **Digest ID** – An ID that the database uses to uniquely identify a SQL digest. A SQL digest can contain one or more SQL statements with literals removed and white space standardized. The literals are replaced with question marks (?).

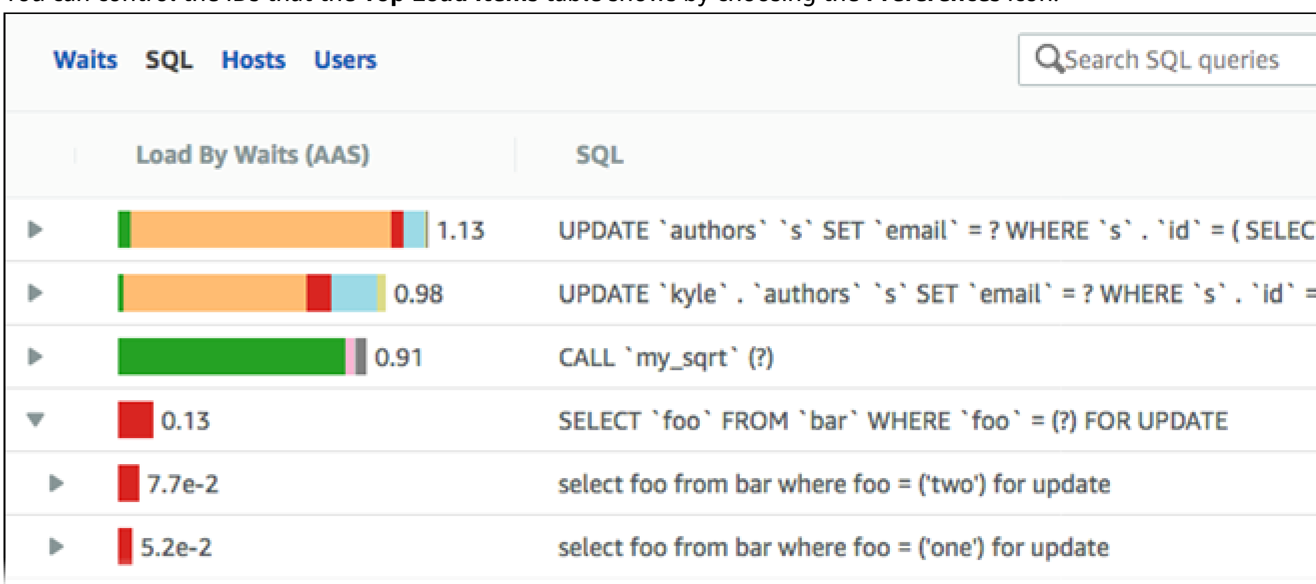
  For Amazon RDS for MariaDB, MySQL, and PostgreSQL DB instances, you can use a digest ID to find a specific SQL digest.

  For Oracle and SQL Server DB instances, the digest ID is the same as the SQL ID. The top row in the **Top Load Items** table is the actual SQL statement, including the literals.
- **Support Digest ID** – A hash value of the digest ID. This value is only for referencing a digest ID when you are working with AWS Support. AWS Support doesn't have access to your actual digest IDs and SQL text.

In the **Top Load Items** table, you can open a top statement to view its IDs. The following screenshot shows an open top statement.



You can control the IDs that the **Top Load Items** table shows by choosing the **Preferences** icon.



When you choose the **Preferences** icon, the **Preferences** window opens.

Enable the IDs that you want to have visible in the **Top Load Items** table, and choose **Save**.

Analyzing Database Load Using the Performance Insights Dashboard

If the **Average Active Sessions** chart shows a bottleneck, you can find out where the load is coming from. To do so, look at the top load items table below the **Average Active Sessions** chart. Choose a particular item, like a SQL query or a user, to drill down into that item and see details about it.

DB load grouped by waits and top SQL queries is the default Performance Insights dashboard view. This combination typically provides the most insight into performance issues. DB load grouped by waits shows if there are any resource or concurrency bottlenecks in the database. In this case, the **SQL** tab of the top load items table shows which queries are driving that load.

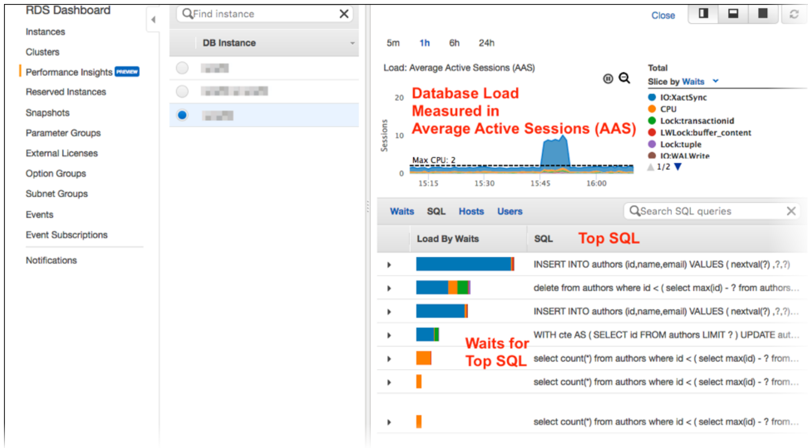
Your typical workflow for diagnosing performance issues is as follows:

1. Review the **Average Active Sessions** chart and see if there are any incidents of database load exceeding the **Max CPU** line.
2. If there is, look at the **Average Active Sessions** chart and identify which wait state or states are primarily responsible.
3. Identify the digest queries causing the load by seeing which of the queries the **SQL** tab on the top load items table are contributing most to those wait states. You can identify these by the **DB Load by Wait** column.
4. Choose one of these digest queries in the **SQL** tab to expand it and see the child queries that it is composed of.

For example, in the dashboard following, **IO:XactSync** waits are a frequent issue. **CPU** wait is less, but it still contributes to load.

The first four roll-up queries in the **SQL** tab of the top load items table correlate strongly to the first state. Thus, those are the ones to drill into and examine the child queries of. You do so to determine how they are contributing to the performance issue.

The last three roll-up queries are the major contributors to CPU. These are the queries to investigate if CPU load is an issue.



Analyzing Statistics for Running Queries

In Amazon RDS Performance Insights, you can find statistics on running queries in the **Top Load Items** section. To view these statistics, view top SQL. Performance Insights collects statistics only for the most common queries, and these usually match the top queries by load shown in the Performance Insights dashboard.

Topics

Statistics for MariaDB and MySQL

Performance Insights collects SQL digest statistics from the `events_statements_summary_by_digest` table. This table is managed by the database and doesn't have an eviction policy. If the table becomes full, new SQL queries aren't tracked. To address this issue, Performance Insights automatically truncates the table when it's nearly full.

Performance Insights automatically truncates the table only if your parameter group doesn't have an explicitly set value for the `performance_schema` parameter. You can examine the `performance_schema` parameter, and if the value of source is `user`, then you set a value. If you want Performance Insights to truncate the table automatically, then reset the value for the `performance_schema` parameter. You can view the source of a parameter value by viewing the parameter in the AWS Management Console or by running the AWS CLI describe-db-parameters command. The following message is shown in the AWS Management Console when the table is full:

```
Performance Insights is unable to collect SQL Digest statistics on new queries because the
 table events_statements_summary_by_digest is full.
Please truncate events_statements_summary_by_digest table to clear the issue. Check the
 User Guide for more details.
```

The following SQL statistics are available for MariaDB and MySQL DB instances.

Metric	Unit
db.sql_tokenized.stats.count_star_per_sec	Calls per second

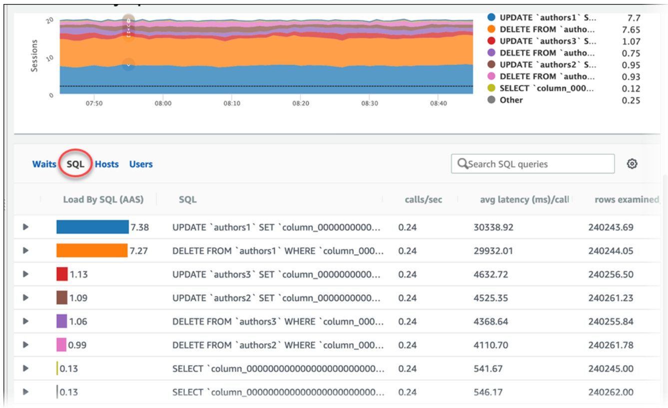
Metric	Unit
db.sql_tokenized.stats.sum_timer_wait_per_sec	Average active executions per second (AAE)
db.sql_tokenized.stats.sum_select_full_join_per_sec	Select full join per second
db.sql_tokenized.stats.sum_select_range_check_per_sec	Select range check per second
db.sql_tokenized.stats.sum_select_scan_per_sec	Select scan per second
db.sql_tokenized.stats.sum_sort_merge_passes_per_sec	Sort merge passes per second
db.sql_tokenized.stats.sum_sort_scan_per_sec	Sort scans per second
db.sql_tokenized.stats.sum_sort_range_per_sec	Sort ranges per second
db.sql_tokenized.stats.sum_sort_rows_per_sec	Sort rows per second
db.sql_tokenized.stats.sum_rows_affected_per_sec	Rows affected per second
db.sql_tokenized.stats.sum_rows_examined_per_sec	Rows examined per second
db.sql_tokenized.stats.sum_rows_sent_per_sec	Rows sent per second
db.sql_tokenized.stats.sum_created_tmp_disk_tables_per_sec	Created temporary disk tables per second
db.sql_tokenized.stats.sum_created_tmp_tables_per_sec	Created temporary tables per second
db.sql_tokenized.stats.sum_lock_time_per_sec	Lock time per second (in ms)

The following metrics provide per call statistics for a SQL statement.

Metric	Unit
db.sql_tokenized.stats.sum_timer_wait_per_call	Average latency per call (in ms)
db.sql_tokenized.stats.sum_select_full_join_per_call	Select full joins per call
db.sql_tokenized.stats.sum_select_range_check_per_call	Select range check per call
db.sql_tokenized.stats.sum_select_scan_per_call	Select scans per call
db.sql_tokenized.stats.sum_sort_merge_passes_per_call	Sort merge passes per call
db.sql_tokenized.stats.sum_sort_scan_per_call	Sort scans per call
db.sql_tokenized.stats.sum_sort_range_per_call	Sort ranges per call
db.sql_tokenized.stats.sum_sort_rows_per_call	Sort rows per call
db.sql_tokenized.stats.sum_rows_affected_per_call	Rows affected per call
db.sql_tokenized.stats.sum_rows_examined_per_call	Rows examined per call
db.sql_tokenized.stats.sum_rows_sent_per_call	Rows sent per call
db.sql_tokenized.stats.sum_created_tmp_disk_tables_per_call	Created temporary disk tables per call
db.sql_tokenized.stats.sum_created_tmp_tables_per_call	Created temporary tables per call
db.sql_tokenized.stats.sum_lock_time_per_call	Lock time per call (in ms)

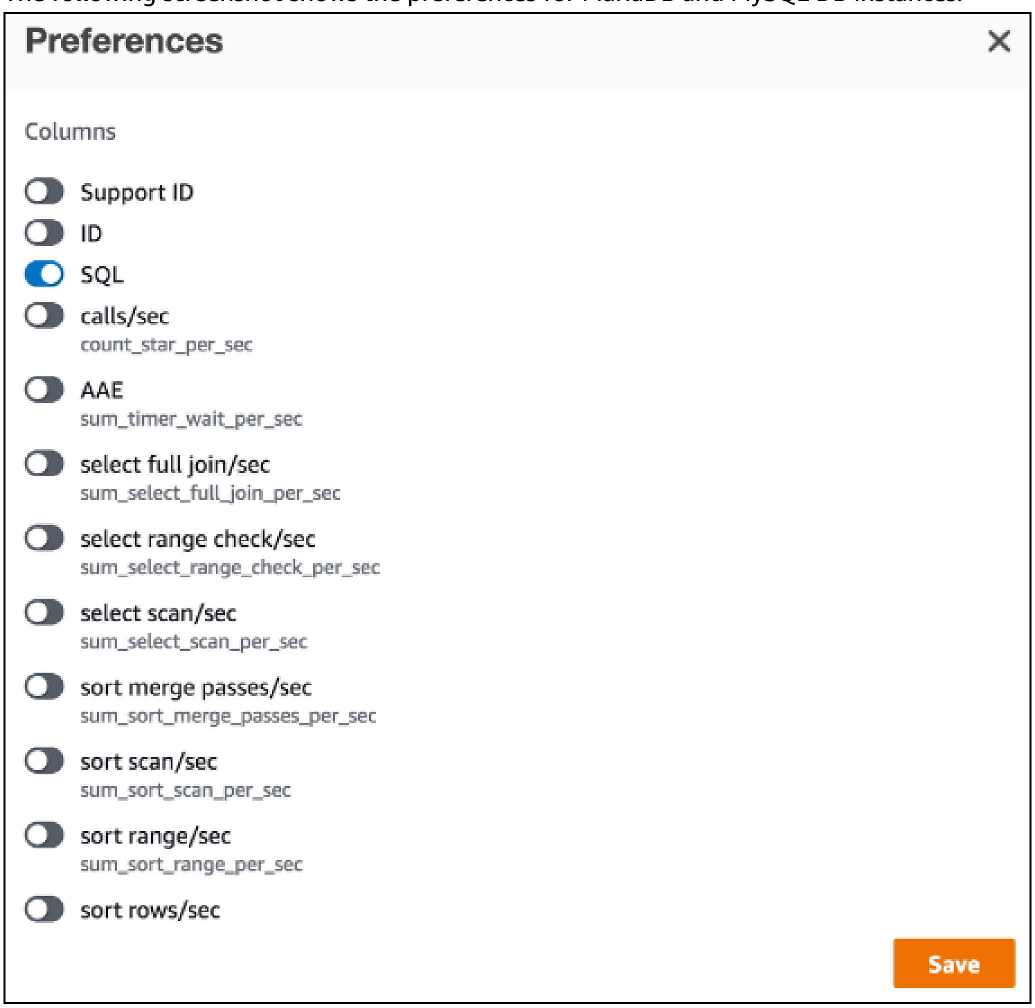
Analyzing MariaDB and MySQL Metrics for SQL Statements That Are Running

Using the AWS Management Console, you can view the metrics for a running SQL query by choosing the **SQL** tab and expanding the query.



Choose which statistics to display by choosing the gear icon in the upper-right corner of the chart.

The following screenshot shows the preferences for MariaDB and MySQL DB instances.



Statistics for Amazon RDS for Oracle

The following SQL statistics are available for Oracle DB instances.

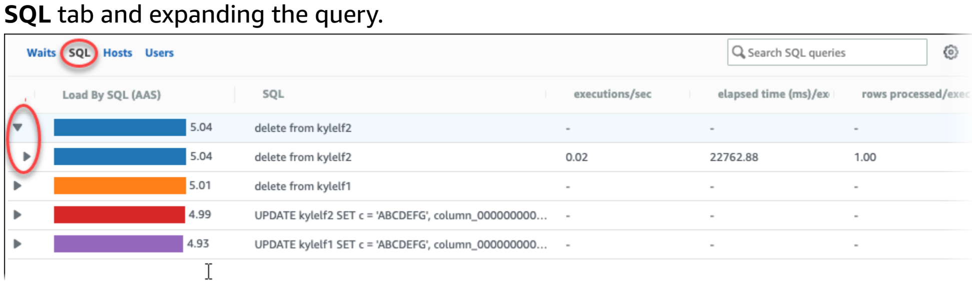
Metric	Unit
db.sql.stats.executions_per_sec	Number of executions per second
db.sql.stats.elapsed_time_per_sec	Average active executions (AAE)
db.sql.stats.rows_processed_per_sec	Rows processed per second
db.sql.stats.buffer_gets_per_sec	Buffer gets per second
db.sql.stats.physical_read_requests_per_sec	Physical reads per second
db.sql.stats.physical_write_requests_per_sec	Physical writes per second
db.sql.stats.total_sharable_mem_per_sec	Total shareable memory per second (in bytes)
db.sql.stats.cpu_time_per_sec	CPU time per second (in ms)

The following metrics provide per call statistics for a SQL statement.

Metric	Unit
db.sql.stats.elapsed_time_per_exec	Elapsed time per executions (in ms)
db.sql.stats.rows_processed_per_exec	Rows processed per execution
db.sql.stats.buffer_gets_per_exec	Buffer gets per execution
db.sql.stats.physical_read_requests_per_exec	Physical reads per execution
db.sql.stats.physical_write_requests_per_exec	Physical writes per execution
db.sql.stats.total_sharable_mem_per_exec	Total shareable memory per execution (in bytes)
db.sql.stats.cpu_time_per_exec	CPU time per execution (in ms)

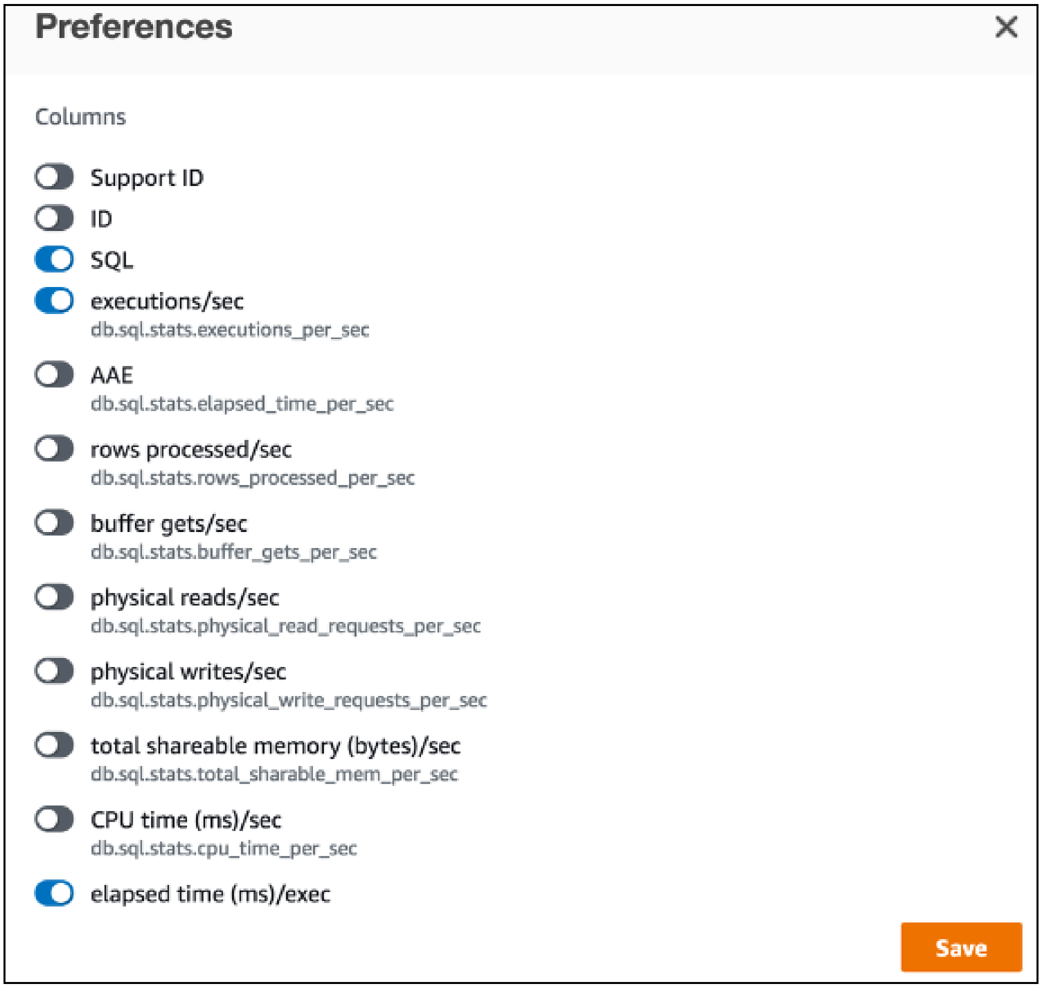
Analyzing Oracle Metrics for SQL Statements That Are Running

Using the AWS Management Console, you can view the metrics for a running SQL query by choosing the **SQL** tab and expanding the query.



Choose which statistics to display by choosing the gear icon in the upper-right corner of the chart.

The following screenshot shows the preferences for Oracle DB instances.



Viewing More SQL Text in the Performance Insights Dashboard

By default, each row in the **Top Load Items** table shows 500 bytes of SQL text for each SQL statement. When a SQL statement is larger than 500 bytes, you can view more of the SQL statement by opening the statement in the Performance Insights dashboard. The Performance Insights dashboard can display up to 4,096 bytes for a SQL statement. You can copy the displayed SQL statement. To view more than 4,096 bytes, choose **Download full SQL** to view the SQL text up to the DB engine limit.

The limit for SQL text depends on the DB engine. The following limits apply:

- Amazon RDS for Microsoft SQL Server – 4,096 characters
- Amazon RDS for MySQL and MariaDB – 1,024 bytes
- Amazon RDS for Oracle – 1,000 bytes
- Amazon RDS for PostgreSQL – Set by the `track_activity_query_size` DB instance parameter

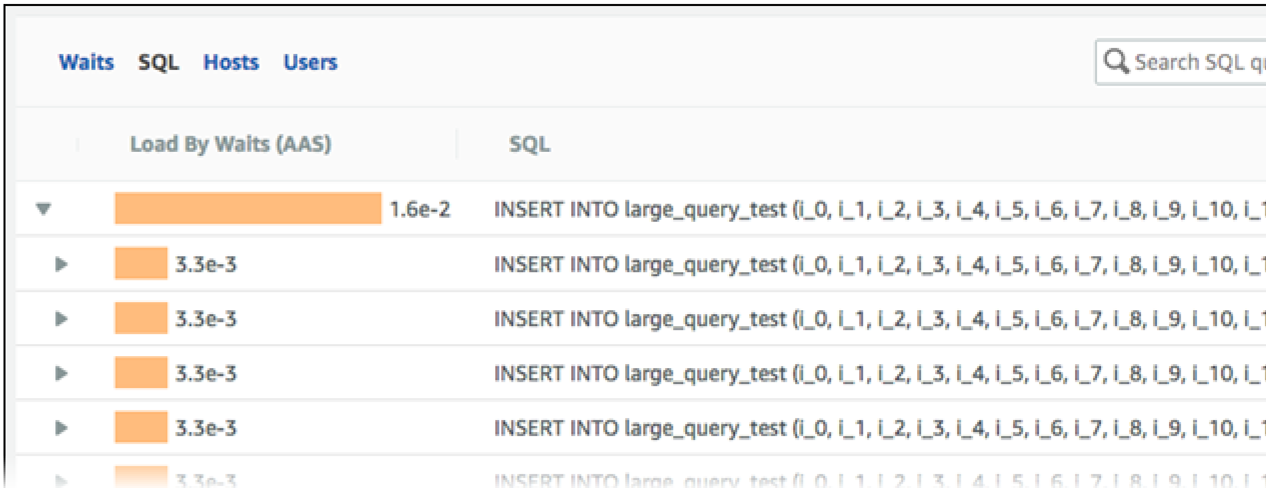
For Amazon RDS for PostgreSQL DB instances, you can control the limit of the SQL text size by setting the `track_activity_query_size` DB instance parameter, up to 102,400 bytes. You can use the AWS Management Console to download SQL text up to the limit you set with this parameter. For more information, see Setting the SQL Text Limit for Amazon RDS for PostgreSQL DB Instances (p. 396).

Important
Currently, you can only view and download more SQL text with the AWS Management Console. The AWS Performance Insights CLI and API can return a maximum of 500 bytes of text.

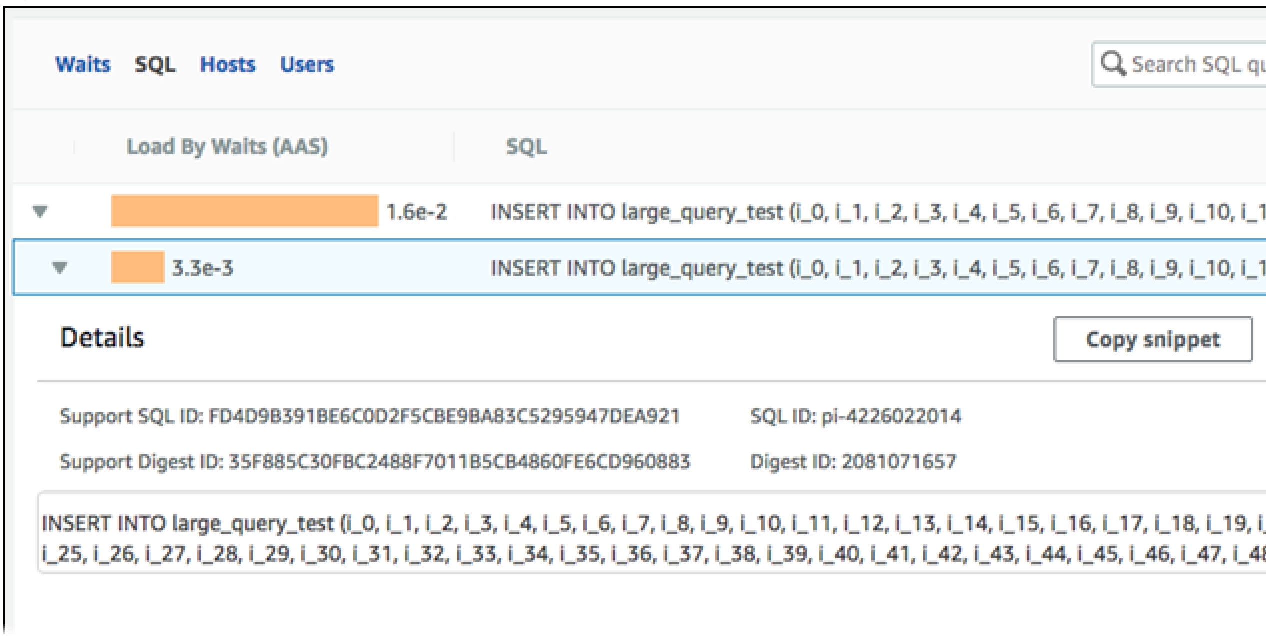
To view more SQL text in the Performance Insights dashboard

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Performance Insights**.
3. Choose a DB instance. The Performance Insights dashboard is displayed for that DB instance.

   SQL statements with text larger than 500 bytes look similar to the following image.



4. Open a SQL statement to view more of the SQL text.



   The Performance Insights dashboard can display up to 4,096 bytes for each SQL statement.

5. (Optional) Choose **Copy snippet** to copy the displayed SQL statement, or choose **Download full SQL** to download the SQL statement to view the SQL text up to the DB engine limit.

Note
To copy or download the SQL statement, disable pop-up blockers.

Setting the SQL Text Limit for Amazon RDS for PostgreSQL DB Instances

For Amazon RDS for PostgreSQL DB instances, you can control the limit for the SQL text that can be shown on the Performance Insights dashboard.

To do so, modify the `track_activity_query_size` DB instance parameter. The default setting for the `track_activity_query_size` parameter is 1,024 bytes.

You can increase the number of bytes to increase the SQL text size visible in the Performance Insights dashboard. The limit for the parameter is 102,400 bytes. For more information about the `track_activity_query_size` DB instance parameter, see Run-time Statistics in the PostgreSQL documentation.

To modify the parameter, change the parameter setting in the parameter group that is associated with the Amazon RDS for PostgreSQL DB instance.

If the Amazon RDS for PostgreSQL DB instance is using the default parameter group, complete the following steps:

1. Create a new DB instance parameter group for the appropriate DB engine and DB engine version.
2. Set the parameter in the new parameter group.
3. Associate the new parameter group with the DB instance.

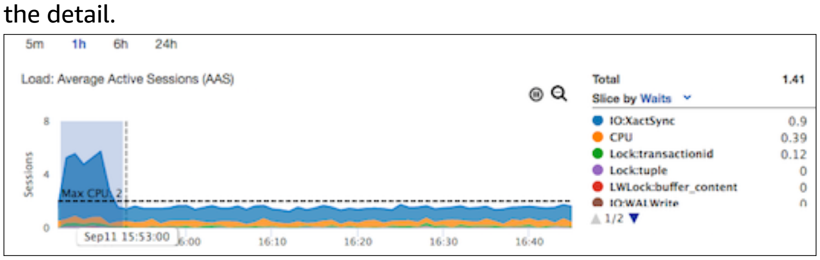
For information about setting a DB instance parameter, see Modifying Parameters in a DB Parameter Group (p. 204).

Additional User Interface Features

You can use other features of the Performance Insights user interface to help analyze performance data.

Click-and-Drag Zoom In

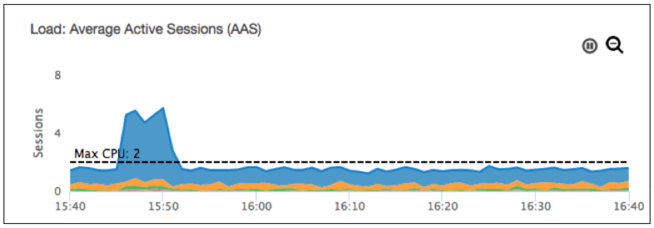
In the Performance Insights interface, you can choose a small portion of the load chart and zoom in on the detail.



To zoom in on a portion of the load chart, choose the start time and drag to the end of the time period you want. When you do this, the selected area is highlighted. When you release the mouse, the load chart zooms in on the selected region, and the **Top N** table is recalculated.

Pause and Zoom Out

In the upper-right corner of the load chart, you can find the **Pause** and **Zoom out** tools.



When you choose **Pause**, the load chart stops autorefreshing. When you choose **Pause** again, the chart resumes autorefreshing.

When you choose **Zoom out**, the load chart zooms out to the next largest time interval.

Performance Insights API

The Amazon RDS Performance Insights API provides visibility into the performance of your RDS instance, when Performance Insights is enabled for supported engine types. Amazon CloudWatch Logs provides the authoritative source for vended monitoring metrics for AWS services. Performance Insights offers a domain-specific view of database load measured as average active sessions and provided to API consumers as a two-dimensional time-series dataset. The time dimension of the data provides database load data for each time point in the queried time range. Each time point decomposes overall load in relation to the requested dimensions, such as `SQL`, `Wait-event`, `User`, or `Host`, measured at that time point.

Amazon RDS Performance Insights monitors your Amazon RDS DB instance so that you can analyze and troubleshoot database performance. One way to view Performance Insights data is in the AWS Management Console. Performance Insights also provides a public API so that you can query your own data. The API can be used to offload data into a database, add Performance Insights data to existing monitoring dashboards, or to build monitoring tools. To use the Performance Insights API, enable Performance Insights on one of your Amazon RDS DB instances. For information about enabling Performance Insights, see Enabling Performance Insights (p. 377).

The Performance Insights API provides the following operations.

Performance Insights Operation	AWS CLI Command	Description
`DescribeDimensionKeys`	`aws pi describe-dimension-keys`	Retrieves the top N dimension keys for a metric for a specific time period.
`GetResourceMetrics`	`aws pi get-resource-metrics`	Retrieves Performance Insights metrics for a set of data sources, over a time period. You can provide specific dimension groups and dimensions, and provide aggregation and filtering criteria for each group.

For more information about the Performance Insights API, see the Amazon RDS Performance Insights API Reference.

AWS CLI for Performance Insights

You can view Performance Insights data using the AWS CLI. You can view help for the AWS CLI commands for Performance Insights by entering the following on the command line.

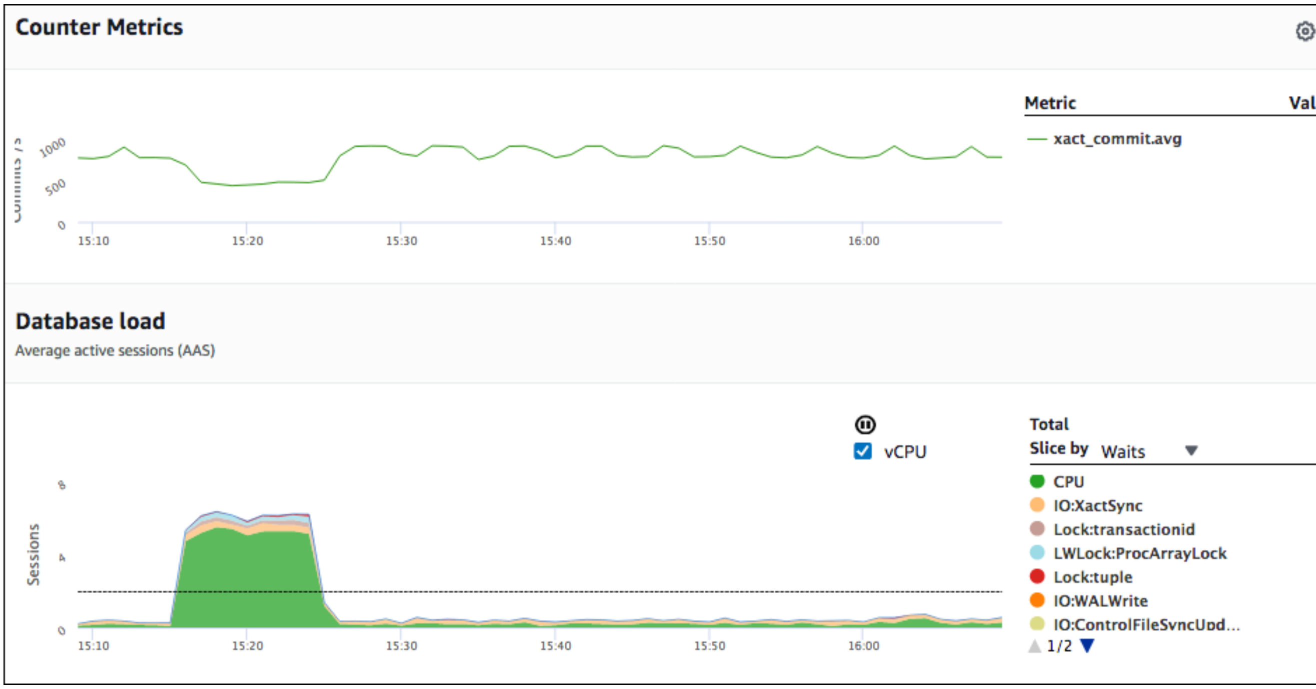
```
aws pi help
```

If you don't have the AWS CLI installed, see Installing the AWS Command Line Interface in the *AWS CLI User Guide* for information about installing it.

Retrieving Time-Series Metrics

The `GetResourceMetrics` operation retrieves one or more time-series metrics from the Performance Insights data. `GetResourceMetrics` requires a metric and time period, and returns a response with a list of data points.

For example, the AWS Management Console uses `GetResourceMetrics` in two places in the Performance Insights dashboard. `GetResourceMetrics` is used to populate the **Counter Metrics** chart and in the **Database Load** chart, as seen in the following image.



All the metrics returned by `GetResourceMetrics` are standard time-series metrics with one exception. The exception is `db.load`, which is the core metric in Performance Insights. This metric is displayed in the **Database Load** chart. The `db.load` metric is different from the other time-series metrics because you can break it into subcomponents called dimensions. In the previous image, `db.load` is broken down and grouped by the waits states that make up the `db.load`.

> **Note**
> `GetResourceMetrics` can also return the `db.sampleload` metric, but the `db.load` metric is appropriate in most cases.

For information about the counter metrics returned by `GetResourceMetrics`, see Performance Insights Counters (p. 411).

The following calculations are supported for the metrics:

- Average – The average value for the metric over a period of time. Append `.avg` to the metric name.

- Minimum – The minimum value for the metric over a period of time. Append `.min` to the metric name.
- Maximum – The maximum value for the metric over a period of time. Append `.max` to the metric name.
- Sum – The sum of the metric values over a period of time. Append `.sum` to the metric name.
- Sample count – The number of times the metric was collected over a period of time. Append `.sample_count` to the metric name.

For example, assume that a metric is collected for 300 seconds (5 minutes), and that the metric is collected one time each minute. The values for each minute are 1, 2, 3, 4, and 5. In this case, the following calculations are returned:

- Average – 3
- Minimum – 1
- Maximum – 5
- Sum – 15
- Sample count – 5

For information about using the `get-resource-metrics` AWS CLI command, see `get-resource-metrics`.

For the `--metric-queries` option, specify one or more queries that you want to get results for. Each query consists of a mandatory `Metric` and optional `GroupBy` and `Filter` parameters. The following is an example of a `--metric-queries` option specification.

```
{
   "Metric": "string",
   "GroupBy": {
     "Group": "string",
     "Dimensions": ["string", ...],
     "Limit": integer
   },
   "Filter": {"string": "string"
     ...}
}
```

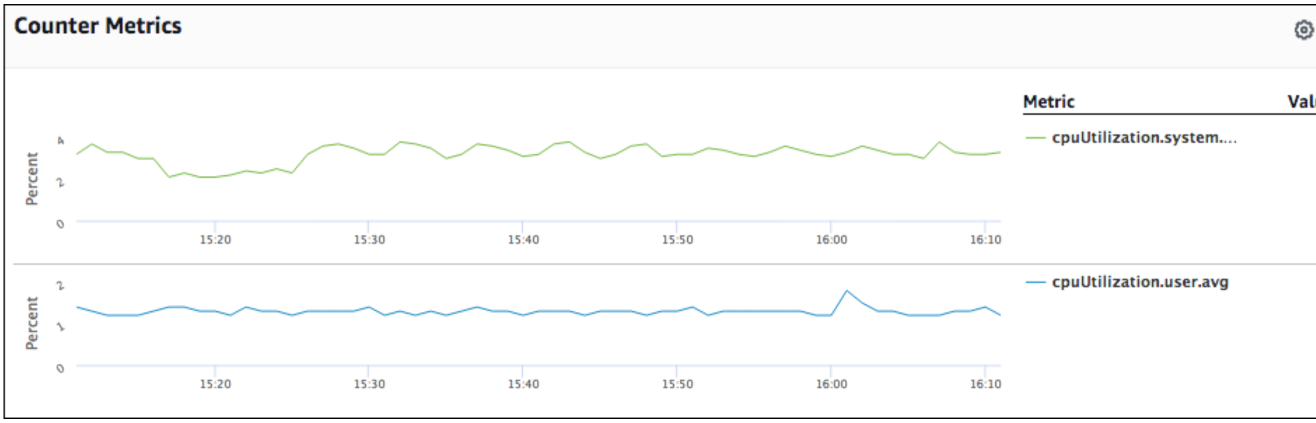
AWS CLI Examples for Performance Insights

The following are several examples that use the AWS CLI for Performance Insights.

Topics

Retrieving Counter Metrics

The following screenshot shows two counter metrics charts in the AWS Management Console.



The following example shows how to gather the same data that the AWS Management Console uses to generate the two counter metric charts.

For Linux, macOS, or Unix:

```
aws pi get-resource-metrics \
   --service-type RDS \
   --identifier db-ID \
   --start-time 2018-10-30T00:00:00Z \
   --end-time   2018-10-30T01:00:00Z \
   --period-in-seconds 60 \
   --metric-queries '[{"Metric": "os.cpuUtilization.user.avg"  },
                      {"Metric": "os.cpuUtilization.idle.avg"}]'
```

For Windows:

```
aws pi get-resource-metrics ^
   --service-type RDS ^
   --identifier db-ID ^
   --start-time 2018-10-30T00:00:00Z ^
   --end-time   2018-10-30T01:00:00Z ^
   --period-in-seconds 60 ^
   --metric-queries '[{"Metric": "os.cpuUtilization.user.avg"  },
                      {"Metric": "os.cpuUtilization.idle.avg"}]'
```

You can also make a command easier to read by specifying a file for the `--metrics-query` option. The following example uses a file called query.json for the option. The file has the following contents.

```
[
    {
        "Metric": "os.cpuUtilization.user.avg"
    },
    {
        "Metric": "os.cpuUtilization.idle.avg"
    }
]
```

Run the following command to use the file.

For Linux, macOS, or Unix:

```
aws pi get-resource-metrics \
   --service-type RDS \
   --identifier db-ID \
   --start-time 2018-10-30T00:00:00Z \
   --end-time   2018-10-30T01:00:00Z \
   --period-in-seconds 60 \
   --metric-queries file://query.json
```

For Windows:

```
aws pi get-resource-metrics ^
   --service-type RDS ^
   --identifier db-ID ^
   --start-time 2018-10-30T00:00:00Z ^
   --end-time   2018-10-30T01:00:00Z ^
   --period-in-seconds 60 ^
   --metric-queries file://query.json
```

The preceding example specifies the following values for the options:

- `--service-type` – `RDS` for Amazon RDS
- `--identifier` – The resource ID for the DB instance
- `--start-time` and `--end-time` – The ISO 8601 `DateTime` values for the period to query, with multiple supported formats

It queries for a one-hour time range:

- `--period-in-seconds` – `60` for a per-minute query
- `--metric-queries` – An array of two queries, each just for one metric.

  The metric name uses dots to classify the metric in a useful category, with the final element being a function. In the example, the function is `avg` for each query. As with Amazon CloudWatch, the supported functions are `min`, `max`, `total`, and `avg`.

The response looks similar to the following.

```
{
    "Identifier": "db-XXX",
    "AlignedStartTime": 1540857600.0,
    "AlignedEndTime": 1540861200.0,
    "MetricList": [
        { //A list of key/datapoints
            "Key": {
                "Metric": "os.cpuUtilization.user.avg" //Metric1
            },
            "DataPoints": [
                //Each list of datapoints has the same timestamps and same number of items
                {
                    "Timestamp": 1540857660.0, //Minute1
                    "Value": 4.0
                },
```

```
                {
                    "Timestamp": 1540857720.0, //Minute2
                    "Value": 4.0
                },
                {
                    "Timestamp": 1540857780.0, //Minute 3
                    "Value": 10.0
                }
                //... 60 datapoints for the os.cpuUtilization.user.avg metric
            ]
        },
        {
            "Key": {
                "Metric": "os.cpuUtilization.idle.avg" //Metric2
            },
            "DataPoints": [
                {
                    "Timestamp": 1540857660.0, //Minute1
                    "Value": 12.0
                },
                {
                    "Timestamp": 1540857720.0, //Minute2
                    "Value": 13.5
                },
                //... 60 datapoints for the os.cpuUtilization.idle.avg metric
            ]
        }
    ] //end of MetricList
} //end of response
```

The response has an `Identifier`, `AlignedStartTime` and `AlignedEndTime`. B the `--period-in-seconds` value was `60`, the start and end times have been aligned to the minute. If the `--period-in-seconds` was `3600`, the start and end times would have been aligned to the hour.

The `MetricList` in the response has a number of entries, each with a `Key` and a `DataPoints` entry. Each `DataPoint` has a `Timestamp` and a `Value`. Each `Datapoints` list has 60 data points because the queries are for per-minute data over an hour, with `Timestamp1/Minute1`, `Timestamp2/Minute2`, and so on up to `Timestamp60/Minute60`.

Because the query is for two different counter metrics, there are two elements in the response `MetricList`.

Retrieving the DB Load Average for Top Wait Events

The following example is the same query that the AWS Management Console uses to generate a stacked area line graph. This example retrieves the `db.load.avg` for the last hour with load divided according to the top seven wait events. The command is the same as the command in Retrieving Counter Metrics (p. 399). However, the query.json file has the following contents.

```
[
    {
        "Metric": "db.load.avg",
        "GroupBy": { "Group": "db.wait_event", "Limit": 7 }
    }
]
```

Run the following command.

For Linux, macOS, or Unix:

```
aws pi get-resource-metrics \
   --service-type RDS \
   --identifier db-ID \
   --start-time 2018-10-30T00:00:00Z \
   --end-time   2018-10-30T01:00:00Z \
   --period-in-seconds 60 \
   --metric-queries file://query.json
```

For Windows:

```
aws pi get-resource-metrics ^
   --service-type RDS ^
   --identifier db-ID ^
   --start-time 2018-10-30T00:00:00Z ^
   --end-time   2018-10-30T01:00:00Z ^
   --period-in-seconds 60 ^
   --metric-queries file://query.json
```

The example specifies the metric of `db.load.avg` and a `GroupBy` of the top seven wait events. For details about valid values for this example, see DimensionGroup in the *Performance Insights API Reference.*

The response looks similar to the following.

```
{
    "Identifier": "db-XXX",
    "AlignedStartTime": 1540857600.0,
    "AlignedEndTime": 1540861200.0,
    "MetricList": [
        { //A list of key/datapoints
            "Key": {
                //A Metric with no dimensions. This is the total db.load.avg
                "Metric": "db.load.avg"
            },
            "DataPoints": [
                //Each list of datapoints has the same timestamps and same number of items
                {
                    "Timestamp": 1540857660.0, //Minute1
                    "Value": 0.5166666666666667
                },
                {
                    "Timestamp": 1540857720.0, //Minute2
                    "Value": 0.38333333333333336
                },
                {
                    "Timestamp": 1540857780.0, //Minute 3
                    "Value": 0.26666666666666666
                }
                //... 60 datapoints for the total db.load.avg key
            ]
        },
        {
            "Key": {
                //Another key. This is db.load.avg broken down by CPU
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.name": "CPU",
```

```
                    "db.wait_event.type": "CPU"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1540857660.0, //Minute1
                    "Value": 0.35
                },
                {
                    "Timestamp": 1540857720.0, //Minute2
                    "Value": 0.15
                },
                //... 60 datapoints for the CPU key
            ]
        },
        //... In total we have 8 key/datapoints entries, 1) total, 2-8) Top Wait Events
    ] //end of MetricList
} //end of response
```

In this response, there are eight entries in the `MetricList`. There is one entry for the total `db.load.avg`, and seven entries each for the `db.load.avg` divided according to one of the top seven wait events. Unlike in the first example, because there was a grouping dimension, there must be one key for each grouping of the metric. There can't be only one key for each metric, as in the basic counter metric use case.

Retrieving the DB Load Average for Top SQL

The following example groups `db.wait_events` by the top 10 SQL statements. There are two different groups for SQL statements:

- `db.sql` – The full SQL statement, such as `select * from customers where customer_id = 123`
- `db.sql_tokenized` – The tokenized SQL statement, such as `select * from customers where customer_id = ?`

When analyzing database performance, it can be useful to consider SQL statements that only differ by their parameters as one logic item. So, you can use `db.sql_tokenized` when querying. However, especially when you are interested in explain plans, sometimes it's more useful to examine full SQL statements with parameters, and query grouping by `db.sql`. There is a parent-child relationship between tokenized and full SQL, with multiple full SQL (children) grouped under the same tokenized SQL (parent).

The command in this example is the similar to the command in Retrieving the DB Load Average for Top Wait Events (p. 402). However, the query.json file has the following contents.

```
[
    {
        "Metric": "db.load.avg",
        "GroupBy": { "Group": "db.sql_tokenized", "Limit": 10 }
    }
]
```

The following example uses `db.sql_tokenized`.

For Linux, macOS, or Unix:

```
aws pi get-resource-metrics \
   --service-type RDS \
   --identifier db-ID \
   --start-time 2018-10-29T00:00:00Z \
   --end-time   2018-10-30T00:00:00Z \
   --period-in-seconds 3600 \
   --metric-queries file://query.json
```

For Windows:

```
aws pi get-resource-metrics ^
   --service-type RDS ^
   --identifier db-ID ^
   --start-time 2018-10-29T00:00:00Z ^
   --end-time   2018-10-30T00:00:00Z  ^
   --period-in-seconds 3600 ^
   --metric-queries file://query.json
```

This example queries over 24 hours, with a one hour period-in-seconds.

The example specifies the metric of `db.load.avg` and a `GroupBy` of the top seven wait events. For details about valid values for this example, see DimensionGroup in the *Performance Insights API Reference*.

The response looks similar to the following.

```
{
    "AlignedStartTime": 1540771200.0,
    "AlignedEndTime": 1540857600.0,
    "Identifier": "db-XXX",

    "MetricList": [ //11 entries in the MetricList
        {
            "Key": { //First key is total
                "Metric": "db.load.avg"
            }
            "DataPoints": [ //Each DataPoints list has 24 per-hour Timestamps and a value
                {
                    "Value": 1.6964980544747081,
                    "Timestamp": 1540774800.0
                },
                //... 24 datapoints
            ]
        },
        {
            "Key": { //Next key is the top tokenized SQL
                "Dimensions": {
                    "db.sql_tokenized.statement": "INSERT INTO authors (id,name,email)
 VALUES\n( nextval(?)  ,?,?)",
                    "db.sql_tokenized.db_id": "pi-2372568224",
                    "db.sql_tokenized.id": "AKIAIOSFODNN7EXAMPLE"
                },
                "Metric": "db.load.avg"
            },
            "DataPoints": [ //... 24 datapoints
            ]
        },
        // In total 11 entries, 10 Keys of top tokenized SQL, 1 total key
```

```
    ] //End of MetricList
} //End of response
```

This response has 11 entries in the `MetricList` (1 total, 10 top tokenized SQL), with each entry having 24 per-hour `DataPoints`.

For tokenized SQL, there are three entries in each dimensions list:

- `db.sql_tokenized.statement` – The tokenized SQL statement.
- `db.sql_tokenized.db_id` – Either the native database ID used to refer to the SQL, or a synthetic ID that Performance Insights generates for you if the native database ID isn't available. This example returns the `pi-2372568224` synthetic ID.
- `db.sql_tokenized.id` – The ID of the query inside Performance Insights.

  In the AWS Management Console, this ID is called the Support ID. It's named this because the ID is data that AWS Support can examine to help you troubleshoot an issue with your database. AWS takes the security and privacy of your data extremely seriously, and almost all data is stored encrypted with your AWS KMS key. Therefore, nobody inside AWS can look at this data. In the example preceding, both the `tokenized.statement` and the `tokenized.db_id` are stored encrypted. If you have an issue with your database, AWS Support can help you by referencing the Support ID.

When querying, it might be convenient to specify a `Group` in `GroupBy`. However, for finer-grained control over the data that's returned, specify the list of dimensions. For example, if all that is needed is the `db.sql_tokenized.statement`, then a `Dimensions` attribute can be added to the query.json file.

```
[
    {
        "Metric": "db.load.avg",
        "GroupBy": {
            "Group": "db.sql_tokenized",
            "Dimensions":["db.sql_tokenized.statement"],
            "Limit": 10
        }
    }
]
```

Retrieving the DB Load Average Filtered by SQL

The preceding image shows that a particular query is selected, and the top average active sessions stacked area line graph is scoped to that query. Although the query is still for the top seven overall wait events, the value of the response is filtered. The filter causes it to take into account only sessions that are a match for the particular filter.

The corresponding API query in this example is similar to the command in Retrieving the DB Load Average for Top SQL (p. 404). However, the query.json file has the following contents.

```
[
 {
        "Metric": "db.load.avg",
        "GroupBy": { "Group": "db.wait_event", "Limit": 5  },
        "Filter": { "db.sql_tokenized.id": "AKIAIOSFODNN7EXAMPLE" }
    }
]
```

For Linux, macOS, or Unix:

```
aws pi get-resource-metrics \
   --service-type RDS \
   --identifier db-ID \
   --start-time 2018-10-30T00:00:00Z \
   --end-time   2018-10-30T01:00:00Z \
   --period-in-seconds 60 \
   --metric-queries file://query.json
```

For Windows:

```
aws pi get-resource-metrics ^
   --service-type RDS ^
   --identifier db-ID ^
```

```
   --start-time 2018-10-30T00:00:00Z ^
   --end-time   2018-10-30T01:00:00Z ^
   --period-in-seconds 60 ^
   --metric-queries file://query.json
```

The response looks similar to the following.


```
{
    "Identifier": "db-XXX",
    "AlignedStartTime": 1556215200.0,
    "MetricList": [
        {
            "Key": {
                "Metric": "db.load.avg"
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 1.4878117913832196
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 1.192823803967328
                }
            ]
        },
        {
            "Key": {
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.type": "io",
                    "db.wait_event.name": "wait/io/aurora_redo_log_flush"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 1.1360544217687074
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 1.058051341890315
                }
            ]
        },
        {
            "Key": {
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.type": "io",
                    "db.wait_event.name": "wait/io/table/sql/handler"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 0.16241496598639457
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 0.05163360560093349
                }
            ]
```

```
        },
        {
            "Key": {
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.type": "synch",
                    "db.wait_event.name": "wait/synch/mutex/innodb/
aurora_lock_thread_slot_futex"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 0.11479591836734694
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 0.013127187864644107
                }
            ]
        },
        {
            "Key": {
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.type": "CPU",
                    "db.wait_event.name": "CPU"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 0.05215419501133787
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 0.05805134189031505
                }
            ]
        },
        {
            "Key": {
                "Metric": "db.load.avg",
                "Dimensions": {
                    "db.wait_event.type": "synch",
                    "db.wait_event.name": "wait/synch/mutex/innodb/lock_wait_mutex"
                }
            },
            "DataPoints": [
                {
                    "Timestamp": 1556218800.0,
                    "Value": 0.017573696145124718
                },
                {
                    "Timestamp": 1556222400.0,
                    "Value": 0.002333722287047841
                }
            ]
        }
    ],
    "AlignedEndTime": 1556222400.0
} //end of response
```

In this response, all values are filtered according to the contribution of tokenized SQL AKIAIOSFODNN7EXAMPLE specified in the query.json file. The keys also might follow a different order than a query without a filter, because it's the top five wait events that affected the filtered SQL.

Performance Insights Metrics Published to Amazon CloudWatch

Performance Insights automatically publishes metrics to Amazon CloudWatch. The same data can be queried from Performance Insights, but having the metrics in CloudWatch makes it easy to add CloudWatch alarms. It also makes it easy to add the metrics to existing CloudWatch Dashboards.

Metric	Description
DBLoad	The number of active sessions for the DB engine. Typically, you want the data for the average number of active sessions. In Performance Insights, this data is queried as `db.load.avg`.
DBLoadCPU	The number of active sessions where the wait event type is CPU. In Performance Insights, this data is queried as `db.load.avg`, filtered by the wait event type `CPU`.
DBLoadNonCPU	The number of active sessions where the wait event type is not CPU.

Note
These metrics are published to CloudWatch only if there is load on the DB instance.

You can examine these metrics using the CloudWatch console, the AWS CLI, or the CloudWatch API.

For example, you can get the statistics for the `DBLoad` metric by running the get-metric-statistics command.

```
aws cloudwatch get-metric-statistics --region us-west-2 --namespace AWS/RDS --metric-name
 DBLoad  --period 60 --statistics Average --start-time 1532035185 --end-time 1532036185 --
dimensions  Name=DBInstanceIdentifier,Value=db-loadtest-0
```

This example generates output similar to the following.

```
{
"Datapoints": [
{
"Timestamp": "2018-07-19T21:30:00Z",
"Unit": "None",
"Average": 2.1
},
{
"Timestamp": "2018-07-19T21:34:00Z",
"Unit": "None",
"Average": 1.7
},
{
"Timestamp": "2018-07-19T21:35:00Z",
```

```
"Unit": "None",
"Average": 2.8
},
{
"Timestamp": "2018-07-19T21:31:00Z",
"Unit": "None",
"Average": 1.5
},
{
"Timestamp": "2018-07-19T21:32:00Z",
"Unit": "None",
"Average": 1.8
},
{
"Timestamp": "2018-07-19T21:29:00Z",
"Unit": "None",
"Average": 3.0
},
{
"Timestamp": "2018-07-19T21:33:00Z",
"Unit": "None",
"Average": 2.4
}
],
"Label": "DBLoad"
}
```


For more information about CloudWatch, see What is Amazon CloudWatch? in the *Amazon CloudWatch User Guide*.

Performance Insights Counters

With counter metrics, you can customize the Performance Insights dashboard to include up to 10 additional graphs. These graphs that show a selection of dozens of operating system and database performance metrics. This information can be correlated with database load to help identify and analyze performance problems.

Topics

Performance Insights Operating System Counters

The following operating system counters are available with Performance Insights for Aurora PostgreSQL. You can find definitions for these metrics in Viewing Enhanced Monitoring by Using CloudWatch Logs (p. 368).

Counter	Type	Metric
active	memory	os.memory.active
buffers	memory	os.memory.buffers
cached	memory	os.memory.cached

Counter	Type	Metric
dirty	memory	os.memory.dirty
free	memory	os.memory.free
hugePagesFree	memory	os.memory.hugePagesFree
hugePagesRsvd	memory	os.memory.hugePagesRsvd
hugePagesSize	memory	os.memory.hugePagesSize
hugePagesSurp	memory	os.memory.hugePagesSurp
hugePagesTotal	memory	os.memory.hugePagesTotal
inactive	memory	os.memory.inactive
mapped	memory	os.memory.mapped
pageTables	memory	os.memory.pageTables
slab	memory	os.memory.slab
total	memory	os.memory.total
writeback	memory	os.memory.writeback
guest	cpuUtilization	os.cpuUtilization.guest
idle	cpuUtilization	os.cpuUtilization.idle
irq	cpuUtilization	os.cpuUtilization.irq
nice	cpuUtilization	os.cpuUtilization.nice
steal	cpuUtilization	os.cpuUtilization.steal
system	cpuUtilization	os.cpuUtilization.system
total	cpuUtilization	os.cpuUtilization.total
user	cpuUtilization	os.cpuUtilization.user
wait	cpuUtilization	os.cpuUtilization.wait
avgQueueLen	diskIO	os.diskIO.avgQueueLen
avgReqSz	diskIO	os.diskIO.avgReqSz
await	diskIO	os.diskIO.await
readIOsPS	diskIO	os.diskIO.readIOsPS
readKb	diskIO	os.diskIO.readKb
readKbPS	diskIO	os.diskIO.readKbPS
rrqmPS	diskIO	os.diskIO.rrqmPS
tps	diskIO	os.diskIO.tps
util	diskIO	os.diskIO.util

Counter	Type	Metric
writeIOsPS	diskIO	os.diskIO.writeIOsPS
writeKb	diskIO	os.diskIO.writeKb
writeKbPS	diskIO	os.diskIO.writeKbPS
wrqmPS	diskIO	os.diskIO.wrqmPS
blocked	tasks	os.tasks.blocked
running	tasks	os.tasks.running
sleeping	tasks	os.tasks.sleeping
stopped	tasks	os.tasks.stopped
total	tasks	os.tasks.total
zombie	tasks	os.tasks.zombie
one	loadAverageMinute	os.loadAverageMinute.one
fifteen	loadAverageMinute	os.loadAverageMinute.fifteen
five	loadAverageMinute	os.loadAverageMinute.five
cached	swap	os.swap.cached
free	swap	os.swap.free
in	swap	os.swap.in
out	swap	os.swap.out
total	swap	os.swap.total
maxFiles	fileSys	os.fileSys.maxFiles
usedFiles	fileSys	os.fileSys.usedFiles
usedFilePercent	fileSys	os.fileSys.usedFilePercent
usedPercent	fileSys	os.fileSys.usedPercent
used	fileSys	os.fileSys.used
total	fileSys	os.fileSys.total
rx	network	os.network.rx
tx	network	os.network.tx
numVCPUs	general	os.general.numVCPUs

Performance Insights Counters for Amazon RDS for MariaDB and MySQL

The following database counters are available with Performance Insights for Amazon RDS for MariaDB and MySQL.

Topics

Native Counters for RDS MariaDB and RDS MySQL

You can find definitions for these native metrics in Server Status Variables in the MySQL documentation.

Counter	Type	Unit	Metric
Com_analyze	SQL	Queries per second	db.SQL.Com_analyze
Com_optimize	SQL	Queries per second	db.SQL.Com_optimize
Com_select	SQL	Queries per second	db.SQL.Com_select
Innodb_rows_deleted	SQL	Rows per second	db.SQL.Innodb_rows_deleted
Innodb_rows_inserted	SQL	Rows per second	db.SQL.Innodb_rows_inserted
Innodb_rows_read	SQL	Rows per second	db.SQL.Innodb_rows_read
Innodb_rows_updated	SQL	Rows per second	db.SQL.Innodb_rows_updated
Select_full_join	SQL	Queries per second	db.SQL.Select_full_join
Select_full_range_join	SQL	Queries per second	db.SQL.Select_full_range_join
Select_range	SQL	Queries per second	db.SQL.Select_range
Select_range_check	SQL	Queries per second	db.SQL.Select_range_check
Select_scan	SQL	Queries per second	db.SQL.Select_scan
Slow_queries	SQL	Queries per second	db.SQL.Slow_queries
Sort_merge_passes	SQL	Queries per second	db.SQL.Sort_merge_passes
Sort_range	SQL	Queries per second	db.SQL.Sort_range
Sort_rows	SQL	Queries per second	db.SQL.Sort_rows
Sort_scan	SQL	Queries per second	db.SQL.Sort_scan
Questions	SQL	Queries per second	db.SQL.Questions
Innodb_row_lock_time	Locks	Milliseconds (average)	db.Locks.Innodb_row_lock_time
Table_locks_immediate	Locks	Requests per second	db.Locks.Table_locks_immediate
Table_locks_waited	Locks	Requests per second	db.Locks.Table_locks_waited
Aborted_clients	Users	Connections	db.Users.Aborted_clients
Aborted_connects	Users	Connections	db.Users.Aborted_connects
Threads_created	Users	Connections	db.Users.Threads_created
Threads_running	Users	Connections	db.Users.Threads_running
Innodb_data_writes	IO	Operations per second	db.IO.Innodb_data_writes

Counter	Type	Unit	Metric
Innodb_dblwr_writes	IO	Operations per second	db.IO.Innodb_dblwr_writes
Innodb_log_write_requests	IO	Operations per second	db.IO.Innodb_log_write_requests
Innodb_log_writes	IO	Operations per second	db.IO.Innodb_log_writes
Innodb_pages_written	IO	Pages per second	db.IO.Innodb_pages_written
Created_tmp_disk_tables	Temp	Tables per second	db.Temp.Created_tmp_disk_tables
Created_tmp_tables	Temp	Tables per second	db.Temp.Created_tmp_tables
Innodb_buffer_pool_pages_data	Cache	Pages	db.Cache.Innodb_buffer_pool_pages_d
Innodb_buffer_pool_pages_total	Cache	Pages	db.Cache.Innodb_buffer_pool_pages_t
Innodb_buffer_pool_read_requests	Cache	Pages per second	db.Cache.Innodb_buffer_pool_read_re
Innodb_buffer_pool_reads	Cache	Pages per second	db.Cache.Innodb_buffer_pool_reads
Opened_tables	Cache	Tables	db.Cache.Opened_tables
Opened_table_definitions	Cache	Tables	db.Cache.Opened_table_definitions
Qcache_hits	Cache	Queries	db.Cache.Qcache_hits

Non-Native Counters for Amazon RDS for MariaDB and MySQL

Non-native counter metrics are counters defined by Amazon RDS. A non-native metric can be a metric that you get with a specific query. A non-native metric also can be a derived metric, where two or more native counters are used in calculations for ratios, hit rates, or latencies.

Counter	Type	Metric	Description	Definition
innodb_buffer_pool_hits	Cache	db.Cache.innodb_buffer_pool_hits	The number of reads that InnoDB could satisfy from the buffer pool.	`innodb_buffer_pool_read_requests - innodb_buffer_pool_reads`
innodb_buffer_pool_hit_rate	Cache	db.Cache.innodb_buffer_pool_hit_rate	The percentage of reads that InnoDB could satisfy from the buffer pool.	`100 * innodb_buffer_pool_read_requests / (innodb_buffer_pool_read_requests + innodb_buffer_pool_reads)`
innodb_buffer_pool_usage	Cache	db.Cache.innodb_buffer_pool_usage	The percentage of the InnoDB buffer pool that contains data (pages). **Note** When using compressed tables, this value can vary. For more information, see the information about `Innodb_buffer_pool_pages_data`	`Innodb_buffer_pool_pages_data / Innodb_buffer_pool_pages_total * 100.0`

Counter	Type	Metric	Description	Definition
			and `Innodb_buffer_pool_pages_total` in Server Status Variables in the MySQL documentation.	
query_cache_hit_rate	Cache	db.Cache.query_cache_hit_rate	MySQL result set cache (query cache) hit ratio.	`Qcache_hits / (QCache_hits + Com_select) * 100`
innodb_datafile_writes_to_disk	IO	db.IO.innodb_datafile_writes_to_disk	The number of InnoDB data file writes to disk, excluding double write and redo logging write operations.	`Innodb_data_writes - Innodb_log_writes - Innodb_dblwr_writes`
innodb_rows_changed	SQL	db.SQL.innodb_rows_changed	The total InnoDB row operations.	`db.SQL.Innodb_rows_inserted + db.SQL.Innodb_rows_deleted + db.SQL.Innodb_rows_updated`
active_transactions	Transactions	db.Transactions.active_transactions	The total active transactions.	`SELECT COUNT(1) AS active_transactions FROM INFORMATION_SCHEMA.INNODB_TRX`
innodb_deadlocks	Locks	db.Locks.innodb_deadlocks	The total number of deadlocks.	`SELECT COUNT AS innodb_deadlocks FROM INFORMATION_SCHEMA.INNODB_METRICS WHERE NAME='lock_deadlocks'`
innodb_lock_timeouts	Locks	db.Locks.innodb_lock_timeouts	The total number of deadlocks that timed out.	`SELECT COUNT AS innodb_lock_timeouts FROM INFORMATION_SCHEMA.INNODB_METRICS WHERE NAME='lock_timeouts'`
innodb_row_lock_waits	Locks	db.Locks.innodb_row_lock_waits	The total number of row locks that resulted in a wait.	`SELECT COUNT AS innodb_row_lock_waits FROM INFORMATION_SCHEMA.INNODB_METRICS WHERE NAME='lock_row_lock_waits'`

Performance Insights Counters for Amazon RDS for Microsoft SQL Server

The following database counters are available with Performance Insights for RDS for Microsoft SQL Server.

Native Counters for RDS for Microsoft SQL Server

You can find definitions for these native metrics in Use SQL Server Objects in the Microsoft SQL Server documentation.

Counter	Type	Unit	Metric
Forwarded Records	Access Methods	Records per second	db.Access Methods.Forwarded Records
Page Splits	Access Methods	Splits per second	db.Access Methods.Page Splits
Buffer cache hit ratio	Buffer Manager	Ratio	db.Buffer Manager.Buffer cache hit ratio
Page life expectancy	Buffer Manager	Expectancy in seconds	db.Buffer Manager.Page life expectancy
Page lookups	Buffer Manager	Lookups per second	db.Buffer Manager.Page lookups
Page reads	Buffer Manager	Reads per second	db.Buffer Manager.Page reads
Page writes	Buffer Manager	Writes per second	db.Buffer Manager.Page writes
Active Transactions	Databases	Transactions	db.Databases.Active Transactions (_Total)
Log Bytes Flushed	Databases	Bytes flushed per second	db.Databases.Log Bytes Flushed (_Total)
Log Flush Waits	Databases	Waits per second	db.Databases.Log Flush Waits (_Total)
Log Flushes	Databases	Flushes per second	db.Databases.Log Flushes (_Total)
Write Transactions	Databases	Transactions per second	db.Databases.Write Transactions (_Total)
Processes blocked	General Statistics	Processes blocked	db.General Statistics.Processes blocked
User Connections	General Statistics	Connections	db.General Statistics.User Connections
Latch Waits	Latches	Waits per second	db.Latches.Latch Waits
Number of Deadlocks	Locks	Deadlocks per second	db.Locks.Number of Deadlocks (_Total)

Counter	Type	Unit	Metric
Memory Grants Pending	Memory Manager	Memory grants	db.Memory Manager.Memory Grants Pending
Batch Requests	SQL Statistics	Requests per second	db.SQL Statistics.Batch Requests
SQL Compilations	SQL Statistics	Compilations per second	db.SQL Statistics.SQL Compilations
SQL Re-Compilations	SQL Statistics	Re-compilations per second	db.SQL Statistics.SQL Re-Compilations

Performance Insights Counters for Amazon RDS for Oracle

The following database counters are available with Performance Insights for RDS for Oracle.

Native Counters for RDS for Oracle

You can find definitions for these native metrics in Statistics Descriptions in the Oracle documentation.

Note

For the `CPU used by this session` counter metric, the unit has been transformed from the native centiseconds to active sessions to make the value easier to use. For example, CPU send in the DB Load chart represents the demand for CPU. The counter metric `CPU used by this session` represents the amount of CPU used by Oracle sessions. You can compare CPU send to the `CPU used by this session` counter metric. When demand for CPU is higher than CPU used, sessions are waiting for CPU time.

Counter	Type	Unit	Metric
CPU used by this session	User	Active sessions	db.User.CPU used by this session
SQL*Net roundtrips to/from client	User	Roundtrips per second	db.User.SQL*Net roundtrips to/from client
Bytes received via SQL*Net from client	User	Bytes per second	db.User.bytes received via SQL*Net from client
User commits	User	Commits per second	db.User.user commits
Logons cumulative	User	Logons per second	db.User.logons cumulative
User calls	User	Calls per second	db.User.user calls
Bytes sent via SQL*Net to client	User	Bytes per second	db.User.bytes sent via SQL*Net to client
User rollbacks	User	Rollbacks per second	db.User.user rollbacks
Redo size	Redo	Bytes per second	db.Redo.redo size
Parse count (total)	SQL	Parses per second	db.SQL.parse count (total)

Counter	Type	Unit	Metric
Parse count (hard)	SQL	Parses per second	db.SQL.parse count (hard)
Table scan rows gotten	SQL	Rows per second	db.SQL.table scan rows gotten
Sorts (memory)	SQL	Sorts per second	db.SQL.sorts (memory)
Sorts (disk)	SQL	Sorts per second	db.SQL.sorts (disk)
Sorts (rows)	SQL	Sorts per second	db.SQL.sorts (rows)
Physical read bytes	Cache	Bytes per second	db.Cache.physical read bytes
DB block gets	Cache	Blocks per second	db.Cache.db block gets
DBWR checkpoints	Cache	Checkpoints per minute	db.Cache.DBWR checkpoints
Physical reads	Cache	Reads per second	db.Cache.physical reads
Consistent gets from cache	Cache	Gets per second	db.Cache.consistent gets from cache
DB block gets from cache	Cache	Gets per second	db.Cache.db block gets from cache
Consistent gets	Cache	Gets per second	db.Cache.consistent gets

Performance Insights Counters for Amazon RDS for PostgreSQL

The following database counters are available with Performance Insights for Amazon RDS for PostgreSQL.

Topics

Native Counters for Amazon RDS for PostgreSQL

You can find definitions for these native metrics in Viewing Statistics in the PostgreSQL documentation.

Counter	Type	Unit	Metric
blks_hit	Cache	Blocks per second	db.Cache.blks_hit
buffers_alloc	Cache	Blocks per second	db.Cache.buffers_alloc
buffers_checkpoint	Checkpoint	Blocks per second	db.Checkpoint.buffers_checkpoint
checkpoint_sync_time	Checkpoint	Milliseconds per checkpoint	db.Checkpoint.checkpoint_sync_time

Counter	Type	Unit	Metric
checkpoint_write_time	Checkpoint	Milliseconds per checkpoint	db.Checkpoint.checkpoint_write_time
checkpoints_req	Checkpoint	Checkpoints per minute	db.Checkpoint.checkpoints_req
checkpoints_timed	Checkpoint	Checkpoints per minute	db.Checkpoint.checkpoints_timed
maxwritten_clean	Checkpoint	Bgwriter clean stops per minute	db.Checkpoint.maxwritten_clean
deadlocks	Concurrency	Deadlocks per minute	db.Concurrency.deadlocks
blk_read_time	IO	Milliseconds	db.IO.blk_read_time
blks_read	IO	Blocks per second	db.IO.blks_read
buffers_backend	IO	Blocks per second	db.IO.buffers_backend
buffers_backend_fsync	IO	Blocks per second	db.IO.buffers_backend_fsync
buffers_clean	IO	Blocks per second	db.IO.buffers_clean
tup_deleted	SQL	Tuples per second	db.SQL.tup_deleted
tup_fetched	SQL	Tuples per second	db.SQL.tup_fetched
tup_inserted	SQL	Tuples per second	db.SQL.tup_inserted
tup_returned	SQL	Tuples per second	db.SQL.tup_returned
tup_updated	SQL	Tuples per second	db.SQL.tup_updated
temp_bytes	Temp	Bytes per second	db.Temp.temp_bytes
temp_files	Temp	Files per minute	db.Temp.temp_files
active_transactions	Transactions	Transactions	db.Transactions.active_transactions
blocked_transactions	Transactions	Transactions	db.Transactions.blocked_transactions
max_used_xact_ids	Transactions	Transactions	db.Transactions.max_used_xact_ids
xact_commit	Transactions	Commits per second	db.Transactions.xact_commit
xact_rollback	Transactions	Rollbacks per second	db.Transactions.xact_rollback
numbackends	User	Connections	db.User.numbackends
archived_count	WAL	Files per minute	db.WAL.archived_count
archive_failed_count	WAL	Files per minute	db.WAL.archive_failed_count

Non-Native Counters for Amazon RDS for PostgreSQL

Non-native counter metrics are counters defined by Amazon RDS. A non-native metric can be a metric that you get with a specific query. A non-native metric also can be a derived metric, where two or more native counters are used in calculations for ratios, hit rates, or latencies.

Counter	Type	Metric	Description	Definition
checkpoint_sync_latency	Checkpoint	db.Checkpoint.checkpoint_sync_latency	The total amount of time that has been spent in the portion of checkpoint processing where files are synchronized to disk.	`checkpoint_sync_time / (checkpoints_timed + checkpoints_req)`
checkpoint_write_latency	Checkpoint	db.Checkpoint.checkpoint_write_latency	The total amount of time that has been spent in the portion of checkpoint processing where files are written to disk.	`checkpoint_write_time / (checkpoints_timed + checkpoints_req)`
read_latency	IO	db.IO.read_latency	The time spent reading data file blocks by backends in this instance.	`blk_read_time / blks_read`

Logging Performance Insights Calls by Using AWS CloudTrail

Performance Insights is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Performance Insights. CloudTrail captures all API calls for Performance Insights as events. This capture includes calls from the Amazon RDS console and from code calls to the Performance Insights API operations.

If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for Performance Insights. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. Using the data collected by CloudTrail, you can determine certain information. This information includes the request that was made to Performance Insights, the IP address the request was made from, who made the request, and when it was made. It also includes additional details.

To learn more about CloudTrail, see the AWS CloudTrail User Guide.

Working with Performance Insights Information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in Performance Insights, that activity is recorded in a CloudTrail event along with other AWS service events in the CloudTrail console in **Event history**. You can view, search, and download recent events in your AWS account. For more information, see Viewing Events with CloudTrail Event History in *AWS CloudTrail User Guide.*

For an ongoing record of events in your AWS account, including events for Performance Insights, create a trail. A *trail* enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all AWS Regions. The trail logs events from all AWS Regions in the AWS partition and delivers the log files to the Amazon S3 bucket that you specify. Additionally, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see the following topics in *AWS CloudTrail User Guide:*

- Overview for Creating a Trail
- CloudTrail Supported Services and Integrations
- Configuring Amazon SNS Notifications for CloudTrail

- Receiving CloudTrail Log Files from Multiple Regions and Receiving CloudTrail Log Files from Multiple Accounts

All Performance Insights operations are logged by CloudTrail and are documented in the Performance Insights API Reference. For example, calls to the `DescribeDimensionKeys` and `GetResourceMetrics` operations generate entries in the CloudTrail log files.

Every event or log entry contains information about who generated the request. The identity information helps you determine the following:

- Whether the request was made with root or IAM user credentials.
- Whether the request was made with temporary security credentials for a role or federated user.
- Whether the request was made by another AWS service.

For more information, see the CloudTrail userIdentity Element.

Understanding Performance Insights Log File Entries

A *trail* is a configuration that enables delivery of events as log files to an Amazon S3 bucket that you specify. CloudTrail log files contain one or more log entries. An *event* represents a single request from any source. Each event includes information about the requested operation, the date and time of the operation, request parameters, and so on. CloudTrail log files aren't an ordered stack trace of the public API calls, so they don't appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the `GetResourceMetrics` operation.

```
{
    "eventVersion": "1.05",
    "userIdentity": {
        "type": "IAMUser",
         "principalId": "AKIAIOSFODNN7EXAMPLE",
        "arn": "arn:aws:iam::123456789012:user/johndoe",
        "accountId": "123456789012",
        "accessKeyId": "AKIAI44QH8DHBEXAMPLE",
        "userName": "johndoe"
    },
    "eventTime": "2019-12-18T19:28:46Z",
    "eventSource": "pi.amazonaws.com",
    "eventName": "GetResourceMetrics",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "72.21.198.67",
    "userAgent": "aws-cli/1.16.240 Python/3.7.4 Darwin/18.7.0 botocore/1.12.230",
    "requestParameters": {
        "identifier": "db-YTDU5J5V66X7CXSCVDFD2V3SZM",
        "metricQueries": [
            {
                "metric": "os.cpuUtilization.user.avg"
            },
            {
                "metric": "os.cpuUtilization.idle.avg"
            }
        ],
        "startTime": "Dec 18, 2019 5:28:46 PM",
        "periodInSeconds": 60,
        "endTime": "Dec 18, 2019 7:28:46 PM",
        "serviceType": "RDS"
    },
    "responseElements": null,
```

```
    "requestID": "9ffbe15c-96b5-4fe6-bed9-9fccff1a0525",
    "eventID": "08908de0-2431-4e2e-ba7b-f5424f908433",
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
}
```

Using Amazon RDS Recommendations

Amazon RDS provides automated recommendations for database resources, such as DB instances, read replicas, and DB parameter groups. These recommendations provide best practice guidance by analyzing DB instance configuration, usage, and performance data.

You can find examples of these recommendations in the following table.

Type	Description	Recommendation	Additional Information
Engine version outdated	Your DB instance is not running the latest minor engine version.	We recommend that you upgrade to the latest version because it contains the latest security fixes and other improvements.	Upgrading a DB Instance Engine Version (p. 241)
Pending maintenance available	You have pending maintenance available on your DB instance.	We recommend that you perform the pending maintenance available on your DB instance. Updates to the operating system most often occur for security issues and should be done as soon as possible.	Maintaining a DB Instance (p. 234)
Automated backups disabled	Your DB instance has automated backups disabled.	We recommend that you enable automated backups on your DB instance. Automated backups enable point-in-time recovery of your DB instance. You receive backup storage up to the storage size of your DB instance at no additional charge.	Working With Backups (p. 291)
Magnetic volumes in use	Your DB instance is using magnetic storage.	Magnetic storage is not recommended for most DB instances. We recommend switching to General Purpose (SSD) storage or provisioned IOPS storage.	Amazon RDS DB Instance Storage (p. 29)
EC2-Classic platform in use	Your DB instance is using the legacy EC2-Classic platform.	We recommend moving your DB instance to the EC2-VPC platform for better network access control. Amazon VPC provides a virtual network that is logically isolated from other virtual networks in the AWS Cloud.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434)
Enhanced Monitoring disabled	Your DB instance doesn't have Enhanced Monitoring enabled.	We recommend enabling Enhanced Monitoring. Enhanced Monitoring provides real-time operating system metrics for monitoring and troubleshooting.	Enhanced Monitoring (p. 362)
Encryption disabled	Your DB instance doesn't have encryption enabled.	We recommend enabling encryption. You can encrypt your existing Amazon RDS DB instances by restoring from an encrypted snapshot.	Encrypting Amazon RDS Resources (p. 1358)
Previous generation	Your DB instance is running on a	Previous-generation DB instance classes have been replaced by DB	DB Instance Classes (p. 7)

Type	Description	Recommendation	Additional Information
DB instance class in use	previous-generation DB instance class.	instance classes with better price, better performance, or both. We recommend running your DB instance on a later generation DB instance class.	
Huge pages not used for an Oracle DB instance	The `use_large_pages` parameter is not set to `ONLY` in the DB parameter group used by your DB instance.	For increased database scalability, we recommend setting `use_large_pages` to `ONLY` in the DB parameter group used by your DB instance.	Using Huge Pages with an Oracle DB Instance (p. 867)
Nondefault custom memory parameters	Your DB parameter group sets memory parameters that diverge too much from the default values.	Settings that diverge too much from the default values can cause poor performance and errors. We recommend setting custom memory parameters to their default values in the DB parameter group used by the DB instance.	Working with DB Parameter Groups (p. 202)
Change buffering enabled for a MySQL DB instance	Your DB parameter group has change buffering enabled.	Change buffering allows a MySQL DB instance to defer some writes necessary to maintain secondary indexes. This configuration can improve performance slightly, but it can create a large delay in crash recovery. During crash recovery, the secondary index must be brought up to date. So, the benefits of change buffering are outweighed by the potentially very long crash recovery events. We recommend disabling change buffering.	Best practices for configuring parameters for Amazon RDS for MySQL, part 1: Parameters related to performance on the AWS Database Blog
Query cache enabled for a MySQL DB instance	Your DB parameter group has query cache parameter enabled.	The query cache can cause the DB instance to appear to stall when changes require the cache to be purged. Most workloads don't benefit from a query cache. The query cache was removed from MySQL version 8.0. We recommend that you disable the query cache parameter.	Best practices for configuring parameters for Amazon RDS for MySQL, part 1: Parameters related to performance on the AWS Database Blog
Logging to table	Your DB parameter group sets logging output to `TABLE`.	Setting logging output to `TABLE` uses more storage than setting this parameter to `FILE`. To avoid reaching the storage limit, we recommend setting the logging output parameter to `FILE`.	MySQL Database Log Files (p. 468)

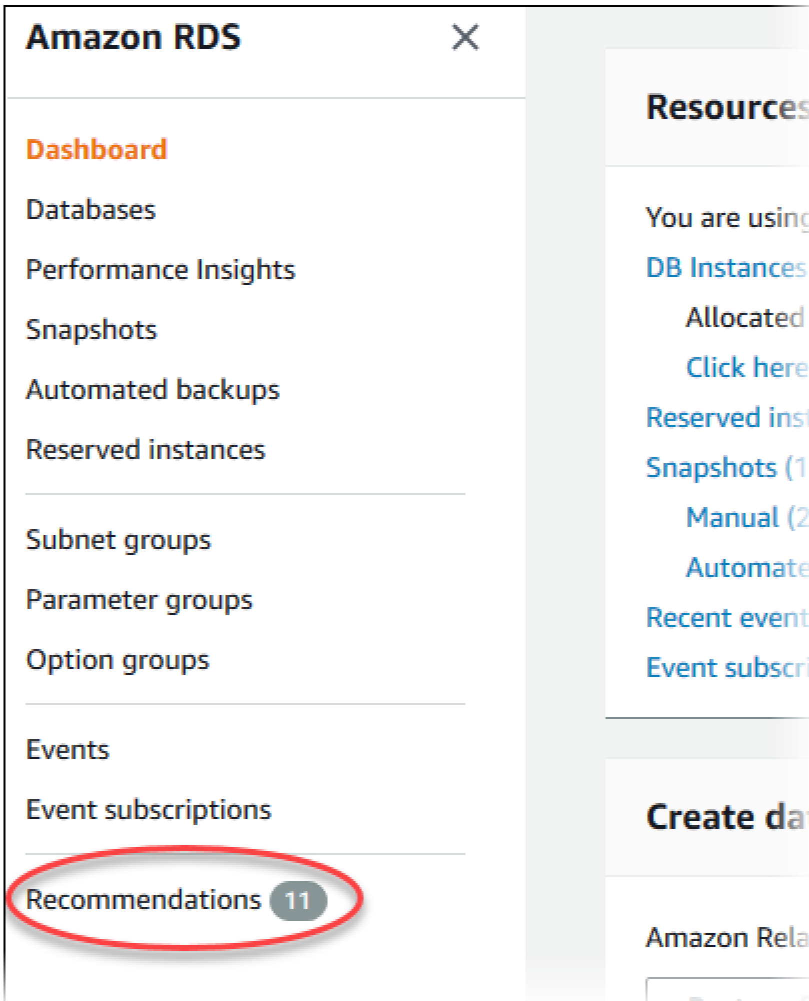
Amazon RDS generates recommendations for a resource when the resource is created or modified. Amazon RDS also periodically scans your resources and generates recommendations.

Responding to Amazon RDS Recommendations

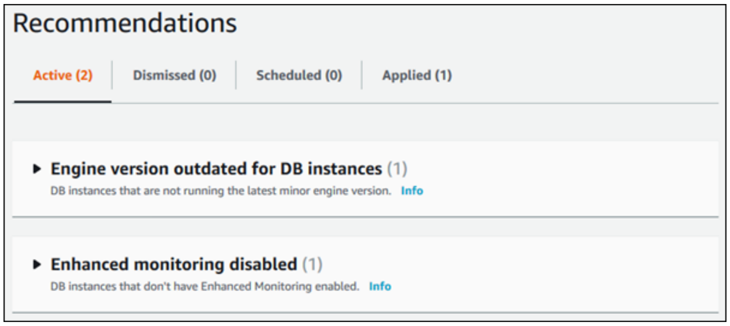
You can find recommendations in the AWS Management Console. You can perform the recommended action immediately, schedule it for the next maintenance window, or dismiss it.

To respond to Amazon RDS recommendations

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Recommendations**.



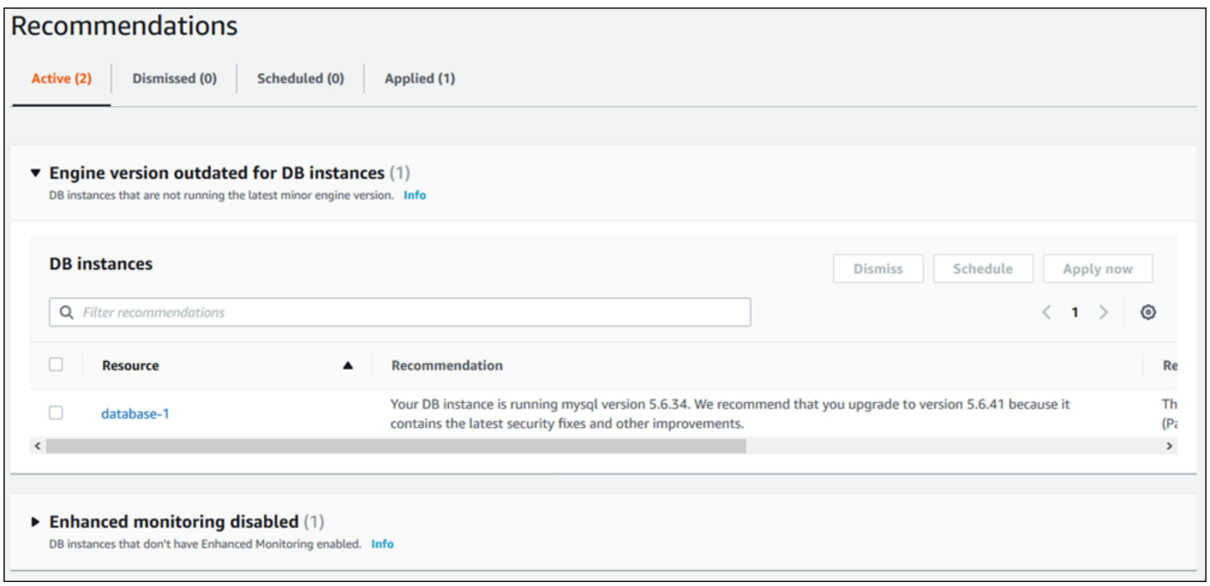
The Recommendations page appears.



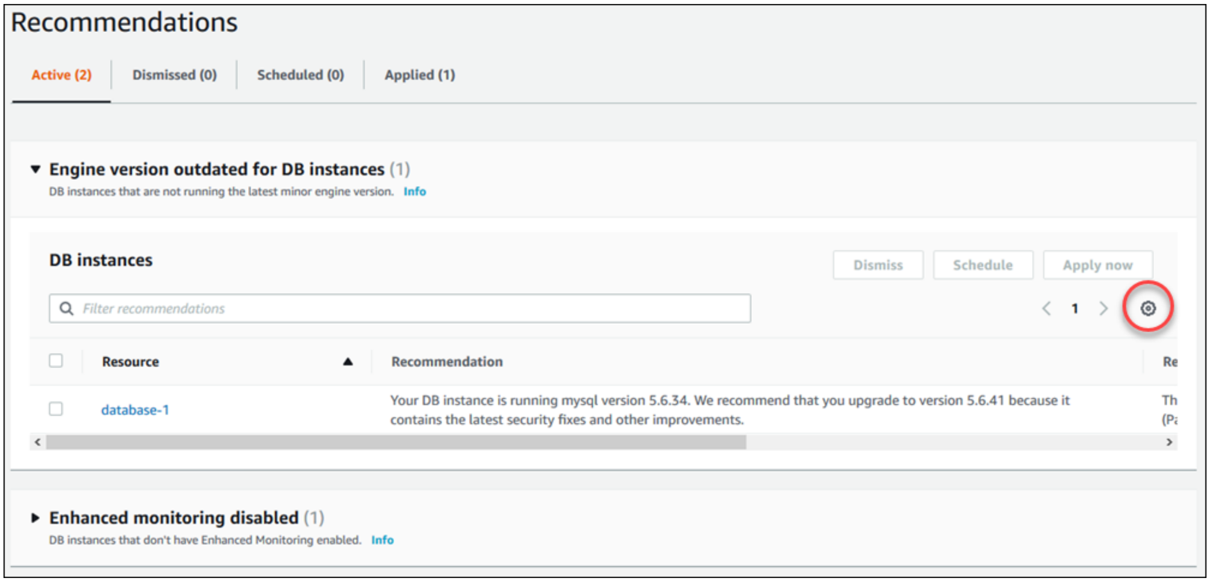
3. On the **Recommendations** page, choose one of the following:

   - **Active** – Shows the current recommendations that you can apply, dismiss, or schedule.
   - **Dismissed** – Shows the recommendations that have been dismissed. When you choose **Dismissed**, you can apply these dismissed recommendations.
   - **Scheduled** – Shows the recommendations that are scheduled but not yet applied. These recommendations will be applied in the next scheduled maintenance window.
   - **Applied** – Shows the recommendations that are currently applied.

   From any list of recommendations, you can open a section to view the recommendations in that section.



   To configure preferences for displaying recommendations in each section, choose the **Preferences** icon.



From the **Preferences** window that appears, you can set display options. These options include the visible columns and the number of recommendations to display on the page.

4. Manage your active recommendations:

   a. Choose **Active** and open one or more sections to view the recommendations in them.

   b. Choose one or more recommendations and choose **Apply now** (to apply them immediately), **Schedule** (to apply them in next maintenance window), or **Dismiss**.

      If the **Apply now** button appears for a recommendation but is unavailable (grayed out), the DB instance is not available. You can apply recommendations immediately only if the DB instance status is **available**. For example, you can't apply recommendations immediately to the DB instance if its status is **modifying**. In this case, wait for the DB instance to be available and then apply the recommendation.

      If the **Apply now** button doesn't appear for a recommendation, you can't apply the recommendation using the **Recommendations** page. You can modify the DB instance to apply the recommendation manually.

      For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

      Note
      When you choose **Apply now**, a brief DB instance outage might result.

Using Amazon RDS Event Notification

Topics

Amazon RDS uses the Amazon Simple Notification Service (Amazon SNS) to provide notification when an Amazon RDS event occurs. These notifications can be in any notification form supported by Amazon SNS for an AWS Region, such as an email, a text message, or a call to an HTTP endpoint.

Amazon RDS groups these events into categories that you can subscribe to so that you can be notified when an event in that category occurs. You can subscribe to an event category for a DB instance, DB snapshot, DB parameter group, or DB security group. For example, if you subscribe to the Backup category for a given DB instance, you are notified whenever a backup-related event occurs that affects the DB instance. If you subscribe to a configuration change category for a DB security group, you are notified when the DB security group is changed. You also receive notification when an event notification subscription changes.

Event notifications are sent to the addresses that you provide when you create the subscription. You might want to create several different subscriptions, such as one subscription receiving all event notifications and another subscription that includes only critical events for your production DB instances. You can easily turn off notification without deleting a subscription by choosing **No** for **Enabled** in the Amazon RDS console or by setting the `Enabled` parameter to `false` using the AWS CLI or Amazon RDS API.

> **Important**
> Amazon RDS doesn't guarantee the order of events sent in an event stream. The event order is subject to change.

> **Note**
> Amazon RDS event notifications using SMS text messages are currently available for topic Amazon Resource Names (ARNs) and Amazon RDS resources in the US-East (Northern Virginia) Region. For more information on using text messages with SNS, see Sending and Receiving SMS Notifications Using Amazon SNS in the *Amazon Simple Notification Service Developer Guide*.

Amazon RDS uses the ARN of an Amazon SNS topic to identify each subscription. The Amazon RDS console creates the ARN for you when you create the subscription. If you use the CLI or API, you create the ARN by using the Amazon SNS console or the Amazon SNS API when you create a subscription.

Billing for Amazon RDS event notification is through the Amazon Simple Notification Service (Amazon SNS). Amazon SNS fees apply when using event notification. For more information on Amazon SNS billing, see Amazon Simple Notification Service Pricing.

The process for subscribing to Amazon RDS event notification is as follows:

1. Create an Amazon RDS event notification subscription by using the Amazon RDS console, AWS CLI, or API.
2. Amazon RDS sends an approval email or SMS message to the addresses you submitted with your subscription. To confirm your subscription, choose the link in the notification you were sent.

3. When you have confirmed the subscription, the status of your subscription is updated in the Amazon RDS console's **My Event Subscriptions** section.
4. You then begin to receive event notifications.

> **Note**
> When Amazon SNS sends a notification to a subscribed HTTP or HTTPS endpoint, the POST message sent to the endpoint has a message body that contains a JSON document. For more information, see Amazon SNS Message and JSON Formats in the *Amazon Simple Notification Service Developer Guide*.
> You can use AWS Lambda to process event notifications from a DB instance. For more information, see Using AWS Lambda with Amazon RDS in the *AWS Lambda Developer Guide*.

The following section lists all categories and events that you can be notified of. It also provides information about subscribing to and working with Amazon RDS event subscriptions.

Amazon RDS Event Categories and Event Messages

Amazon RDS generates a significant number of events in categories that you can subscribe to using the Amazon RDS Console, AWS CLI, or the API. Each category applies to a source type, which can be a DB instance, DB snapshot, DB security group, or DB parameter group.

The following table shows the event category and a list of events when a DB instance is the source type.

Category	Amazon RDS Event ID	Description
availability	RDS-EVENT-0006	The DB instance restarted.
availability	RDS-EVENT-0004	DB instance shutdown.
availability	RDS-EVENT-0022	An error has occurred while restarting MySQL or MariaDB.
backup	RDS-EVENT-0001	Backing up DB instance.
backup	RDS-EVENT-0002	Finished DB Instance backup.
configuration change	RDS-EVENT-0009	The DB instance has been added to a security group.
configuration change	RDS-EVENT-0024	The DB instance is being converted to a Multi-AZ DB instance.
configuration change	RDS-EVENT-0030	The DB instance is being converted to a Single-AZ DB instance.
configuration change	RDS-EVENT-0012	Applying modification to database instance class.
configuration change	RDS-EVENT-0018	The current storage settings for this DB instance are being changed.
configuration change	RDS-EVENT-0011	A parameter group for this DB instance has changed.
configuration change	RDS-EVENT-0092	A parameter group for this DB instance has finished updating.

Category	Amazon RDS Event ID	Description
configuration change	RDS-EVENT-0028	Automatic backups for this DB instance have been disabled.
configuration change	RDS-EVENT-0032	Automatic backups for this DB instance have been enabled.
configuration change	RDS-EVENT-0033	There are [count] users that match the master user name. Users not tied to a specific host have been reset.
configuration change	RDS-EVENT-0025	The DB instance has been converted to a Multi-AZ DB instance.
configuration change	RDS-EVENT-0029	The DB instance has been converted to a Single-AZ DB instance.
configuration change	RDS-EVENT-0014	The DB instance class for this DB instance has changed.
configuration change	RDS-EVENT-0017	The storage settings for this DB instance have changed.
configuration change	RDS-EVENT-0010	The DB instance has been removed from a security group.
configuration change	RDS-EVENT-0016	The master password for the DB instance has been reset.
configuration change	RDS-EVENT-0067	An attempt to reset the master password for the DB instance has failed.
configuration change	RDS-EVENT-0078	The Enhanced Monitoring configuration has been changed.
creation	RDS-EVENT-0005	DB instance created.
deletion	RDS-EVENT-0003	The DB instance has been deleted.
failover	RDS-EVENT-0034	Amazon RDS is not attempting a requested failover because a failover recently occurred on the DB instance.
failover	RDS-EVENT-0013	A Multi-AZ failover that resulted in the promotion of a standby instance has started.
failover	RDS-EVENT-0015	A Multi-AZ failover that resulted in the promotion of a standby instance is complete. It may take several minutes for the DNS to transfer to the new primary DB instance.
failover	RDS-EVENT-0065	The instance has recovered from a partial failover.
failover	RDS-EVENT-0049	A Multi-AZ failover has completed.
failover	RDS-EVENT-0050	A Multi-AZ activation has started after a successful instance recovery.
failover	RDS-EVENT-0051	A Multi-AZ activation is complete. Your database should be accessible now.

Category	Amazon RDS Event ID	Description
failure	RDS-EVENT-0031	The DB instance has failed due to an incompatible configuration or an underlying storage issue. Begin a point-in-time-restore for the DB instance.
failure	RDS-EVENT-0036	The DB instance is in an incompatible network. Some of the specified subnet IDs are invalid or do not exist.
failure	RDS-EVENT-0035	The DB instance has invalid parameters. For example, if the DB instance could not start because a memory-related parameter is set too high for this instance class, the customer action would be to modify the memory parameter and reboot the DB instance.
failure	RDS-EVENT-0058	Error while creating Statspack user account PERFSTAT. Please drop the account before adding the Statspack option.
failure	RDS-EVENT-0079	Enhanced Monitoring cannot be enabled without the enhanced monitoring IAM role. For information on creating the enhanced monitoring IAM role, see To create an IAM role for Amazon RDS Enhanced Monitoring (p. 363).
failure	RDS-EVENT-0080	Enhanced Monitoring was disabled due to an error making the configuration change. It is likely that the enhanced monitoring IAM role is configured incorrectly. For information on creating the enhanced monitoring IAM role, see To create an IAM role for Amazon RDS Enhanced Monitoring (p. 363).
failure	RDS-EVENT-0081	The IAM role that you use to access your Amazon S3 bucket for SQL Server native backup and restore is configured incorrectly. For more information, see Setting Up for Native Backup and Restore (p. 577).
low storage	RDS-EVENT-0089	The DB instance has consumed more than 90% of its allocated storage. You can monitor the storage space for a DB instance using the **Free Storage Space** metric. For more information, see Viewing DB Instance Metrics (p. 356).
low storage	RDS-EVENT-0007	The allocated storage for the DB instance has been exhausted. To resolve this issue, you should allocate additional storage for the DB instance. For more information, see the RDS FAQ. You can monitor the storage space for a DB instance using the **Free Storage Space** metric. For more information, see Viewing DB Instance Metrics (p. 356).
maintenance	RDS-EVENT-0026	Offline maintenance of the DB instance is taking place. The DB instance is currently unavailable.
maintenance	RDS-EVENT-0027	Offline maintenance of the DB instance is complete. The DB instance is now available.
maintenance	RDS-EVENT-0047	Patching of the DB instance has completed.

Category	Amazon RDS Event ID	Description
maintenance	RDS-EVENT-0155	The DB instance has a DB engine minor version upgrade available.
notification	RDS-EVENT-0044	Operator-issued notification. For more information, see the event message.
notification	RDS-EVENT-0048	Patching of the DB instance has been delayed.
notification	RDS-EVENT-0054	The MySQL storage engine you are using is not InnoDB, which is the recommended MySQL storage engine for Amazon RDS. For information about MySQL storage engines, see Supported Storage Engines for MySQL on Amazon RDS.
notification	RDS-EVENT-0055	The number of tables you have for your DB instance exceeds the recommended best practices for Amazon RDS. Please reduce the number of tables on your DB instance. For information about recommended best practices, see Amazon RDS Basic Operational Guidelines (p. 125).
notification	RDS-EVENT-0056	The number of databases you have for your DB instance exceeds the recommended best practices for Amazon RDS. Please reduce the number of databases on your DB instance. For information about recommended best practices, see Amazon RDS Basic Operational Guidelines (p. 125).
notification	RDS-EVENT-0064	The TDE key has been rotated. For information about recommended best practices, see Amazon RDS Basic Operational Guidelines (p. 125).
notification	RDS-EVENT-0084	You attempted to convert a DB instance to Multi-AZ, but it contains in-memory file groups that are not supported for Multi-AZ. For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).
notification	RDS-EVENT-0087	The DB instance has been stopped.
notification	RDS-EVENT-0088	The DB instance has been started.
notification	RDS-EVENT-0154	The DB instance is being started due to it exceeding the maximum allowed time being stopped.

Category	Amazon RDS Event ID	Description
notification	RDS-EVENT-0157	RDS can't modify the DB instance class because the target instance class can't support the number of databases that exist on the source DB instance. The error message appears as: "The instance has *N* databases, but after conversion it would only support *N*". For more information, see Limits for Microsoft SQL Server DB Instances (p. 544).
notification	RDS-EVENT-0158	DB instance is in a state that can't be upgraded.
read replica	RDS-EVENT-0045	An error has occurred in the read replication process. For more information, see the event message. For information on troubleshooting read replica errors, see Troubleshooting a MySQL Read Replica Problem (p. 777).
read replica	RDS-EVENT-0046	The read replica has resumed replication. This message appears when you first create a read replica, or as a monitoring message confirming that replication is functioning properly. If this message follows an RDS-EVENT-0045 notification, then replication has resumed following an error or after replication was stopped.
read replica	RDS-EVENT-0057	Replication on the read replica was terminated.
read replica	RDS-EVENT-0062	Replication on the read replica was manually stopped.
read replica	RDS-EVENT-0063	Replication on the read replica was reset.
recovery	RDS-EVENT-0020	Recovery of the DB instance has started. Recovery time will vary with the amount of data to be recovered.
recovery	RDS-EVENT-0021	Recovery of the DB instance is complete.
recovery	RDS-EVENT-0023	A manual backup has been requested but Amazon RDS is currently in the process of creating a DB snapshot. Submit the request again after Amazon RDS has completed the DB snapshot.
recovery	RDS-EVENT-0052	Recovery of the Multi-AZ instance has started. Recovery time will vary with the amount of data to be recovered.
recovery	RDS-EVENT-0053	Recovery of the Multi-AZ instance is complete.
recovery	RDS-EVENT-0066	The SQL Server DB instance is re-establishing its mirror. Performance will be degraded until the mirror is reestablished. A database was found with non-FULL recovery model. The recovery model was changed back to FULL and mirroring recovery was started. (<dbname>: <recovery model found>[,…])”

Category	Amazon RDS Event ID	Description
restoration	RDS-EVENT-0008	The DB instance has been restored from a DB snapshot.
restoration	RDS-EVENT-0019	The DB instance has been restored from a point-in-time backup.

The following table shows the event category and a list of events when a DB parameter group is the source type.

Category	RDS Event ID	Description
configuration change	RDS-EVENT-0037	The parameter group was modified.

The following table shows the event category and a list of events when a DB security group is the source type.

Category	RDS Event ID	Description
configuration change	RDS-EVENT-0038	The security group has been modified.
failure	RDS-EVENT-0039	The security group owned by [user] does not exist; authorization for the security group has been revoked.

The following table shows the event category and a list of events when a DB snapshot is the source type.

Category	RDS Event ID	Description
creation	RDS-EVENT-0040	A manual DB snapshot is being created.
creation	RDS-EVENT-0042	A manual DB snapshot has been created.
creation	RDS-EVENT-0090	An automated DB snapshot is being created.
creation	RDS-EVENT-0091	An automated DB snapshot has been created.
deletion	RDS-EVENT-0041	A DB snapshot has been deleted.
notification	RDS-EVENT-0059	Started the copy of the cross region DB snapshot [DB snapshot name] from source region [region name].
notification	RDS-EVENT-0060	Finished the copy of the cross region DB snapshot [DB snapshot name] from source region [region name] in [time] minutes.
notification	RDS-EVENT-0061	The copy of a cross region DB snapshot failed.
notification	RDS-EVENT-0159	DB snapshot export task failed.
notification	RDS-EVENT-0160	DB snapshot export task canceled.

Category	RDS Event ID	Description
notification	RDS-EVENT-0161	DB snapshot export task completed.
restoration	RDS-EVENT-0043	A DB instance is being restored from a DB snapshot.

The following table shows the event category and a list of events when an Aurora DB cluster is the source type.

Category	RDS Event ID	Description
failover	RDS-EVENT-0069	A failover for the DB cluster has failed.
failover	RDS-EVENT-0070	A failover for the DB cluster has restarted.
failover	RDS-EVENT-0071	A failover for the DB cluster has finished.
failover	RDS-EVENT-0072	A failover for the DB cluster has begun within the same Availability Zone.
failover	RDS-EVENT-0073	A failover for the DB cluster has begun across Availability Zones.
failure	RDS-EVENT-0083	Aurora was unable to copy backup data from an Amazon S3 bucket. It is likely that the permissions for Aurora to access the Amazon S3 bucket are configured incorrectly. For more information, see Migrating Data from an External MySQL Database to an Amazon Aurora MySQL DB Cluster.
maintenance	RDS-EVENT-0156	The DB cluster has a DB engine minor version upgrade available.
notification	RDS-EVENT-0076	Migration to an Aurora DB cluster failed.
notification	RDS-EVENT-0077	An attempt to convert a table from the source database to InnoDB failed during the migration to an Aurora DB cluster.
notification	RDS-EVENT-0141	Scaling initiated for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0142	Scaling completed for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0143	Scaling failed for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0144	Automatic pause initiated for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0145	The Aurora Serverless DB cluster paused.
notification	RDS-EVENT-0146	Pause cancelled for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0147	Resume initiated for the Aurora Serverless DB cluster.
notification	RDS-EVENT-0148	Resume completed for the Aurora Serverless DB cluster.

Category	RDS Event ID	Description
notification	RDS-EVENT-0149	Seamless scaling completed with the force option for the Aurora Serverless DB cluster. Connections might have been interrupted as required.
notification	RDS-EVENT-0150	The DB cluster stopped.
notification	RDS-EVENT-0151	The DB cluster started.
notification	RDS-EVENT-0152	The DB cluster stop failed.
notification	RDS-EVENT-0153	The DB cluster is being started due to it exceeding the maximum allowed time being stopped.

The following table shows the event category and a list of events when an Aurora DB cluster snapshot is the source type.

Category	RDS Event ID	Description
backup	RDS-EVENT-0074	Creation of a manual DB cluster snapshot has started.
backup	RDS-EVENT-0075	A manual DB cluster snapshot has been created.
notification	RDS-EVENT-0162	DB cluster snapshot export task failed.
notification	RDS-EVENT-0163	DB cluster snapshot export task canceled.
notification	RDS-EVENT-0164	DB cluster snapshot export task completed.
backup	RDS-EVENT-0168	Creating automated cluster snapshot.
backup	RDS-EVENT-0169	Automated cluster snapshot created.
creation	RDS-EVENT-0170	DB cluster created.
deletion	RDS-EVENT-0171	DB cluster deleted.
notification	RDS-EVENT-0172	Renamed DB cluster from [old DB cluster name] to [new DB cluster name].

Subscribing to Amazon RDS Event Notification

You can create an Amazon RDS event notification subscription so you can be notified when an event occurs for a given DB instance, DB snapshot, DB security group, or DB parameter group. The simplest way to create a subscription is with the RDS console. If you choose to create event notification subscriptions using the CLI or API, you must create an Amazon Simple Notification Service topic and subscribe to that topic with the Amazon SNS console or Amazon SNS API. You will also need to retain the Amazon Resource Name (ARN) of the topic because it is used when submitting CLI commands or API operations. For information on creating an SNS topic and subscribing to it, see Getting Started with Amazon SNS in the *Amazon Simple Notification Service Developer Guide*.

You can specify the type of source you want to be notified of and the Amazon RDS source that triggers the event. These are defined by the **SourceType** (type of source) and the **SourceIdentifier** (the Amazon RDS source generating the event). If you specify both the **SourceType** and **SourceIdentifier**, such as `SourceType = db-instance` and `SourceIdentifier = myDBInstance1`, you receive all the DB instance events for the specified source. If you specify a **SourceType** but don't specify a **SourceIdentifier**, you receive notice of the events for that source type for all your Amazon RDS sources. If you don't specify either the **SourceType** or the **SourceIdentifier**, you are notified of events generated from all Amazon RDS sources belonging to your customer account.

> **Note**
> Event notifications might take up to five minutes to be delivered.
> Amazon RDS event notification is only available for unencrypted SNS topics. If you specify an encrypted SNS topic, event notifications aren't sent for the topic.

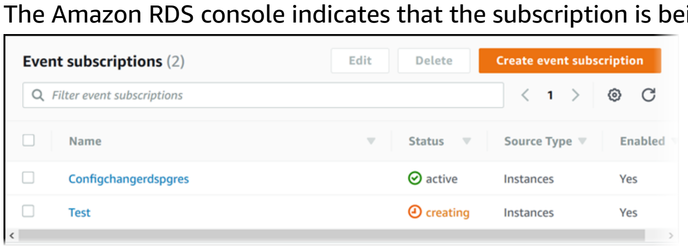
Console

To subscribe to RDS event notification

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In navigation pane, choose **Event subscriptions**.
3. In the **Event subscriptions** pane, choose **Create event subscription**.
4. In the **Create event subscription** dialog box, do the following:

    a. For **Name**, enter a name for the event notification subscription.
    b. For **Send notifications to**, choose an existing Amazon SNS ARN for an Amazon SNS topic, or choose **create topic** to enter the name of a topic and a list of recipients.
    c. For **Source type**, choose a source type.
    d. Choose **Yes** to enable the subscription. If you want to create the subscription but to not have notifications sent yet, choose **No**.
    e. Depending on the source type you selected, choose the event categories and sources that you want to receive event notifications for.
    f. Choose **Create**.

The Amazon RDS console indicates that the subscription is being created.



AWS CLI

To subscribe to RDS event notification, use the AWS CLI `create-event-subscription` command. Include the following required parameters:

- `--subscription-name`
- `--sns-topic-arn`

Example

For Linux, macOS, or Unix:

```
aws rds create-event-subscription \
    --subscription-name myeventsubscription \
    --sns-topic-arn arn:aws:sns:us-east-1:802#########:myawsuser-RDS \
    --enabled
```

For Windows:

```
aws rds create-event-subscription ^
    --subscription-name myeventsubscription ^
    --sns-topic-arn arn:aws:sns:us-east-1:802#########:myawsuser-RDS ^
    --enabled
```

API

To subscribe to Amazon RDS event notification, call the Amazon RDS API function `CreateEventSubscription`. Include the following required parameters:

- `SubscriptionName`
- `SnsTopicArn`

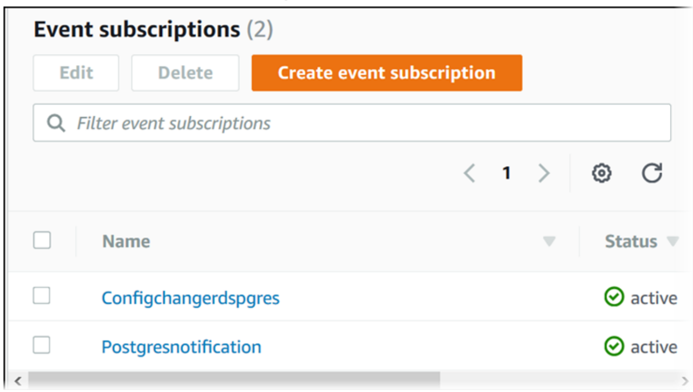
Listing Your Amazon RDS Event Notification Subscriptions

You can list your current Amazon RDS event notification subscriptions.

Console

To list your current Amazon RDS event notification subscriptions

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Event subscriptions**. The **Event subscriptions** pane shows all your event notification subscriptions.



AWS CLI

To list your current Amazon RDS event notification subscriptions, use the AWS CLI `describe-event-subscriptions` command.

Example

The following example describes all event subscriptions.

```
aws rds describe-event-subscriptions
```

The following example describes the `myfirsteventsubscription`.

```
aws rds describe-event-subscriptions --subscription-name myfirsteventsubscription
```

API

To list your current Amazon RDS event notification subscriptions, call the Amazon RDS API `DescribeEventSubscriptions` action.

Example

The following code example lists up to 100 event subscriptions.

```
https://rds.us-east-1.amazonaws.com/
   ?Action=DescribeEventSubscriptions
```

```
    &MaxRecords=100
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20140428/us-east-1/rds/aws4_request
    &X-Amz-Date=20140428T161907Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=4208679fe967783a1a149c826199080a066085d5a88227a80c6c0cadb3e8c0d4
```

The following example describes the `myfirsteventsubscription`.

```
https://rds.us-east-1.amazonaws.com/
    ?Action=DescribeEventSubscriptions
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &SubscriptionName=myfirsteventsubscription
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20140428/us-east-1/rds/aws4_request
    &X-Amz-Date=20140428T161907Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=4208679fe967783a1a149c826199080a066085d5a88227a80c6c0cadb3e8c0d4
```

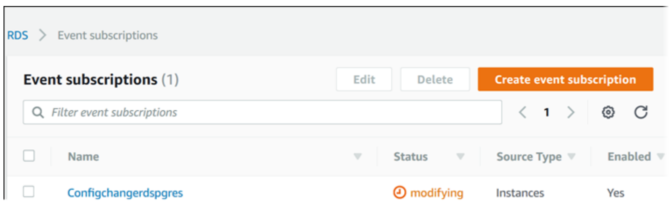
Modifying an Amazon RDS Event Notification Subscription

After you have created a subscription, you can change the subscription name, source identifier, categories, or topic ARN.

Console

To modify an Amazon RDS event notification subscription

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Event subscriptions**.
3. In the **Event subscriptions** pane, choose the subscription that you want to modify and choose **Edit**.
4. Make your changes to the subscription in either the **Target** or **Source** section.
5. Choose **Edit**. The Amazon RDS console indicates that the subscription is being modified.



AWS CLI

To modify an Amazon RDS event notification subscription, use the AWS CLI `modify-event-subscription` command. Include the following required parameter:

- `--subscription-name`

Example

The following code enables `myeventsubscription`.

For Linux, macOS, or Unix:

```
aws rds modify-event-subscription \
    --subscription-name myeventsubscription \
    --enabled
```

For Windows:

```
aws rds modify-event-subscription ^
    --subscription-name myeventsubscription ^
    --enabled
```

API

To modify an Amazon RDS event, call the Amazon RDS API operation `ModifyEventSubscription`. Include the following required parameter:

- `SubscriptionName`

Adding a Source Identifier to an Amazon RDS Event Notification Subscription

You can add a source identifier (the Amazon RDS source generating the event) to an existing subscription.

Console

You can easily add or remove source identifiers using the Amazon RDS console by selecting or deselecting them when modifying a subscription. For more information, see Modifying an Amazon RDS Event Notification Subscription (p. 442).

AWS CLI

To add a source identifier to an Amazon RDS event notification subscription, use the AWS CLI `add-source-identifier-to-subscription` command. Include the following required parameters:

- `--subscription-name`
- `--source-identifier`

Example

The following example adds the source identifier `mysqldb` to the `myrdseventsubscription` subscription.

For Linux, macOS, or Unix:

```
aws rds add-source-identifier-to-subscription \
    --subscription-name myrdseventsubscription \
    --source-identifier mysqldb
```

For Windows:

```
aws rds add-source-identifier-to-subscription ^
    --subscription-name myrdseventsubscription ^
    --source-identifier mysqldb
```

API

To add a source identifier to an Amazon RDS event notification subscription, call the Amazon RDS API `AddSourceIdentifierToSubscription`. Include the following required parameters:

- `SubscriptionName`
- `SourceIdentifier`

Removing a Source Identifier from an Amazon RDS Event Notification Subscription

You can remove a source identifier (the Amazon RDS source generating the event) from a subscription if you no longer want to be notified of events for that source.

Console

You can easily add or remove source identifiers using the Amazon RDS console by selecting or deselecting them when modifying a subscription. For more information, see Modifying an Amazon RDS Event Notification Subscription (p. 442).

AWS CLI

To remove a source identifier from an Amazon RDS event notification subscription, use the AWS CLI `remove-source-identifier-from-subscription` command. Include the following required parameters:

- `--subscription-name`
- `--source-identifier`

Example

The following example removes the source identifier `mysqldb` from the `myrdseventsubscription` subscription.

For Linux, macOS, or Unix:

```
aws rds remove-source-identifier-from-subscription \
    --subscription-name myrdseventsubscription \
    --source-identifier mysqldb
```

For Windows:

```
aws rds remove-source-identifier-from-subscription ^
    --subscription-name myrdseventsubscription ^
    --source-identifier mysqldb
```

API

To remove a source identifier from an Amazon RDS event notification subscription, use the Amazon RDS API `RemoveSourceIdentifierFromSubscription` command. Include the following required parameters:

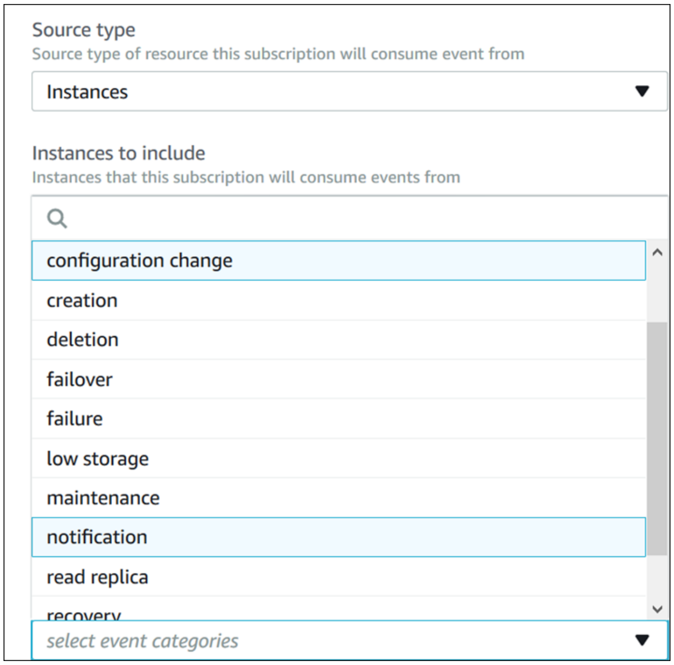
- `SubscriptionName`
- `SourceIdentifier`

Listing the Amazon RDS Event Notification Categories

All events for a resource type are grouped into categories. To view the list of categories available, use the following procedures.

Console

When you create or modify an event notification subscription, the event categories are displayed in the Amazon RDS console. For more information, see Modifying an Amazon RDS Event Notification Subscription (p. 442).



AWS CLI

To list the Amazon RDS event notification categories, use the AWS CLI `describe-event-categories` command. This command has no required parameters.

Example

```
aws rds describe-event-categories
```

API

To list the Amazon RDS event notification categories, use the Amazon RDS API `DescribeEventCategories` command. This command has no required parameters.

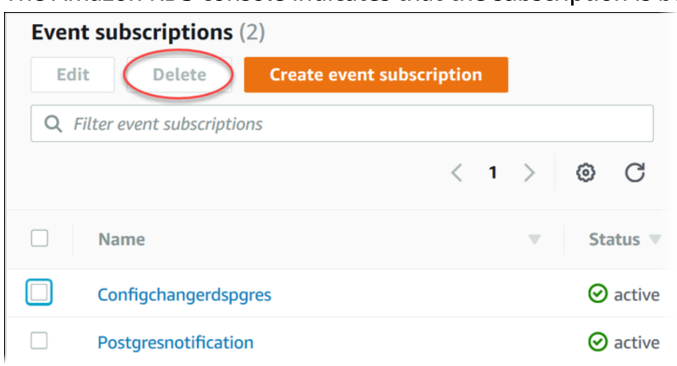
Deleting an Amazon RDS Event Notification Subscription

You can delete a subscription when you no longer need it. All subscribers to the topic will no longer receive event notifications specified by the subscription.

Console

To delete an Amazon RDS event notification subscription

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **DB Event Subscriptions**.
3. In the **My DB Event Subscriptions** pane, choose the subscription that you want to delete.
4. Choose **Delete**.
5. The Amazon RDS console indicates that the subscription is being deleted.



AWS CLI

To delete an Amazon RDS event notification subscription, use the AWS CLI `delete-event-subscription` command. Include the following required parameter:

- `--subscription-name`

Example

The following example deletes the subscription `myrdssubscription`.

```
aws rds delete-event-subscription --subscription-name myrdssubscription
```

API

To delete an Amazon RDS event notification subscription, use the RDS API `DeleteEventSubscription` command. Include the following required parameter:

- `SubscriptionName`

Viewing Amazon RDS Events

Amazon RDS keeps a record of events that relate to your DB instances, DB snapshots, DB security groups, and DB parameter groups. This information includes the date and time of the event, the source name and source type of the event, and a message associated with the event.

You can retrieve events for your RDS resources through the AWS Management Console, which shows events from the past 24 hours. You can also retrieve events for your RDS resources by using the describe-events AWS CLI command, or the DescribeEvents RDS API operation. If you use the AWS CLI or the RDS API to view events, you can retrieve events for up to the past 14 days.

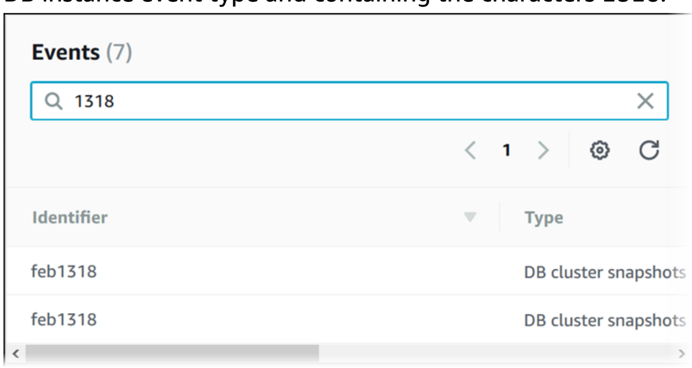
Note

If you need to store events for longer periods of time, you can send Amazon RDS events to CloudWatch Events. For more information, see Getting CloudWatch Events and Amazon EventBridge Events for Amazon RDS (p. 450)

Console

To view all Amazon RDS instance events for the past 24 hours

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Events**. The available events appear in a list.
3. Use the **Filter** list to filter the events by type, and use the text box to the right of the **Filter** list to further filter your results. For example, the following screenshot shows a list of events filtered by the DB instance event type and containing the characters `1318`.



AWS CLI

To view all Amazon RDS instance events for the past 7 days

You can view all Amazon RDS instance events for the past 7 days by calling the describe-events AWS CLI command and setting the `--duration` parameter to `10080`.

```
aws rds describe-events --duration 10080
```

API

To view all Amazon RDS instance events for the past 14 days

You can view all Amazon RDS instance events for the past 14 days by calling the DescribeEvents RDS API operation and setting the `Duration` parameter to `20160`.

```
https://rds.us-west-2.amazonaws.com/
   ?Action=DescribeEvents
   &Duration=20160
   &MaxRecords=100
   &SignatureMethod=HmacSHA256
   &SignatureVersion=4
   &Version=2014-10-31
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20140421/us-west-2/rds/aws4_request
   &X-Amz-Date=20140421T194733Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=8e313cabcdbd9766c56a2886b5b298fd944e0b7cfa248953c82705fdd0374f27
```

Getting CloudWatch Events and Amazon EventBridge Events for Amazon RDS

Amazon CloudWatch Events and Amazon EventBridge both enable you to automate AWS services and respond to system events such as application availability issues or resource changes. Events from AWS services are delivered to CloudWatch Events and EventBridge nearly in real time. You can write simple rules to indicate which events interest you and what automated actions to take when an event matches a rule.

You can set a variety of targets—such as an AWS Lambda function or an Amazon SNS topic—which receive events in JSON format. For more information, see the Amazon CloudWatch Events User Guide and the Amazon EventBridge User Guide.

For example, you can configure Amazon RDS to send events to CloudWatch Events or Amazon EventBridge whenever a DB instance is created or deleted.

Topics

Sending Amazon RDS Events to CloudWatch Events

You can create CloudWatch Events rules to send Amazon RDS events to CloudWatch Events.

Use the following steps to create a CloudWatch Events rule that triggers on an event emitted by an AWS service.

To create a rule that triggers on an event:

1. Open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. Under **Events** in the navigation pane, choose **Rules**.
3. Choose **Create rule**.
4. For **Event Source**, do the following:
   a. Choose **Event Pattern**.
   b. For **Service Name**, choose **Relational Database Service (RDS)**.
   c. For **Event Type**, choose the type of Amazon RDS resource that triggers the event. For example, if a DB instance triggers the event, choose **RDS DB Instance Event**.
5. For **Targets**, choose **Add Target**, then choose the **CloudWatch log group**.
6. For **Log Group**, enter a name for the log group to store the events.
7. Choose **Configure details**. For **Rule definition**, type a name and description for the rule.
8. Choose **Create rule**.

DB Instance Events

The following is an example of a DB instance event.

```
{
  "version": "0",
  "id": "68f6e973-1a0c-d37b-f2f2-94a7f62ffd4e",
  "detail-type": "RDS DB Instance Event",
  "source": "aws.rds",
  "account": "123456789012",
  "time": "2018-09-27T22:36:43Z",
  "region": "us-east-1",
  "resources": [
    "arn:aws:rds:us-east-1:123456789012:db:my-db-instance"
  ],
  "detail": {
    "EventCategories": [
      "failover"
    ],
    "SourceType": "DB_INSTANCE",
    "SourceArn": "arn:aws:rds:us-east-1:123456789012:db:my-db-instance",
    "Date": "2018-09-27T22:36:43.292Z",
    "SourceIdentifier": "rds:my-db-instance",
    "Message": "A Multi-AZ failover has completed."
  }
}
```

DB Parameter Group Events

The following is an example of a DB parameter group event.

```
{
  "version": "0",
  "id": "844e2571-85d4-695f-b930-0153b71dcb42",
  "detail-type": "RDS DB Parameter Group Event",
  "source": "aws.rds",
  "account": "123456789012",
  "time": "2018-10-06T12:26:13Z",
  "region": "us-east-1",
  "resources": [
    "arn:aws:rds:us-east-1:123456789012:pg:my-db-param-group"
  ],
  "detail": {
    "EventCategories": [
      "configuration change"
    ],
    "SourceType": "DB_PARAM",
    "SourceArn": "arn:aws:rds:us-east-1:123456789012:pg:my-db-param-group",
    "Date": "2018-10-06T12:26:13.882Z",
    "SourceIdentifier": "rds:my-db-param-group",
    "Message": "Updated parameter time_zone to UTC with apply method immediate"
  }
}
```

DB Security Group Events

The following is an example of a DB security group event.

```
{
```

```
  "version": "0",
  "id": "844e2571-85d4-695f-b930-0153b71dcb42",
  "detail-type": "RDS DB Security Group Event",
  "source": "aws.rds",
  "account": "123456789012",
  "time": "2018-10-06T12:26:13Z",
  "region": "us-east-1",
  "resources": [
    "arn:aws:rds:us-east-1:123456789012:secgrp:my-security-group"
  ],
  "detail": {
    "EventCategories": [
      "configuration change"
    ],
    "SourceType": "SECURITY_GROUP",
    "SourceArn": "arn:aws:rds:us-east-1:123456789012:secgrp:my-security-group",
    "Date": "2018-10-06T12:26:13.882Z",
    "SourceIdentifier": "rds:my-security-group",
    "Message": "Applied change to security group"
  }
}
```


DB Snapshot Events

The following is an example of a DB snapshot event.


```
{
  "version": "0",
  "id": "844e2571-85d4-695f-b930-0153b71dcb42",
  "detail-type": "RDS DB Snapshot Event",
  "source": "aws.rds",
  "account": "123456789012",
  "time": "2018-10-06T12:26:13Z",
  "region": "us-east-1",
  "resources": [
    "arn:aws:rds:us-east-1:123456789012:snapshot:rds:my-db-snapshot"
  ],
  "detail": {
    "EventCategories": [
      "deletion"
    ],
    "SourceType": "SNAPSHOT",
    "SourceArn": "arn:aws:rds:us-east-1:123456789012:snapshot:rds:my-db-snapshot",
    "Date": "2018-10-06T12:26:13.882Z",
    "SourceIdentifier": "rds:my-db-snapshot",
    "Message": "Deleted manual snapshot"
  }
}
```

Amazon RDS Database Log Files

You can view, download, and watch database logs using the AWS Management Console, the AWS Command Line Interface (AWS CLI), or the Amazon RDS API. Viewing, downloading, or watching transaction logs isn't supported.

For engine-specific information, see the following:

- MariaDB Database Log Files (p. 457)
- Microsoft SQL Server Database Log Files (p. 465)
- MySQL Database Log Files (p. 468)
- Oracle Database Log Files (p. 476)
- PostgreSQL Database Log Files (p. 482)

Viewing and Listing Database Log Files

You can view database log files for your DB engine by using the AWS Management Console. You can list what log files are available for download or monitoring by using the AWS CLI or Amazon RDS API.

> **Note**
> If you can't view the list of log files for an existing Oracle DB instance, reboot the instance to view the list.

Console

To view a database log file

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the name of the DB instance that has the log file that you want to view.
4. Choose the **Logs & events** tab.
5. Scroll down to the **Logs** section.
6. In the **Logs** section, choose the log that you want to view, and then choose **View**.

AWS CLI

To list the available database log files for a DB instance, use the AWS CLI `describe-db-log-files` command.

The following example returns a list of log files for a DB instance named `my-db-instance`.

Example

```
aws rds describe-db-log-files --db-instance-identifier my-db-instance
```

RDS API

To list the available database log files for a DB instance, use the Amazon RDS API `DescribeDBLogFiles` action.

Downloading a Database Log File

You can use the AWS Management Console, AWS CLI or API to download a database log file.

Console

To download a database log file

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the name of the DB instance that has the log file that you want to view.
4. Choose the **Logs & events** tab.
5. Scroll down to the **Logs** section.
6. In the **Logs** section, choose the button next to the log that you want to download, and then choose **Download**.
7. Open the context (right-click) menu for the link provided, and then choose **Save Link As**. Enter the location where you want the log file to be saved, and then choose **Save**.

AWS CLI

To download a database log file, use the AWS CLI command `download-db-log-file-portion`. By default, this command downloads only the latest portion of a log file. However, you can download an entire file by specifying the parameter `--starting-token 0`.

The following example shows how to download the entire contents of a log file called *log/ERROR.4* and store it in a local file called *errorlog.txt*.

Example

For Linux, macOS, or Unix:

```
aws rds download-db-log-file-portion \
      --db-instance-identifier myexampledb \
      --starting-token 0 --output text \
      --log-file-name log/ERROR.4 > errorlog.txt
```

For Windows:

```
aws rds download-db-log-file-portion ^
      --db-instance-identifier myexampledb ^
      --starting-token 0 --output text ^
      --log-file-name log/ERROR.4 > errorlog.txt
```

RDS API

To download a database log file, use the Amazon RDS API `DownloadDBLogFilePortion` action.

Watching a Database Log File

You can monitor the contents of a log file by using the AWS Management Console.

Console

To watch a database log file

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the name of the DB instance that has the log file that you want to view.
4. Choose the **Logs & events** tab.
5. In the **Logs** section, choose a log file, and then choose **Watch**.

Publishing Database Logs to Amazon CloudWatch Logs

In addition to viewing and downloading DB instance logs, you can publish logs to Amazon CloudWatch Logs. With CloudWatch Logs, you can perform real-time analysis of the log data, store the data in highly durable storage, and manage the data with the CloudWatch Logs Agent. AWS retains log data published to CloudWatch Logs for an indefinite time period unless you specify a retention period. For more information, see Change Log Data Retention in CloudWatch Logs.

For engine-specific information, see the following:

- the section called “Publishing MariaDB Logs to Amazon CloudWatch Logs” (p. 458)
- the section called “Publishing MySQL Logs to CloudWatch Logs” (p. 470)
- the section called “Publishing Oracle Logs to Amazon CloudWatch Logs” (p. 478)
- the section called “Publishing PostgreSQL Logs to CloudWatch Logs” (p. 483)
- the section called “Publishing SQL Server Logs to Amazon CloudWatch Logs” (p. 465)

Reading Log File Contents Using REST

Amazon RDS provides a REST endpoint that allows access to DB instance log files. This is useful if you need to write an application to stream Amazon RDS log file contents.

The syntax is:

```
GET /v13/downloadCompleteLogFile/DBInstanceIdentifier/LogFileName HTTP/1.1
Content-type: application/json
host: rds.region.amazonaws.com
```

The following parameters are required:

- *DBInstanceIdentifier*—the name of the DB instance that contains the log file you want to download.
- *LogFileName*—the name of the log file to be downloaded.

The response contains the contents of the requested log file, as a stream.

The following example downloads the log file named *log/ERROR.6* for the DB instance named *sample-sql* in the *us-west-2* region.

```
GET /v13/downloadCompleteLogFile/sample-sql/log/ERROR.6 HTTP/1.1
host: rds.us-west-2.amazonaws.com
X-Amz-Security-Token: AQoDYXdzEIH//////////
wEa0AIXLhngC5zp9CyB1R6abwKrXHVR5efnAVN3XvR7IwqKYalFSn6UyJuEFTft9nObglx4QJ+GXV9cpACkETq=
X-Amz-Date: 20140903T233749Z
X-Amz-Algorithm: AWS4-HMAC-SHA256
X-Amz-Credential: AKIADQKE4SARGYLE/20140903/us-west-2/rds/aws4_request
X-Amz-SignedHeaders: host
X-Amz-Content-SHA256: e3b0c44298fc1c229afbf4c8996fb92427ae41e4649b934de495991b7852b855
X-Amz-Expires: 86400
X-Amz-Signature: 353a4f14b3f250142d9afc34f9f9948154d46ce7d4ec091d0cdabbcf8b40c558
```

If you specify a nonexistent DB instance, the response consists of the following error:

- `DBInstanceNotFound`—*`DBInstanceIdentifier`* does not refer to an existing DB instance. (HTTP status code: 404)

MariaDB Database Log Files

You can monitor the MariaDB error log, slow query log, and the general log. The MariaDB error log is generated by default; you can generate the slow query and general logs by setting parameters in your DB parameter group. Amazon RDS rotates all of the MariaDB log files; the intervals for each type are given following.

You can monitor the MariaDB logs directly through the Amazon RDS console, Amazon RDS API, Amazon RDS CLI, or AWS SDKs. You can also access MariaDB logs by directing the logs to a database table in the main database and querying that table. You can use the mysqlbinlog utility to download a binary log.

For more information about viewing, downloading, and watching file-based database logs, see Amazon RDS Database Log Files (p. 453).

Accessing MariaDB Error Logs

The MariaDB error log is written to the `<host-name>.err` file. You can view this file by using the Amazon RDS console or by retrieving the log using the Amazon RDS API, Amazon RDS CLI, or AWS SDKs. The `<host-name>.err` file is flushed every 5 minutes, and its contents are appended to `mysql-error-running.log`. The `mysql-error-running.log` file is then rotated every hour and the hourly files generated during the last 24 hours are retained. Each log file has the hour it was generated (in UTC) appended to its name. The log files also have a timestamp that helps you determine when the log entries were written.

MariaDB writes to the error log only on startup, shutdown, and when it encounters errors. A DB instance can go hours or days without new entries being written to the error log. If you see no recent entries, it's because the server did not encounter an error that resulted in a log entry.

Accessing the MariaDB Slow Query and General Logs

The MariaDB slow query log and the general log can be written to a file or a database table by setting parameters in your DB parameter group. For information about creating and modifying a DB parameter group, see Working with DB Parameter Groups (p. 202). You must set these parameters before you can view the slow query log or general log in the Amazon RDS console or by using the Amazon RDS API, AWS CLI, or AWS SDKs.

You can control MariaDB logging by using the parameters in this list:

- `slow_query_log`: To create the slow query log, set to 1. The default is 0.
- `general_log`: To create the general log, set to 1. The default is 0.
- `long_query_time`: To prevent fast-running queries from being logged in the slow query log, specify a value for the shortest query execution time to be logged, in seconds. The default is 10 seconds; the minimum is 0. If log_output = FILE, you can specify a floating point value that goes to microsecond resolution. If log_output = TABLE, you must specify an integer value with second resolution. Only queries whose execution time exceeds the `long_query_time` value are logged. For example, setting `long_query_time` to 0.1 prevents any query that runs for less than 100 milliseconds from being logged.
- `log_queries_not_using_indexes`: To log all queries that do not use an index to the slow query log, set this parameter to 1. The default is 0. Queries that do not use an index are logged even if their execution time is less than the value of the `long_query_time` parameter.
- `log_output` *`option`*: You can specify one of the following options for the `log_output` parameter:
  - **TABLE** (default)– Write general queries to the `mysql.general_log` table, and slow queries to the `mysql.slow_log` table.
  - **FILE**– Write both general and slow query logs to the file system. Log files are rotated hourly.

- **NONE**– Disable logging.

When logging is enabled, Amazon RDS rotates table logs or deletes log files at regular intervals. This measure is a precaution to reduce the possibility of a large log file either blocking database use or affecting performance. `FILE` and `TABLE` logging approach rotation and deletion as follows:

- When `FILE` logging is enabled, log files are examined every hour and log files older than 24 hours are deleted. In some cases, the remaining combined log file size after the deletion might exceed the threshold of 2 percent of a DB instance's allocated space. In these cases, the largest log files are deleted until the log file size no longer exceeds the threshold.
- When `TABLE` logging is enabled, in some cases log tables are rotated every 24 hours. This rotation occurs if the space used by the table logs is more than 20 percent of the allocated storage space or the size of all logs combined is greater than 10 GB. If the amount of space used for a DB instance is greater than 90 percent of the DB instance's allocated storage space, then the thresholds for log rotation are reduced. Log tables are then rotated if the space used by the table logs is more than 10 percent of the allocated storage space or the size of all logs combined is greater than 5 GB.

  When log tables are rotated, the current log table is copied to a backup log table and the entries in the current log table are removed. If the backup log table already exists, then it is deleted before the current log table is copied to the backup. You can query the backup log table if needed. The backup log table for the `mysql.general_log` table is named `mysql.general_log_backup`. The backup log table for the `mysql.slow_log` table is named `mysql.slow_log_backup`.

  You can rotate the `mysql.general_log` table by calling the `mysql.rds_rotate_general_log` procedure. You can rotate the `mysql.slow_log` table by calling the `mysql.rds_rotate_slow_log` procedure.

  Table logs are rotated during a database version upgrade.

Amazon RDS records both `TABLE` and `FILE` log rotation in an Amazon RDS event and sends you a notification.

To work with the logs from the Amazon RDS console, Amazon RDS API, Amazon RDS CLI, or AWS SDKs, set the `log_output` parameter to FILE. Like the MariaDB error log, these log files are rotated hourly. The log files that were generated during the previous 24 hours are retained.

For more information about the slow query and general logs, go to the following topics in the MariaDB documentation:

- Slow Query Log
- General Query Log

Publishing MariaDB Logs to Amazon CloudWatch Logs

You can configure your Amazon RDS MariaDB DB instance to publish log data to a log group in Amazon CloudWatch Logs. With CloudWatch Logs, you can perform real-time analysis of the log data, and use CloudWatch to create alarms and view metrics. You can use CloudWatch Logs to store your log records in highly durable storage.

Amazon RDS publishes each MariaDB database log as a separate database stream in the log group. For example, if you configure the export function to include the slow query log, slow query data is stored in a slow query log stream in the `/aws/rds/instance/my_instance/slowquery` log group.

The error log is enabled by default. The following table summarizes the requirements for the other MariaDB logs.

Log	Requirement
Audit log	The DB instance must use a custom option group with the `MARIADB_AUDIT_PLUGIN` option.
General log	The DB instance must use a custom parameter group with the parameter setting `general_log = 1` to enable the general log.
Slow query log	The DB instance must use a custom parameter group with the parameter setting `slow_query_log = 1` to enable the slow query log.
Log output	The DB instance must use a custom parameter group with the parameter setting `log_output = FILE` to write logs to the file system and publish them to CloudWatch Logs.

Console

To publish MariaDB logs to CloudWatch Logs from the console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**.
4. In the **Log exports** section, choose the logs that you want to start publishing to CloudWatch Logs.
5. Choose **Continue**, and then choose **Modify DB Instance** on the summary page.

AWS CLI

You can publish a MariaDB logs with the AWS CLI. You can call the `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--cloudwatch-logs-export-configuration`

> **Note**
> A change to the `--cloudwatch-logs-export-configuration` option is always applied to the DB instance immediately. Therefore, the `--apply-immediately` and `--no-apply-immediately` options have no effect.

You can also publish MariaDB logs by calling the following AWS CLI commands:

- `create-db-instance`
- `restore-db-instance-from-db-snapshot`
- `restore-db-instance-from-s3`
- `restore-db-instance-to-point-in-time`

Run one of these AWS CLI commands with the following options:

- `--db-instance-identifier`

- `--enable-cloudwatch-logs-exports`
- `--db-instance-class`
- `--engine`

Other options might be required depending on the AWS CLI command you run.

Example

The following example modifies an existing MariaDB DB instance to publish log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `EnableLogTypes`, and its value is an array of strings with any combination of `audit`, `error`, `general`, and `slowquery`.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":
["audit","error","general","slowquery"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":
["audit","error","general","slowquery"]}'
```

Example

The following command creates a MariaDB DB instance and publishes log files to CloudWatch Logs. The `--enable-cloudwatch-logs-exports` value is a JSON array of strings. The strings can be any combination of `audit`, `error`, `general`, and `slowquery`.

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --enable-cloudwatch-logs-exports '["audit","error","general","slowquery"]' \
    --db-instance-class db.m4.large \
    --engine mariadb
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier mydbinstance ^
    --enable-cloudwatch-logs-exports '["audit","error","general","slowquery"]' ^
    --db-instance-class db.m4.large ^
    --engine mariadb
```

RDS API

You can publish MariaDB logs with the RDS API. You can call the `ModifyDBInstance` operation with the following parameters:

- `DBInstanceIdentifier`
- `CloudwatchLogsExportConfiguration`

> **Note**
> A change to the `CloudwatchLogsExportConfiguration` parameter is always applied to the DB instance immediately. Therefore, the `ApplyImmediately` parameter has no effect.

You can also publish MariaDB logs by calling the following RDS API operations:

- `CreateDBInstance`
- `RestoreDBInstanceFromDBSnapshot`
- `RestoreDBInstanceFromS3`
- `RestoreDBInstanceToPointInTime`

Run one of these RDS API operations with the following parameters:

- `DBInstanceIdentifier`
- `EnableCloudwatchLogsExports`
- `Engine`
- `DBInstanceClass`

Other parameters might be required depending on the AWS CLI command you run.

Log File Size

The MariaDB slow query log, error log, and the general log file sizes are constrained to no more than 2 percent of the allocated storage space for a DB instance. To maintain this threshold, logs are automatically rotated every hour and log files older than 24 hours are removed. If the combined log file size exceeds the threshold after removing old log files, then the largest log files are deleted until the log file size no longer exceeds the threshold.

Managing Table-Based MariaDB Logs

You can direct the general and slow query logs to tables on the DB instance by creating a DB parameter group and setting the `log_output` server parameter to `TABLE`. General queries are then logged to the `mysql.general_log` table, and slow queries are logged to the `mysql.slow_log` table. You can query the tables to access the log information. Enabling this logging increases the amount of data written to the database, which can degrade performance.

Both the general log and the slow query logs are disabled by default. In order to enable logging to tables, you must also set the `general_log` and `slow_query_log` server parameters to `1`.

Log tables keep growing until the respective logging activities are turned off by resetting the appropriate parameter to `0`. A large amount of data often accumulates over time, which can use up a considerable percentage of your allocated storage space. Amazon RDS does not allow you to truncate the log tables, but you can move their contents. Rotating a table saves its contents to a backup table and then creates a new empty log table. You can manually rotate the log tables with the following command line procedures, where the command prompt is indicated by `PROMPT>`:

```
PROMPT> CALL mysql.rds_rotate_slow_log;
PROMPT> CALL mysql.rds_rotate_general_log;
```

To completely remove the old data and reclaim the disk space, call the appropriate procedure twice in succession.

Binary Logging Format

MariaDB on Amazon RDS supports the *row-based*, *statement-based*, and *mixed* binary logging formats. The default binary logging format is *mixed*. For details on the different MariaDB binary log formats, see Binary Log Formats in the MariaDB documentation.

If you plan to use replication, the binary logging format is important because it determines the record of data changes that is recorded in the source and sent to the replication targets. For information about the advantages and disadvantages of different binary logging formats for replication, see Advantages and Disadvantages of Statement-Based and Row-Based Replication in the MySQL documentation.

> **Important**
> Setting the binary logging format to row-based can result in very large binary log files. Large binary log files reduce the amount of storage available for a DB instance and can increase the amount of time to perform a restore operation of a DB instance.
> Statement-based replication can cause inconsistencies between the source DB instance and a read replica. For more information, see Unsafe Statements for Statement-based Replication in the MariaDB documentation.

To set the MariaDB binary logging format

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose the parameter group that is used by the DB instance that you want to modify.

   You can't modify a default parameter group. If the DB instance is using a default parameter group, create a new parameter group and associate it with the DB instance.

   For more information on DB parameter groups, see Working with DB Parameter Groups (p. 202).
4. For **Parameter group actions**, choose **Edit**.
5. Set the `binlog_format` parameter to the binary logging format of your choice (**ROW**, **STATEMENT**, or **MIXED**).
6. Choose **Save changes** to save the updates to the DB parameter group.

Accessing MariaDB Binary Logs

You can use the mysqlbinlog utility to download binary logs in text format from MariaDB DB instances. The binary log is downloaded to your local computer. For more information about using the mysqlbinlog utility, go to Using mysqlbinlog in the MariaDB documentation.

To run the mysqlbinlog utility against an Amazon RDS instance, use the following options:

- Specify the `--read-from-remote-server` option.
- `--host`: Specify the DNS name from the endpoint of the instance.
- `--port`: Specify the port used by the instance.
- `--user`: Specify a MariaDB user that has been granted the replication slave permission.
- `--password`: Specify the password for the user, or omit a password value so the utility prompts you for a password.
- `--result-file`: Specify the local file that receives the output.
- Specify the names of one or more binary log files. To get a list of the available logs, use the SQL command SHOW BINARY LOGS.

For more information about mysqlbinlog options, go to mysqlbinlog Options in the MariaDB documentation.

The following is an example:

For Linux, macOS, or Unix:

```
mysqlbinlog \
    --read-from-remote-server \
    --host=mariadbinstance1.1234abcd.region.rds.amazonaws.com \
    --port=3306  \
    --user ReplUser \
    --password <password> \
    --result-file=/tmp/binlog.txt
```

For Windows:

```
mysqlbinlog ^
    --read-from-remote-server ^
    --host=mariadbinstance1.1234abcd.region.rds.amazonaws.com ^
    --port=3306  ^
    --user ReplUser ^
    --password <password> ^
    --result-file=/tmp/binlog.txt
```

Amazon RDS normally purges a binary log as soon as possible, but the binary log must still be available on the instance to be accessed by mysqlbinlog. To specify the number of hours for RDS to retain binary logs, use the `mysql.rds_set_configuration` stored procedure and specify a period with enough time for you to download the logs. After you set the retention period, monitor storage usage for the DB instance to ensure that the retained binary logs do not take up too much storage.

The following example sets the retention period to 1 day:

```
call mysql.rds_set_configuration('binlog retention hours', 24);
```

To display the current setting, use the `mysql.rds_show_configuration` stored procedure:

```
call mysql.rds_show_configuration;
```

Binary Log Annotation

In a MariaDB DB instance, you can use the `Annotate_rows` event to annotate a row event with a copy of the SQL query that caused the row event. This approach provides similar functionality to enabling the `binlog_rows_query_log_events` parameter on a DB instance on MySQL version 5.6 or later.

You can enable binary log annotations globally by creating a custom parameter group and setting the `binlog_annotate_row_events` parameter to **1**. You can also enable annotations at the session level, by calling `SET SESSION binlog_annotate_row_events = 1`. Use the `replicate_annotate_row_events` to replicate binary log annotations to the slave instance if binary logging is enabled on it. No special privileges are required to use these settings.

The following is an example of a row-based transaction in MariaDB. The use of row-based logging is triggered by setting the transaction isolation level to read-committed.

```
CREATE DATABASE IF NOT EXISTS test;
USE test;
CREATE TABLE square(x INT PRIMARY KEY, y INT NOT NULL) ENGINE = InnoDB;
```

```
SET SESSION TRANSACTION ISOLATION LEVEL READ COMMITTED;
BEGIN
INSERT INTO square(x, y) VALUES(5, 5 * 5);
COMMIT;
```

Without annotations, the binary log entries for the transaction look like the following:

```
BEGIN
/*!*/;
# at 1163
# at 1209
#150922  7:55:57 server id 1855786460  end_log_pos 1209         Table_map: `test`.`square`
 mapped to number 76
#150922  7:55:57 server id 1855786460  end_log_pos 1247         Write_rows: table id 76
 flags: STMT_END_F
### INSERT INTO `test`.`square`
### SET
###   @1=5
###   @2=25
# at 1247
#150922  7:56:01 server id 1855786460  end_log_pos 1274         Xid = 62
COMMIT/*!*/;
```

The following statement enables session-level annotations for this same transaction, and disables them after committing the transaction:

```
CREATE DATABASE IF NOT EXISTS test;
USE test;
CREATE TABLE square(x INT PRIMARY KEY, y INT NOT NULL) ENGINE = InnoDB;
SET SESSION TRANSACTION ISOLATION LEVEL READ COMMITTED;
SET SESSION binlog_annotate_row_events = 1;
BEGIN;
INSERT INTO square(x, y) VALUES(5, 5 * 5);
COMMIT;
SET SESSION binlog_annotate_row_events = 0;
```

With annotations, the binary log entries for the transaction look like the following:

```
BEGIN
/*!*/;
# at 423
# at 483
# at 529
#150922  8:04:24 server id 1855786460  end_log_pos 483  Annotate_rows:
#Q> INSERT INTO square(x, y) VALUES(5, 5 * 5)
#150922  8:04:24 server id 1855786460  end_log_pos 529  Table_map: `test`.`square` mapped
 to number 76
#150922  8:04:24 server id 1855786460  end_log_pos 567  Write_rows: table id 76 flags:
 STMT_END_F
### INSERT INTO `test`.`square`
### SET
###   @1=5
###   @2=25
# at 567
#150922  8:04:26 server id 1855786460  end_log_pos 594  Xid = 88
COMMIT/*!*/;
```

Microsoft SQL Server Database Log Files

You can access Microsoft SQL Server error logs, agent logs, trace files, and dump files by using the Amazon RDS console, AWS CLI, or RDS API. For more information about viewing, downloading, and watching file-based database logs, see Amazon RDS Database Log Files (p. 453).

Retention Schedule

Log files are rotated each day and whenever your DB instance is restarted. The following is the retention schedule for Microsoft SQL Server logs on Amazon RDS.

Log Type	Retention Schedule
Error logs	A maximum of 30 error logs are retained. Amazon RDS may delete error logs older than 7 days.
Agent logs	A maximum of 10 agent logs are retained. Amazon RDS may delete agent logs older than 7 days.
Trace files	Trace files are retained according to the trace file retention period of your DB instance. The default trace file retention period is 7 days. To modify the trace file retention period for your DB instance, see Setting the Retention Period for Trace and Dump Files (p. 708).
Dump files	Dump files are retained according to the dump file retention period of your DB instance. The default dump file retention period is 7 days. To modify the dump file retention period for your DB instance, see Setting the Retention Period for Trace and Dump Files (p. 708).

Viewing the SQL Server Error Log by Using the rds_read_error_log Procedure

You can use the Amazon RDS stored procedure `rds_read_error_log` to view error logs and agent logs. For more information, see Using the rds_read_error_log Procedure (p. 707).

Publishing SQL Server Logs to Amazon CloudWatch Logs

With Amazon RDS for SQL Server, you can publish error and agent log events directly to Amazon CloudWatch Logs. Analyze the log data with CloudWatch Logs, then use CloudWatch to create alarms and view metrics.

With CloudWatch Logs, you can do the following:

- Store logs in highly durable storage space with a retention period that you define.
- Search and filter log data.
- Share log data between accounts.
- Export logs to Amazon S3.
- Stream data to Amazon Elasticsearch Service.
- Process log data in real time with Amazon Kinesis Data Streams.

Amazon RDS publishes each SQL Server database log as a separate database stream in the log group. For example, if you publish error logs, error data is stored in an error log stream in the `/aws/rds/instance/my_instance/error` log group.

Note
Publishing SQL Server logs to CloudWatch Logs isn't enabled by default. Publishing trace and dump files isn't supported. Publishing SQL Server logs to CloudWatch Logs is supported in all regions, except for Asia Pacific (Hong Kong).

Console

To publish SQL Server DB logs to CloudWatch Logs from the AWS Management Console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**.
4. In the **Log exports** section, choose the logs that you want to start publishing to CloudWatch Logs.

   You can choose **error**, **agent**, or both.
5. Choose **Continue**, and then choose **Modify DB Instance** on the summary page.

AWS CLI

To publish SQL Server logs, you can use the `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--cloudwatch-logs-export-configuration`

Note
A change to the `--cloudwatch-logs-export-configuration` option is always applied to the DB instance immediately. Therefore, the `--apply-immediately` and `--no-apply-immediately` options have no effect.

You can also publish SQL Server logs using the following commands:

- `create-db-instance`
- `restore-db-instance-from-db-snapshot`
- `restore-db-instance-to-point-in-time`

Example

The following example creates an SQL Server DB instance with CloudWatch Logs publishing enabled. The `--enable-cloudwatch-logs-exports` value is a JSON array of strings that can include `error`, `agent`, or both.

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --enable-cloudwatch-logs-exports '["error","agent"]' \
    --db-instance-class db.m4.large \
    --engine sqlserver-se
```

For Windows:

```
aws rds create-db-instance ^
```

```
    --db-instance-identifier mydbinstance ^
    --enable-cloudwatch-logs-exports "[\"error\",\"agent\"]" ^
    --db-instance-class db.m4.large ^
    --engine sqlserver-se
```

Note

When using the Windows command prompt, you must escape double quotes (") in JSON code by prefixing them with a backslash (\).

Example

The following example modifies an existing SQL Server DB instance to publish log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `EnableLogTypes`, and its value is an array of strings that can include `error`, `agent`, or both.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":["error","agent"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration "{\"EnableLogTypes\":[\"error\",\"agent\"]}"
```

Note

When using the Windows command prompt, you must escape double quotes (") in JSON code by prefixing them with a backslash (\).

Example

The following example modifies an existing SQL Server DB instance to disable publishing agent log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `DisableLogTypes`, and its value is an array of strings that can include `error`, `agent`, or both.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"DisableLogTypes":["agent"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration "{\"DisableLogTypes\":[\"agent\"]}"
```

Note

When using the Windows command prompt, you must escape double quotes (") in JSON code by prefixing them with a backslash (\).

MySQL Database Log Files

You can monitor the MySQL error log, slow query log, and the general log. The MySQL error log is generated by default; you can generate the slow query and general logs by setting parameters in your DB parameter group. Amazon RDS rotates all of the MySQL log files; the intervals for each type are given following.

You can monitor the MySQL logs directly through the Amazon RDS console, Amazon RDS API, AWS CLI, or AWS SDKs. You can also access MySQL logs by directing the logs to a database table in the main database and querying that table. You can use the mysqlbinlog utility to download a binary log.

For more information about viewing, downloading, and watching file-based database logs, see Amazon RDS Database Log Files (p. 453).

Topics

Accessing MySQL Error Logs

The MySQL error log is written to the `mysql-error.log` file. You can view `mysql-error.log` by using the Amazon RDS console or by retrieving the log using the Amazon RDS API, Amazon RDS CLI, or AWS SDKs. `mysql-error.log` is flushed every 5 minutes, and its contents are appended to `mysql-error-running.log`. The `mysql-error-running.log` file is then rotated every hour and the hourly files generated during the last 24 hours are retained. Note that the retention period is different between Amazon RDS and Aurora.

Each log file has the hour it was generated (in UTC) appended to its name. The log files also have a timestamp that helps you determine when the log entries were written.

MySQL writes to the error log only on startup, shutdown, and when it encounters errors. A DB instance can go hours or days without new entries being written to the error log. If you see no recent entries, it's because the server did not encounter an error that would result in a log entry.

Accessing the MySQL Slow Query and General Logs

The MySQL slow query log and the general log can be written to a file or a database table by setting parameters in your DB parameter group. For information about creating and modifying a DB parameter group, see Working with DB Parameter Groups (p. 202). You must set these parameters before you can view the slow query log or general log in the Amazon RDS console or by using the Amazon RDS API, Amazon RDS CLI, or AWS SDKs.

You can control MySQL logging by using the parameters in this list:

- `slow_query_log`: To create the slow query log, set to 1. The default is 0.
- `general_log`: To create the general log, set to 1. The default is 0.

- `long_query_time`: To prevent fast-running queries from being logged in the slow query log, specify a value for the shortest query execution time to be logged, in seconds. The default is 10 seconds; the minimum is 0. If log_output = FILE, you can specify a floating point value that goes to microsecond resolution. If log_output = TABLE, you must specify an integer value with second resolution. Only queries whose execution time exceeds the `long_query_time` value are logged. For example, setting `long_query_time` to 0.1 prevents any query that runs for less than 100 milliseconds from being logged.
- `log_queries_not_using_indexes`: To log all queries that do not use an index to the slow query log, set to 1. The default is 0. Queries that do not use an index are logged even if their execution time is less than the value of the `long_query_time` parameter.
- `log_output` *`option`*: You can specify one of the following options for the `log_output` parameter.
  - **TABLE** (default)– Write general queries to the `mysql.general_log` table, and slow queries to the `mysql.slow_log` table.
  - **FILE**– Write both general and slow query logs to the file system. Log files are rotated hourly.
  - **NONE**– Disable logging.

When logging is enabled, Amazon RDS rotates table logs or deletes log files at regular intervals. This measure is a precaution to reduce the possibility of a large log file either blocking database use or affecting performance. `FILE` and `TABLE` logging approach rotation and deletion as follows:

- When `FILE` logging is enabled, log files are examined every hour and log files older than 24 hours are deleted. In some cases, the remaining combined log file size after the deletion might exceed the threshold of 2 percent of a DB instance's allocated space. In these cases, the largest log files are deleted until the log file size no longer exceeds the threshold.
- When `TABLE` logging is enabled, in some cases log tables are rotated every 24 hours. This rotation occurs if the space used by the table logs is more than 20 percent of the allocated storage space or the size of all logs combined is greater than 10 GB. If the amount of space used for a DB instance is greater than 90 percent of the DB instance's allocated storage space, then the thresholds for log rotation are reduced. Log tables are then rotated if the space used by the table logs is more than 10 percent of the allocated storage space or the size of all logs combined is greater than 5 GB. You can subscribe to the `low_free_storage` event to be notified when log tables are rotated to free up space. For more information, see Using Amazon RDS Event Notification (p. 429).

  When log tables are rotated, the current log table is copied to a backup log table and the entries in the current log table are removed. If the backup log table already exists, then it is deleted before the current log table is copied to the backup. You can query the backup log table if needed. The backup log table for the `mysql.general_log` table is named `mysql.general_log_backup`. The backup log table for the `mysql.slow_log` table is named `mysql.slow_log_backup`.

  You can rotate the `mysql.general_log` table by calling the `mysql.rds_rotate_general_log` procedure. You can rotate the `mysql.slow_log` table by calling the `mysql.rds_rotate_slow_log` procedure.

  Table logs are rotated during a database version upgrade.

To work with the logs from the Amazon RDS console, Amazon RDS API, Amazon RDS CLI, or AWS SDKs, set the `log_output` parameter to FILE. Like the MySQL error log, these log files are rotated hourly. The log files that were generated during the previous 24 hours are retained. Note that the retention period is different between Amazon RDS and Aurora.

For more information about the slow query and general logs, go to the following topics in the MySQL documentation:

- The Slow Query Log
- The General Query Log

Accessing the MySQL Audit Log

To access the audit log, the DB instance must use a custom option group with the `MARIADB_AUDIT_PLUGIN` option. For more information, see MariaDB Audit Plugin Support (p. 795).

Publishing MySQL Logs to CloudWatch Logs

You can configure your Amazon RDS MySQL DB instance to publish log data to a log group in Amazon CloudWatch Logs. With CloudWatch Logs, you can perform real-time analysis of the log data, and use CloudWatch to create alarms and view metrics. You can use CloudWatch Logs to store your log records in highly durable storage.

Amazon RDS publishes each MySQL database log as a separate database stream in the log group. For example, if you configure the export function to include the slow query log, slow query data is stored in a slow query log stream in the `/aws/rds/instance/my_instance/slowquery` log group.

The error log is enabled by default. The following table summarizes the requirements for the other MySQL logs.

Log	Requirement
Audit log	The DB instance must use a custom option group with the `MARIADB_AUDIT_PLUGIN` option.
General log	The DB instance must use a custom parameter group with the parameter setting `general_log = 1` to enable the general log.
Slow query log	The DB instance must use a custom parameter group with the parameter setting `slow_query_log = 1` to enable the slow query log.
Log output	The DB instance must use a custom parameter group with the parameter setting `log_output = FILE` to write logs to the file system and publish them to CloudWatch Logs.

Note
Publishing log files to CloudWatch Logs is only supported for MySQL versions 5.6, 5.7, and 8.0.

Console

To publish MySQL logs to CloudWatch Logs using the console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**.
4. In the **Log exports** section, choose the logs that you want to start publishing to CloudWatch Logs.
5. Choose **Continue**, and then choose **Modify DB Instance** on the summary page.

AWS CLI

You can publish MySQL logs with the AWS CLI. You can call the `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--cloudwatch-logs-export-configuration`

Note
A change to the `--cloudwatch-logs-export-configuration` option is always applied to the DB instance immediately. Therefore, the `--apply-immediately` and `--no-apply-immediately` options have no effect.

You can also publish MySQL logs by calling the following AWS CLI commands:

- `create-db-instance`
- `restore-db-instance-from-db-snapshot`
- `restore-db-instance-from-s3`
- `restore-db-instance-to-point-in-time`

Run one of these AWS CLI commands with the following options:

- `--db-instance-identifier`
- `--enable-cloudwatch-logs-exports`
- `--db-instance-class`
- `--engine`

Other options might be required depending on the AWS CLI command you run.

Example

The following example modifies an existing MySQL DB instance to publish log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `EnableLogTypes`, and its value is an array of strings with any combination of `audit`, `error`, `general`, and `slowquery`.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":
["audit","error","general","slowquery"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":
["audit","error","general","slowquery"]}'
```

Example

The following example creates a MySQL DB instance and publishes log files to CloudWatch Logs. The `--enable-cloudwatch-logs-exports` value is a JSON array of strings. The strings can be any combination of `audit`, `error`, `general`, and `slowquery`.

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --enable-cloudwatch-logs-exports '["audit","error","general","slowquery"]' \
    --db-instance-class db.m4.large \
    --engine MySQL
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier mydbinstance ^
    --enable-cloudwatch-logs-exports '["audit","error","general","slowquery"]' ^
    --db-instance-class db.m4.large ^
    --engine MySQL
```

RDS API

You can publish MySQL logs with the RDS API. You can call the `ModifyDBInstance` action with the following parameters:

- `DBInstanceIdentifier`
- `CloudwatchLogsExportConfiguration`

Note
A change to the `CloudwatchLogsExportConfiguration` parameter is always applied to the DB instance immediately. Therefore, the `ApplyImmediately` parameter has no effect.

You can also publish MySQL logs by calling the following RDS API operations:

- `CreateDBInstance`
- `RestoreDBInstanceFromDBSnapshot`
- `RestoreDBInstanceFromS3`
- `RestoreDBInstanceToPointInTime`

Run one of these RDS API operations with the following parameters:

- `DBInstanceIdentifier`
- `EnableCloudwatchLogsExports`
- `Engine`
- `DBInstanceClass`

Other parameters might be required depending on the AWS CLI command you run.

Log File Size

The MySQL slow query log, error log, and the general log file sizes are constrained to no more than 2 percent of the allocated storage space for a DB instance. To maintain this threshold, logs are automatically rotated every hour and log files older than 24 hours are removed. If the combined log file size exceeds the threshold after removing old log files, then the largest log files are deleted until the log file size no longer exceeds the threshold.

For MySQL, there is a size limit on BLOBs written to the redo log. To account for this limit, ensure that the `innodb_log_file_size` parameter for your MySQL DB instance is 10 times larger than the largest BLOB data size found in your tables, plus the length of other variable length fields (VARCHAR, VARBINARY, TEXT) in the same tables. For information on how to set parameter values, see Working with DB Parameter Groups (p. 202). For information on the redo log BLOB size limit, go to Changes in MySQL 5.6.20.

Managing Table-Based MySQL Logs

You can direct the general and slow query logs to tables on the DB instance by creating a DB parameter group and setting the log_output server parameter to TABLE. General queries are then logged to the mysql.general_log table, and slow queries are logged to the mysql.slow_log table. You can query the tables to access the log information. Enabling this logging increases the amount of data written to the database, which can degrade performance.

Both the general log and the slow query logs are disabled by default. In order to enable logging to tables, you must also set the general_log and slow_query_log server parameters to 1.

Log tables keep growing until the respective logging activities are turned off by resetting the appropriate parameter to 0. A large amount of data often accumulates over time, which can use up a considerable percentage of your allocated storage space. Amazon RDS does not allow you to truncate the log tables, but you can move their contents. Rotating a table saves its contents to a backup table and then creates a new empty log table. You can manually rotate the log tables with the following command line procedures, where the command prompt is indicated by PROMPT>:

```
PROMPT> CALL mysql.rds_rotate_slow_log;
PROMPT> CALL mysql.rds_rotate_general_log;
```

To completely remove the old data and reclaim the disk space, call the appropriate procedure twice in succession.

Binary Logging Format

MySQL on Amazon RDS supports the *row-based*, *statement-based*, and *mixed* binary logging formats for MySQL version 5.6 and later. The default binary logging format is mixed. For DB instances running MySQL versions 5.1 and 5.5, only mixed binary logging is supported. For details on the different MySQL binary log formats, see Binary Logging Formats in the MySQL documentation.

If you plan to use replication, the binary logging format is important because it determines the record of data changes that is recorded in the source and sent to the replication targets. For information about the advantages and disadvantages of different binary logging formats for replication, see Advantages and Disadvantages of Statement-Based and Row-Based Replication in the MySQL documentation.

> **Important**
> Setting the binary logging format to row-based can result in very large binary log files. Large binary log files reduce the amount of storage available for a DB instance and can increase the amount of time to perform a restore operation of a DB instance.
> Statement-based replication can cause inconsistencies between the source DB instance and a read replica. For more information, see Determination of Safe and Unsafe Statements in Binary Logging in the MySQL documentation.

To set the MySQL binary logging format

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose the parameter group used by the DB instance you want to modify.

   You can't modify a default parameter group. If the DB instance is using a default parameter group, create a new parameter group and associate it with the DB instance.

For more information on DB parameter groups, see Working with DB Parameter Groups (p. 202).

4. From **Parameter group actions**, choose **Edit**.
5. Set the `binlog_format` parameter to the binary logging format of your choice (**ROW**, **STATEMENT**, or **MIXED**).
6. Choose **Save changes** to save the updates to the DB parameter group.

Important
Changing the `default.mysql5.6`, `default.mysql5.7`, or `default.mysql8.0` DB parameter group affects all MySQL version DB instances that use that parameter group. If you want to specify different binary logging formats for different MySQL 5.6, 5.7, or 8.0 DB instances in an AWS Region, you need to create your own DB parameter group. This parameter group identifies the different logging format and assigns that DB parameter group to the intended DB instances.

Accessing MySQL Binary Logs

You can use the mysqlbinlog utility to download or stream binary logs from Amazon RDS instances running MySQL 5.6 or later. The binary log is downloaded to your local computer, where you can perform actions such as replaying the log using the mysql utility. For more information about using the mysqlbinlog utility, go to Using mysqlbinlog to Back Up Binary Log Files.

To run the mysqlbinlog utility against an Amazon RDS instance, use the following options:

- Specify the `--read-from-remote-server` option.
- `--host`: Specify the DNS name from the endpoint of the instance.
- `--port`: Specify the port used by the instance.
- `--user`: Specify a MySQL user that has been granted the replication slave permission.
- `--password`: Specify the password for the user, or omit a password value so that the utility prompts you for a password.
- To have the file downloaded in binary format, specify the `--raw` option.
- `--result-file`: Specify the local file to receive the raw output.
- Specify the names of one or more binary log files. To get a list of the available logs, use the SQL command SHOW BINARY LOGS.
- To stream the binary log files, specify the `--stop-never` option.

For more information about mysqlbinlog options, go to mysqlbinlog - Utility for Processing Binary Log Files.

For example, see the following.

For Linux, macOS, or Unix:

```
mysqlbinlog \
    --read-from-remote-server \
    --host=MySQL56Instance1.cg034hpkmmjt.region.rds.amazonaws.com \
    --port=3306  \
    --user ReplUser \
    --password \
    --raw \
    --result-file=/tmp/ \
    binlog.00098
```

For Windows:

```
mysqlbinlog ^
    --read-from-remote-server ^
    --host=MySQL56Instance1.cg034hpkmmjt.region.rds.amazonaws.com ^
    --port=3306  ^
    --user ReplUser ^
    --password ^
    --raw ^
    --result-file=/tmp/ ^
    binlog.00098
```

Amazon RDS normally purges a binary log as soon as possible, but the binary log must still be available on the instance to be accessed by mysqlbinlog. To specify the number of hours for RDS to retain binary logs, use the `mysql.rds_set_configuration` stored procedure and specify a period with enough time for you to download the logs. After you set the retention period, monitor storage usage for the DB instance to ensure that the retained binary logs don't take up too much storage.

Note
The `mysql.rds_set_configuration` stored procedure is only available for MySQL version 5.6 or later.

The following example sets the retention period to 1 day.

```
call mysql.rds_set_configuration('binlog retention hours', 24);
```

To display the current setting, use the `mysql.rds_show_configuration` stored procedure.

```
call mysql.rds_show_configuration;
```

Oracle Database Log Files

You can access Oracle alert logs, audit files, and trace files by using the Amazon RDS console or API. For more information about viewing, downloading, and watching file-based database logs, see Amazon RDS Database Log Files (p. 453).

The Oracle audit files provided are the standard Oracle auditing files. Amazon RDS supports the Oracle fine-grained auditing (FGA) feature. However, log access doesn't provide access to FGA events that are stored in the `SYS.FGA_LOG$` table and that are accessible through the `DBA_FGA_AUDIT_TRAIL` view.

The `DescribeDBLogFiles` API operation that lists the Oracle log files that are available for a DB instance ignores the `MaxRecords` parameter and returns up to 1,000 records.

Retention Schedule

The Oracle database engine might rotate logs files if they get very large. To retain audit or trace files, download them. Storing the files locally reduces your Amazon RDS storage costs and makes more space available for your data.

The following is the retention schedule for Oracle alert logs, audit files, and trace files on Amazon RDS.

Log Type	Retention Schedule
Alert logs	The text alert log is rotated daily with 30-day retention managed by Amazon RDS. The XML alert log is retained for at least seven days. You can access this log by using the `ALERTLOG` view.
Audit files	The default retention period for audit files is seven days. Amazon RDS might delete audit files older than seven days.
Trace files	The default retention period for trace files is seven days. Amazon RDS might delete trace files older than seven days.
Listener logs	The default retention period for the listener logs is seven days. Amazon RDS might delete listener logs older than seven days.

Note
Audit files and trace files share the same retention configuration.

Switching Online Log files

You can use the Amazon RDS procedure `rdsadmin.rdsadmin_util.switch_logfile` to switch online log files. For more information, see Switching Online Log Files (p. 1026).

Retrieving Archived Redo Logs

You can retain archived redo logs. For more information, see Retaining Archived Redo Logs (p. 1029).

Working with Oracle Trace Files

Following, you can find descriptions of Amazon RDS procedures to create, refresh, access, and delete trace files.

Listing Files

You can use either of two procedures to allow access to any file in the `background_dump_dest` path. The first procedure refreshes a view containing a listing of all files currently in `background_dump_dest`.

```
exec rdsadmin.manage_tracefiles.refresh_tracefile_listing;
```

After the view is refreshed, query the following view to access the results.

```
SELECT * FROM rdsadmin.tracefile_listing;
```

An alternative to the previous process is to use `FROM table` to stream nontable data in a table-like format to list database directory contents.

```
SELECT * FROM table(rdsadmin.rds_file_util.listdir('BDUMP'));
```

The following query shows the text of a log file.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','alert_xxx.log'));
```

Generating Trace Files and Tracing a Session

Because there are no restrictions on `alter session`, many standard methods to generate trace files in Oracle remain available to an Amazon RDS DB instance. The following procedures are provided for trace files that require greater access.

Oracle Method	Amazon RDS Method
`oradebug hanganalyze 3`	`exec rdsadmin.manage_tracefiles.hanganalyze;`
`oradebug dump systemstate 266`	`exec rdsadmin.manage_tracefiles.dump_systemstate;`

You can use many standard methods to trace individual sessions connected to an Oracle DB instance in Amazon RDS. To enable tracing for a session, you can run subprograms in PL/SQL packages supplied by Oracle, such as the DBMS_SESSION and DBMS_MONITOR packages. For more information, see Enabling Tracing for a Session in the Oracle documentation.

Retrieving Trace Files

You can retrieve any trace file in `background_dump_dest` using a standard SQL query on an Amazon RDS–managed external table. To use this method, you must execute the procedure to set the location for this table to the specific trace file.

For example, you can use the `rdsadmin.tracefile_listing` view mentioned preceding to list all of the trace files on the system. You can then set the `tracefile_table` view to point to the intended trace file using the following procedure.

```
exec
 rdsadmin.manage_tracefiles.set_tracefile_table_location('CUST01_ora_3260_SYSTEMSTATE.trc');
```

The following example creates an external table in the current schema with the location set to the file provided. You can retrieve the contents into a local file using a SQL query.

```
spool /tmp/tracefile.txt
select * from tracefile_table;
spool off;
```

Purging Trace Files

Trace files can accumulate and consume disk space. Amazon RDS purges trace files by default and log files that are older than seven days. You can view and set the trace file retention period using the `show_configuration` procedure. You should run the command `SET SERVEROUTPUT ON` so that you can view the configuration results.

The following example shows the current trace file retention period, and then sets a new trace file retention period.

```
# Show the current tracefile retention
SQL> exec rdsadmin.rdsadmin_util.show_configuration;
NAME:tracefile retention
VALUE:10080
DESCRIPTION:tracefile expiration specifies the duration in minutes before tracefiles in
 bdump are automatically deleted.

# Set the tracefile retention to 24 hours:
SQL> exec rdsadmin.rdsadmin_util.set_configuration('tracefile retention',1440);

#show the new tracefile retention
SQL> exec rdsadmin.rdsadmin_util.show_configuration;
NAME:tracefile retention
VALUE:1440
DESCRIPTION:tracefile expiration specifies the duration in minutes before tracefiles in
 bdump are automatically deleted.
```

In addition to the periodic purge process, you can manually remove files from the `background_dump_dest`. The following example shows how to purge all files older than five minutes.

```
exec rdsadmin.manage_tracefiles.purge_tracefiles(5);
```

You can also purge all files that match a specific pattern (if you do, don't include the file extension, such as .trc). The following example shows how to purge all files that start with `SCHPOC1_ora_5935`.

```
exec rdsadmin.manage_tracefiles.purge_tracefiles('SCHPOC1_ora_5935');
```

Publishing Oracle Logs to Amazon CloudWatch Logs

You can configure your Amazon RDS Oracle DB instance to publish log data to a log group in Amazon CloudWatch Logs. With CloudWatch Logs, you can analyze the log data, and use CloudWatch to create alarms and view metrics. You can use CloudWatch Logs to store your log records in highly durable storage.

Amazon RDS publishes each Oracle database log as a separate database stream in the log group. For example, if you configure the export function to include the audit log, audit data is stored in an audit log stream in the `/aws/rds/instance/my_instance/audit` log group.

Console

To publish Oracle DB logs to CloudWatch Logs from the AWS Management Console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**.
4. In the **Log exports** section, choose the logs that you want to start publishing to CloudWatch Logs.
5. Choose **Continue**, and then choose **Modify DB Instance** on the summary page.

AWS CLI

To publish Oracle logs, you can use the `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--cloudwatch-logs-export-configuration`

> **Note**
> A change to the `--cloudwatch-logs-export-configuration` option is always applied to the DB instance immediately. Therefore, the `--apply-immediately` and `--no-apply-immediately` options have no effect.

You can also publish Oracle logs using the following commands:

- `create-db-instance`
- `restore-db-instance-from-db-snapshot`
- `restore-db-instance-from-s3`
- `restore-db-instance-to-point-in-time`

Example

The following example creates an Oracle DB instance with CloudWatch Logs publishing enabled. The `--enable-cloudwatch-logs-exports` value is a JSON array of strings. The strings can be any combination of `alert`, `audit`, `listener`, and `trace`.

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --enable-cloudwatch-logs-exports '["trace","audit","alert","listener"]' \
    --db-instance-class db.m5.large \
    --allocated-storage 20 \
    --engine oracle-ee \
    --engine-version 12.1.0.2.v18 \
    --license-model bring-your-own-license \
    --master-username myadmin \
    --master-user-password mypassword
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier mydbinstance ^
    --enable-cloudwatch-logs-exports trace alert audit listener ^
    --db-instance-class db.m5.large ^
    --allocated-storage 20 ^
    --engine oracle-ee ^
    --engine-version 12.1.0.2.v18 ^
```

```
    --license-model bring-your-own-license ^
    --master-username myadmin ^
    --master-user-password mypassword
```

Example

The following example modifies an existing Oracle DB instance to publish log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `EnableLogTypes`, and its value is an array of strings with any combination of `alert`, `audit`, `listener`, and `trace`.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":
["trace","alert","audit","listener"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration EnableLogTypes=\"trace\",\"alert\",\"audit\",
\"listener\"
```

Example

The following example modifies an existing Oracle DB instance to disable publishing audit and listener log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `DisableLogTypes`, and its value is an array of strings with any combination of `alert`, `audit`, `listener`, and `trace`.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"DisableLogTypes":["audit","listener"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration DisableLogTypes=\"audit\",\"listener\"
```

RDS API

You can publish Oracle DB logs with the RDS API. You can call the `ModifyDBInstance` action with the following parameters:

- `DBInstanceIdentifier`
- `CloudwatchLogsExportConfiguration`

> **Note**
> A change to the `CloudwatchLogsExportConfiguration` parameter is always applied to the DB instance immediately. Therefore, the `ApplyImmediately` parameter has no effect.

You can also publish Oracle logs by calling the following RDS API operations:

- `CreateDBInstance`
- `RestoreDBInstanceFromDBSnapshot`
- `RestoreDBInstanceFromS3`
- `RestoreDBInstanceToPointInTime`

Run one of these RDS API operations with the following parameters:

- `DBInstanceIdentifier`
- `EnableCloudwatchLogsExports`
- `Engine`
- `DBInstanceClass`

Other parameters might be required depending on the RDS operation that you run.

Previous Methods for Accessing Alert Logs and Listener Logs

You can view the alert log using the Amazon RDS console. You can also use the following SQL statement to access the alert log.

```
select message_text from alertlog;
```

To access the listener log, use the following SQL statement.

```
select message_text from listenerlog;
```

> **Note**
> Oracle rotates the alert and listener logs when they exceed 10 MB, at which point they are unavailable from Amazon RDS views.

PostgreSQL Database Log Files

Amazon RDS for PostgreSQL generates query and error logs. RDS PostgreSQL writes autovacuum information and rds_admin actions to the error log. PostgreSQL also logs connections, disconnections, and checkpoints to the error log. For more information, see the Error Reporting and Logging in the PostgreSQL documentation.

To set logging parameters for a DB instance, set the parameters in a DB parameter group and associate that parameter group with the DB instance. For more information, see Working with DB Parameter Groups (p. 202).

Topics

Setting the Log Retention Period

To set the retention period for system logs, use the `rds.log_retention_period` parameter. You can find `rds.log_retention_period` in the DB parameter group associated with your DB instance. The unit for this parameter is minutes. For example, a setting of 1,440 retains logs for one day. The default value is 4,320 (three days). The maximum value is 10,080 (seven days). Your instance must have enough allocated storage to contain the retained log files.

To retain older logs, publish them to Amazon CloudWatch Logs. For more information, see Publishing PostgreSQL Logs to CloudWatch Logs (p. 483).

Using Query Logging

To enable query logging for your PostgreSQL DB instance, set two parameters in the DB parameter group associated with your DB instance: `log_statement` and `log_min_duration_statement`.

The `log_statement` parameter controls which SQL statements are logged. We recommend that you set this parameter to `all` to log all statements when you debug issues in your DB instance. The default value is `none`. To log all data definition language (DDL) statements (CREATE, ALTER, DROP, and so on), set this value to `ddl`. To log all DDL and data modification language (DML) statements (INSERT, UPDATE, DELETE, and so on), set this value to `mod`.

The `log_min_duration_statement` parameter sets the limit in milliseconds of a statement to be logged. All SQL statements that run longer than the parameter setting are logged. This parameter is disabled and set to -1 by default. Enabling this parameter can help you find unoptimized queries.

To set up query logging, take the following steps:

1. Set the `log_statement` parameter to `all`. The following example shows the information that is written to the `postgres.log` file.

```
2013-11-05 16:48:56 UTC::@:[2952]:LOG:  received SIGHUP, reloading configuration files
2013-11-05 16:48:56 UTC::@:[2952]:LOG:  parameter "log_statement" changed to "all"
```

   Additional information is written to the postgres.log file when you run a query. The following example shows the type of information written to the file after a query.

```
2013-11-05 16:41:07 UTC::@:[2955]:LOG:  checkpoint starting: time
```

```
2013-11-05 16:41:07 UTC::@:[2955]:LOG:  checkpoint complete: wrote 1 buffers (0.3%);
 0 transaction log file(s) added, 0 removed, 1 recycled; write=0.000 s, sync=0.003 s,
 total=0.012 s; sync files=1, longest=0.003 s, average=0.003 s
2013-11-05 16:45:14 UTC:[local]:master@postgres:[8839]:LOG:  statement: SELECT d.datname
 as "Name",
        pg_catalog.pg_get_userbyid(d.datdba) as "Owner",
        pg_catalog.pg_encoding_to_char(d.encoding) as "Encoding",
        d.datcollate as "Collate",
        d.datctype as "Ctype",
        pg_catalog.array_to_string(d.datacl, E'\n') AS "Access privileges"
 FROM pg_catalog.pg_database d
 ORDER BY 1;
2013-11-05 16:45:
```

2. Set the `log_min_duration_statement` parameter. The following example shows the information that is written to the `postgres.log` file when the parameter is set to `1`.

```
2013-11-05 16:48:56 UTC::@:[2952]:LOG:  received SIGHUP, reloading configuration files
2013-11-05 16:48:56 UTC::@:[2952]:LOG:  parameter "log_min_duration_statement" changed to
 "1"
```

   Additional information is written to the `postgres.log` file when you run a query that exceeds the duration parameter setting. The following example shows the type of information written to the file after a query.

```
2013-11-05 16:51:10 UTC:[local]:master@postgres:[9193]:LOG:  statement: SELECT
 c2.relname, i.indisprimary, i.indisunique, i.indisclustered, i.indisvalid,
 pg_catalog.pg_get_indexdef(i.indexrelid, 0, true),
   pg_catalog.pg_get_constraintdef(con.oid, true), contype, condeferrable, condeferred,
 c2.reltablespace
 FROM pg_catalog.pg_class c, pg_catalog.pg_class c2, pg_catalog.pg_index i
   LEFT JOIN pg_catalog.pg_constraint con ON (conrelid = i.indrelid AND conindid =
 i.indexrelid AND contype IN ('p','u','x'))
 WHERE c.oid = '1255' AND c.oid = i.indrelid AND i.indexrelid = c2.oid
 ORDER BY i.indisprimary DESC, i.indisunique DESC, c2.relname;
2013-11-05 16:51:10 UTC:[local]:master@postgres:[9193]:LOG:  duration: 3.367 ms
2013-11-05 16:51:10 UTC:[local]:master@postgres:[9193]:LOG:  statement: SELECT
 c.oid::pg_catalog.regclass FROM pg_catalog.pg_class c, pg_catalog.pg_inherits i WHERE
 c.oid=i.inhparent AND i.inhrelid = '1255' ORDER BY inhseqno;
2013-11-05 16:51:10 UTC:[local]:master@postgres:[9193]:LOG:  duration: 1.002 ms
2013-11-05 16:51:10 UTC:[local]:master@postgres:[9193]:LOG:  statement:
 SELECT c.oid::pg_catalog.regclass FROM pg_catalog.pg_class c,
 pg_catalog.pg_inherits i WHERE c.oid=i.inhrelid AND i.inhparent = '1255' ORDER BY
 c.oid::pg_catalog.regclass::pg_catalog.text;
2013-11-05 16:51:18 UTC:[local]:master@postgres:[9193]:LOG:  statement: select proname
 from pg_proc;
2013-11-05 16:51:18 UTC:[local]:master@postgres:[9193]:LOG:  duration: 3.469 ms
```

Publishing PostgreSQL Logs to CloudWatch Logs

To store your PostgreSQL log records in highly durable storage, you can use CloudWatch Logs. With CloudWatch Logs, you can also perform real-time analysis of log data and use CloudWatch to view metrics and create alarms.

To work with CloudWatch Logs, configure your RDS for PostgreSQL DB instance to publish log data to a log group.

Note
Publishing log files to CloudWatch Logs is supported only for PostgreSQL versions 9.6.6 and later and 10.4 and later.

You can publish the following log types to CloudWatch Logs for RDS for PostgreSQL:

- Postgresql log
- Upgrade log (not available for Aurora PostgreSQL)

After you complete the configuration, Amazon RDS publishes the log events to log streams within a CloudWatch log group. For example, the PostgreSQL log data is stored within the log group `/aws/rds/instance/my_instance/postgresql`. To view your logs, open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.

Console

To publish PostgreSQL logs to CloudWatch Logs using the console

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the DB instance that you want to modify, and then choose **Modify**.
4. In the **Log exports** section, choose the logs that you want to start publishing to CloudWatch Logs.

   The **Log exports** section is available only for PostgreSQL versions that support publishing to CloudWatch Logs.
5. Choose **Continue**, and then choose **Modify DB Instance** on the summary page.

AWS CLI

You can publish PostgreSQL logs with the AWS CLI. You can call the `modify-db-instance` command with the following parameters:

- `--db-instance-identifier`
- `--cloudwatch-logs-export-configuration`

> **Note**
> A change to the `--cloudwatch-logs-export-configuration` option is always applied to the DB instance immediately. Therefore, the `--apply-immediately` and `--no-apply-immediately` options have no effect.

You can also publish PostgreSQL logs by calling the following CLI commands:

- `create-db-instance`
- `restore-db-instance-from-db-snapshot`
- `restore-db-instance-to-point-in-time`

Run one of these CLI commands with the following options:

- `--db-instance-identifier`
- `--enable-cloudwatch-logs-exports`
- `--db-instance-class`
- `--engine`

Other options might be required depending on the CLI command you run.

Example Modify an instance to publish logs to CloudWatch Logs

The following example modifies an existing PostgreSQL DB instance to publish log files to CloudWatch Logs. The `--cloudwatch-logs-export-configuration` value is a JSON object. The key for this object is `EnableLogTypes`, and its value is an array of strings with any combination of `postgresql` and `upgrade`.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":["postgresql", "upgrade"]}'
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --cloudwatch-logs-export-configuration '{"EnableLogTypes":["postgresql","upgrade"]}'
```

Example Create an instance to publish logs to CloudWatch Logs

The following example creates a PostgreSQL DB instance and publishes log files to CloudWatch Logs. The `--enable-cloudwatch-logs-exports` value is a JSON array of strings. The strings can be any combination of `postgresql` and `upgrade`.

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --enable-cloudwatch-logs-exports '["postgresql","upgrade"]' \
    --db-instance-class db.m4.large \
    --engine postgres
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier mydbinstance ^
    --enable-cloudwatch-logs-exports '["postgresql","upgrade"]' ^
    --db-instance-class db.m4.large ^
    --engine postgres
```

RDS API

You can publish PostgreSQL logs with the RDS API. You can call the `ModifyDBInstance` action with the following parameters:

- `DBInstanceIdentifier`
- `CloudwatchLogsExportConfiguration`

> **Note**
> A change to the `CloudwatchLogsExportConfiguration` parameter is always applied to the DB instance immediately. Therefore, the `ApplyImmediately` parameter has no effect.

You can also publish PostgreSQL logs by calling the following RDS API operations:

- `CreateDBInstance`
- `RestoreDBInstanceFromDBSnapshot`
- `RestoreDBInstanceToPointInTime`

Run one of these RDS API operations with the following parameters:

- `DBInstanceIdentifier`
- `EnableCloudwatchLogsExports`
- `Engine`
- `DBInstanceClass`

Other parameters might be required depending on the operation that you run.

Logging Amazon RDS API Calls with AWS CloudTrail

Amazon RDS is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Amazon RDS. CloudTrail captures all API calls for Amazon RDS as events, including calls from the Amazon RDS console and from code calls to the Amazon RDS APIs. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for Amazon RDS. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to Amazon RDS, the IP address from which the request was made, who made the request, when it was made, and additional details.

To learn more about CloudTrail, see the AWS CloudTrail User Guide.

Amazon RDS Information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in Amazon RDS, that activity is recorded in a CloudTrail event along with other AWS service events in **Event history**. You can view, search, and download recent events in your AWS account. For more information, see Viewing Events with CloudTrail Event History.

For an ongoing record of events in your AWS account, including events for Amazon RDS, create a trail. A trail enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all regions. The trail logs events from all regions in the AWS partition and delivers the log files to the Amazon S3 bucket that you specify. Additionally, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see:

- Overview for Creating a Trail
- CloudTrail Supported Services and Integrations
- Configuring Amazon SNS Notifications for CloudTrail
- Receiving CloudTrail Log Files from Multiple Regions and Receiving CloudTrail Log Files from Multiple Accounts

All Amazon RDS actions are logged by CloudTrail and are documented in the Amazon RDS API Reference. For example, calls to the `CreateDBInstance`, `ModifyDBInstance`, and `CreateDBParameterGroup` actions generate entries in the CloudTrail log files.

Every event or log entry contains information about who generated the request. The identity information helps you determine the following:

- Whether the request was made with root or IAM user credentials.
- Whether the request was made with temporary security credentials for a role or federated user.
- Whether the request was made by another AWS service.

For more information, see the CloudTrail userIdentity Element.

Understanding Amazon RDS Log File Entries

A trail is a configuration that enables delivery of events as log files to an Amazon S3 bucket that you specify. CloudTrail log files contain one or more log entries. An event represents a single request from any source and includes information about the requested action, the date and time of the action, request parameters, and so on. CloudTrail log files are not an ordered stack trace of the public API calls, so they do not appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the `CreateDBInstance` action.


```
{
    "eventVersion": "1.04",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AKIAIOSFODNN7EXAMPLE",
        "arn": "arn:aws:iam::123456789012:user/johndoe",
        "accountId": "123456789012",
        "accessKeyId": "AKIAI44QH8DHBEXAMPLE",
        "userName": "johndoe"
    },
    "eventTime": "2018-07-30T22:14:06Z",
    "eventSource": "rds.amazonaws.com",
    "eventName": "CreateDBInstance",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "192.0.2.0",
    "userAgent": "aws-cli/1.15.42 Python/3.6.1 Darwin/17.7.0 botocore/1.10.42",
    "requestParameters": {
        "enableCloudwatchLogsExports": [
            "audit",
            "error",
            "general",
            "slowquery"
        ],
        "dBInstanceIdentifier": "test-instance",
        "engine": "mysql",
        "masterUsername": "myawsuser",
        "allocatedStorage": 20,
        "dBInstanceClass": "db.m1.small",
        "masterUserPassword": "****"
    },
    "responseElements": {
        "dBInstanceArn": "arn:aws:rds:us-east-1:123456789012:db:test-instance",
        "storageEncrypted": false,
        "preferredBackupWindow": "10:27-10:57",
        "preferredMaintenanceWindow": "sat:05:47-sat:06:17",
        "backupRetentionPeriod": 1,
        "allocatedStorage": 20,
        "storageType": "standard",
        "engineVersion": "5.6.39",
        "dbInstancePort": 0,
        "optionGroupMemberships": [
            {
                "status": "in-sync",
                "optionGroupName": "default:mysql-5-6"
            }
        ],
        "dBParameterGroups": [
            {
                "dBParameterGroupName": "default.mysql5.6",
                "parameterApplyStatus": "in-sync"
            }
        ],
        "monitoringInterval": 0,
        "dBInstanceClass": "db.m1.small",
        "readReplicaDBInstanceIdentifiers": [],
        "dBSubnetGroup": {
            "dBSubnetGroupName": "default",
            "dBSubnetGroupDescription": "default",
            "subnets": [
```

```
            {
                "subnetAvailabilityZone": {"name": "us-east-1b"},
                "subnetIdentifier": "subnet-cbfff283",
                "subnetStatus": "Active"
            },
            {
                "subnetAvailabilityZone": {"name": "us-east-1e"},
                "subnetIdentifier": "subnet-d7c825e8",
                "subnetStatus": "Active"
            },
            {
                "subnetAvailabilityZone": {"name": "us-east-1f"},
                "subnetIdentifier": "subnet-6746046b",
                "subnetStatus": "Active"
            },
            {
                "subnetAvailabilityZone": {"name": "us-east-1c"},
                "subnetIdentifier": "subnet-bac383e0",
                "subnetStatus": "Active"
            },
            {
                "subnetAvailabilityZone": {"name": "us-east-1d"},
                "subnetIdentifier": "subnet-42599426",
                "subnetStatus": "Active"
            },
            {
                "subnetAvailabilityZone": {"name": "us-east-1a"},
                "subnetIdentifier": "subnet-da327bf6",
                "subnetStatus": "Active"
            }
        ],
        "vpcId": "vpc-136a4c6a",
        "subnetGroupStatus": "Complete"
    },
    "masterUsername": "myawsuser",
    "multiAZ": false,
    "autoMinorVersionUpgrade": true,
    "engine": "mysql",
    "cACertificateIdentifier": "rds-ca-2015",
    "dbiResourceId": "db-ETDZIIXHEWY5N7GXVC4SH7H5IA",
    "dBSecurityGroups": [],
    "pendingModifiedValues": {
        "masterUserPassword": "****",
        "pendingCloudwatchLogsExports": {
            "logTypesToEnable": [
                "audit",
                "error",
                "general",
                "slowquery"
            ]
        }
    },
    "dBInstanceStatus": "creating",
    "publiclyAccessible": true,
    "domainMemberships": [],
    "copyTagsToSnapshot": false,
    "dBInstanceIdentifier": "test-instance",
    "licenseModel": "general-public-license",
    "iAMDatabaseAuthenticationEnabled": false,
    "performanceInsightsEnabled": false,
    "vpcSecurityGroups": [
        {
            "status": "active",
            "vpcSecurityGroupId": "sg-f839b688"
        }
    ]
```

```
    },
    "requestID": "daf2e3f5-96a3-4df7-a026-863f96db793e",
    "eventID": "797163d3-5726-441d-80a7-6eeb7464acd4",
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
}
```

Amazon RDS on AWS Outposts (Preview)

This is prerelease documentation for a service in preview release. It is subject to change.

By using AWS Outposts, you can work with the same AWS hardware infrastructure, services, APIs, and tools to build and run your applications on premises as in the cloud. AWS Outposts is ideal for workloads that need low latency access to on-premises applications or systems and for workloads that need to store and process data locally. For more information about AWS Outposts, see AWS Outposts.

With Amazon RDS on AWS Outposts, you can create AWS-managed relational databases in your on-premises data centers. RDS on Outposts enables you to run RDS databases on AWS Outposts. You manage RDS on Outposts databases using the same AWS Management Console, AWS CLI, and RDS API that you use for Amazon RDS databases in the cloud.

Important
Currently, RDS on Outposts is in preview. Don't use RDS on Outposts for databases running production workloads. Also, we strongly recommend not putting sensitive data in databases that you use with the RDS on Outposts preview. You might encounter issues during the preview that cause incorrect results, corrupted data, or both. Over the duration of the preview, we might introduce breaking changes without advance notice.

RDS on Outposts supports automated backups of DB instances. Automated backups enable point-in-time recovery. You can also manually create DB snapshots. Network connectivity between your Outpost and your AWS Region is required to back up and restore DB instances. All DB snapshots and transaction logs from an Outpost are stored in the AWS Region. From the AWS Region, you can restore a DB instance from a DB snapshot to a different Outpost. For more information, see Working With Backups (p. 291).

RDS on Outposts supports automated maintenance and upgrades of DB instances. For more information, see Maintaining a DB Instance (p. 234).

RDS on Outposts uses encryption at rest for DB instances and DB snapshots using your AWS KMS key. For more information about encryption at rest, see Encrypting Amazon RDS Resources (p. 1358).

If network connectivity between your Outpost and its AWS Region is lost, your databases continue to run. You can't create new databases or take new actions on existing databases. If an Outpost's capacity becomes unhealthy while you are disconnected, the database isn't automatically replaced. Additionally, automatic backups don't run if network connectivity is down during the backup window. If there is a hardware failure in disconnected mode, all reads and writes to your databases are disabled. They're disabled because the underlying Amazon EBS volumes stop accepting reads and writes to avoid data loss.

Note
If network connectivity is lost, we recommend that you restore network connectivity as soon as possible for the best RDS on Outposts experience.

Topics

Prerequisites for Amazon RDS on AWS Outposts

The following are prerequisites for using Amazon RDS on AWS Outposts:

- You must have installed and configured AWS Outposts in your on-premises data center. For more information about AWS Outposts, see AWS Outposts.
- You must have at least one subnet available for RDS on Outposts. You can use the same subnet for other workloads.
- You must have a reliable network connection between your Outpost and an AWS Region.

Limitations for Amazon RDS on AWS Outposts

The following are limitations for Amazon RDS on AWS Outposts:

- You can only create DB instances for RDS for MySQL and RDS for PostgreSQL DB instances. Currently, other DB engines aren't supported.
- RDS on Outposts doesn't support use cases that require all data to remain in your data center.

  RDS on Outposts stores database backups and logs in your AWS Region and sends database metrics to Amazon CloudWatch.
- Some Amazon RDS features aren't supported.

Supported DB Instance Classes for Amazon RDS on AWS Outposts

Amazon RDS on AWS Outposts supports the following DB instance classes:

- General Purpose DB instance classes
  - db.m5.24xlarge
  - db.m5.12xlarge
  - db.m5.4xlarge
  - db.m5.2xlarge
  - db.m5.xlarge
  - db.m5.large
- Memory Optimized DB instance classes
  - db.r5.24xlarge
  - db.r5.12xlarge
  - db.r5.4xlarge
  - db.r5.2xlarge
  - db.r5.xlarge
  - db.r5.large

Only General Purpose SSD storage is supported for RDS on Outposts DB instances. For more information about DB instance classes, see DB Instance Classes (p. 7).

Creating DB Instances for Amazon RDS on AWS Outposts

Creating an Amazon RDS on AWS Outposts DB instance is similar to creating an Amazon RDS DB instance in the AWS Cloud. However, you must specify a DB subnet group that is associated with your Outpost.

An Amazon VPC can span all of the Availability Zones in an AWS Region. In AWS Outposts, Outposts are extensions of Availability Zones, and you can extend an Amazon VPC in an account to span multiple Availability Zones and associated Outpost locations. When you configure your Outpost, you associate a subnet group with it to extend your regional Amazon VPC environment to your on-premises facility. Outpost instances and related services appear as part of your regional Amazon VPC, similar to an Availability Zone with associated subnets.

Before you create an RDS on Outposts DB instance, you can create a DB subnet group that includes one subnet that is associated with your Outpost. When you create an RDS on Outposts DB instance, specify this DB subnet group.

For information about configuring AWS Outposts, see the AWS Outposts User Guide.

> **Note**
> The RDS console is the only interface supported for the RDS on Outposts preview. The AWS CLI and RDS API aren't supported.

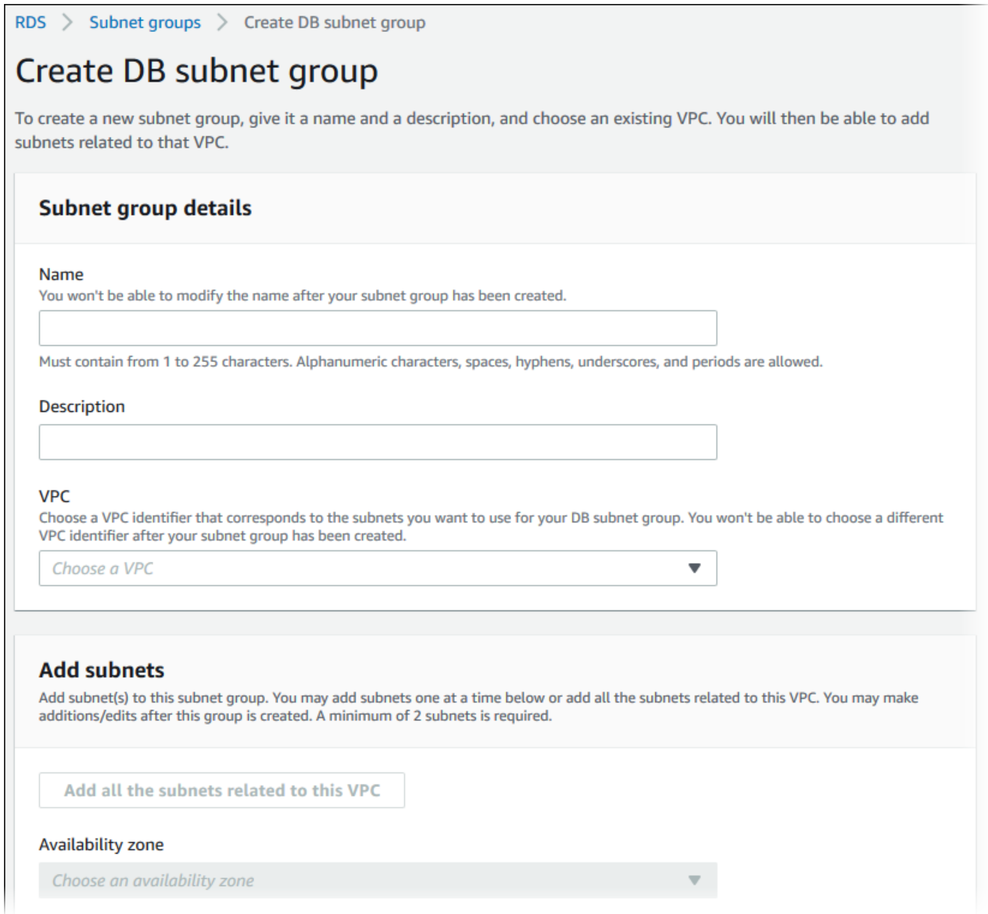
To create an RDS on Outposts DB instance using the console

1. Create a DB subnet group with one subnet that is associated with your Outpost.

   > **Note**
   > To create a DB subnet group for the AWS Cloud, you specify at least two subnets. However, for an Outpost DB subnet group, you can specify only one subnet.

   a. Sign in to the AWS Management Console for the preview, and open the Amazon RDS console.
   b. Choose **Subnet groups**, and then choose **Create DB Subnet Group**.

      The **Create DB subnet group** page appears.



c. Set the following values for your new DB subnet group:

   - **Name –** The name of the DB subnet group
   - **Description –** A description for the DB subnet group
   - **VPC –** The VPC for which you're creating the DB subnet group

d. For **Availability Zone**, choose the Availability Zone for your Outpost.

e. For **Subnet**, choose the subnet for use by RDS on Outposts.

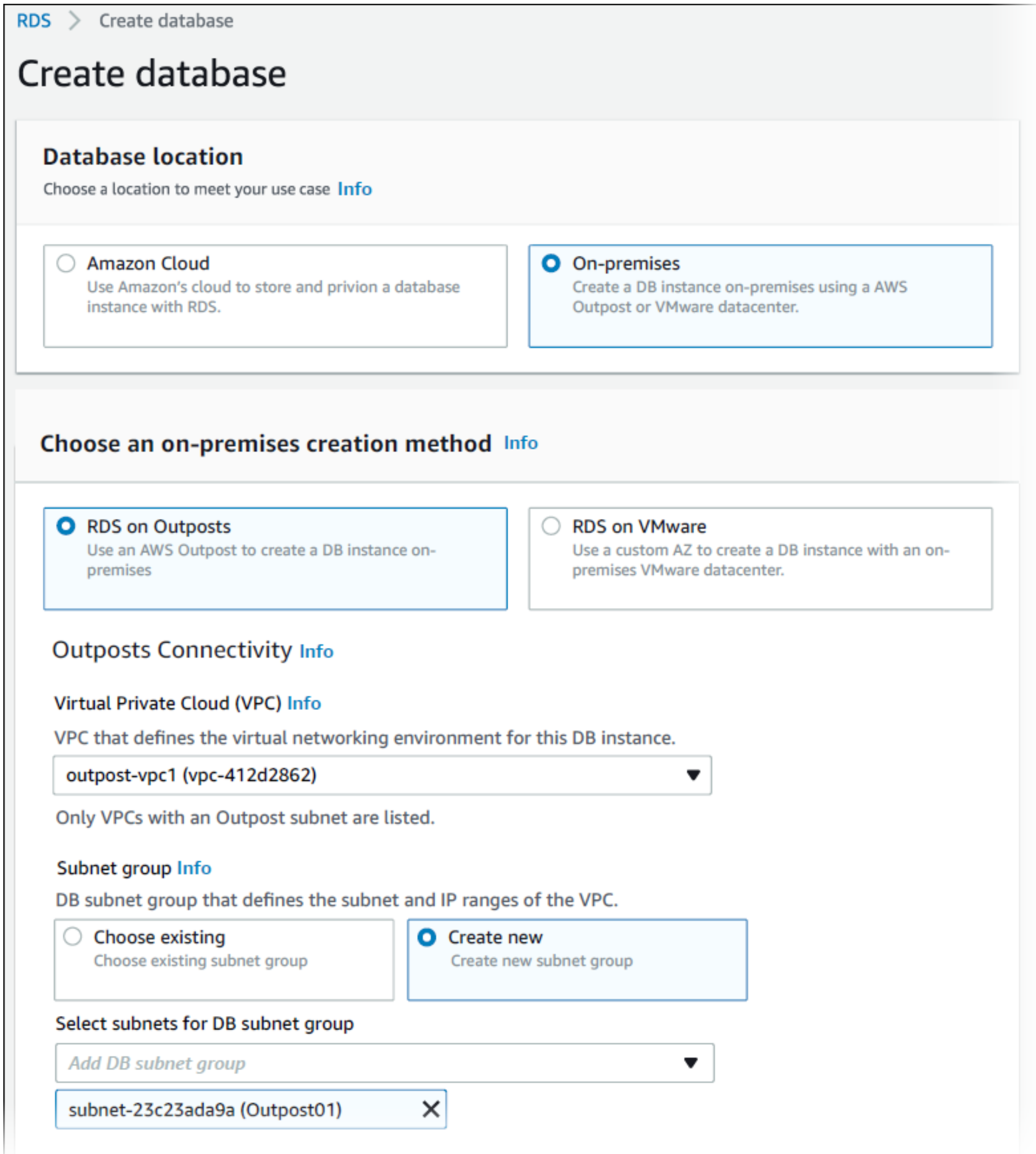
f. Choose **Add subnet**.

   Your DB subnet group must have only one subnet.

g. Choose **Create** to create the DB subnet group.

2. Choose the Outpost for your DB instance.

   The AWS Management Console detects available Outposts that you have configured. Choose the Outpost with the DB subnet group that you created previously.



Choose the following settings:

- **Database location – On-premises**
- **On-premises creation method – RDS on Outposts**
- **Outpost –** The Outpost that uses the Amazon VPC with the DB subnet group for the DB instance
- **Virtual Private Cloud (VPC) –** The Amazon VPC that contains the DB subnet group for the DB instance
- **Subnet group –** The DB subnet group for the DB instance

  You can choose an existing DB subnet group that is associated with the Outpost. If you didn't create a DB subnet group, you can create a new DB subnet group for the Outpost. Only one subnet is allowed in the DB subnet group.

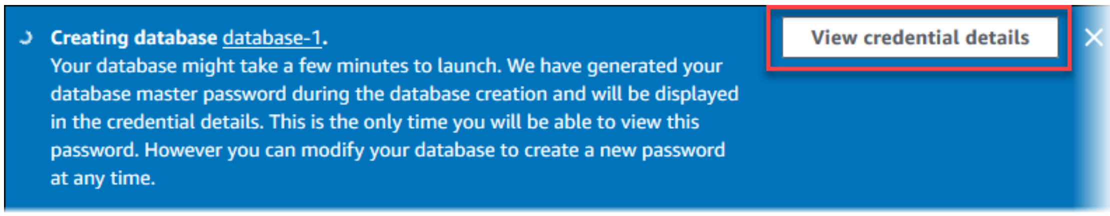
3. For the remaining sections, specify your DB instance settings.

For information about each setting when creating a DB instance, see Settings for DB Instances (p. 141).

4. Choose **Create database**.

   If you chose to use an automatically generated password, the **View credential details** button appears on the **Databases** page.

   To view the master user name and password for the DB instance, choose **View credential details**.

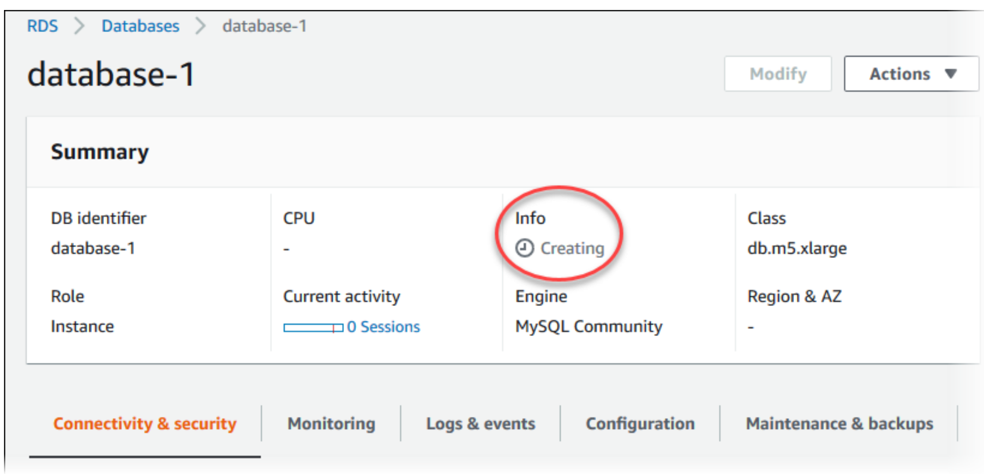


   To connect to the DB instance as the master user, use the user name and password that appear.

   Important
   You can't view the master user password again. If you don't record it, you might have to change it. To change the master user password after the DB instance is available, modify the DB instance. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

5. For **Databases**, choose the name of the new DB instance.

   On the RDS console, the details for the new DB instance appear. The DB instance has a status of **Creating** until the DB instance is created and ready for use. When the state changes to **Available**, you can connect to the DB instance. Depending on the DB instance class and storage allocated, it can take several minutes for the new DB instance to be available.



   After the DB instance is available, you can manage it the same way that you manage RDS DB instances in the cloud.

MariaDB on Amazon RDS

Amazon RDS supports DB instances running several versions of MariaDB. You can use the following major versions:

- MariaDB 10.4
- MariaDB 10.3
- MariaDB 10.2
- MariaDB 10.1
- MariaDB 10.0

For more information about minor version support, see MariaDB on Amazon RDS Versions (p. 499).

You first use the Amazon RDS management tools or interfaces to create an Amazon RDS MariaDB DB instance. You can then use the Amazon RDS tools to perform management actions for the DB instance, such as reconfiguring or resizing the DB instance, authorizing connections to the DB instance, creating and restoring from backups or snapshots, creating Multi-AZ secondaries, creating read replicas, and monitoring the performance of the DB instance. You use standard MariaDB utilities and applications to store and access the data in the DB instance.

MariaDB is available in all of the AWS Regions. For more information about AWS Regions, see Regions, Availability Zones, and Local Zones (p. 37).

You can use Amazon RDS for MariaDB databases to build HIPAA-compliant applications. You can store healthcare-related information, including protected health information (PHI), under an executed Business Associate Agreement (BAA) with AWS. For more information, see HIPAA Compliance. AWS Services in Scope have been fully assessed by a third-party auditor and result in a certification, attestation of compliance, or Authority to Operate (ATO). For more information, see AWS Services in Scope by Compliance Program.

Before creating your first DB instance, you should complete the steps in the setting up section of this guide. For more information, see Setting Up for Amazon RDS (p. 58).

Common Management Tasks for MariaDB on Amazon RDS

The following are the common management tasks you perform with an Amazon RDS DB instance running MariaDB, with links to relevant documentation for each task.

Task Area	Relevant Documentation
Instance Classes, Storage, and PIOPS If you are creating a DB instance for production purposes, you should understand how instance classes, storage types, and Provisioned IOPS work in Amazon RDS.	DB Instance Classes (p. 7) Amazon RDS Storage Types (p. 29)
Multi-AZ Deployments Provide high availability with synchronous standby replication in a different Availability Zone, automatic failover, fault tolerance for DB instances using Multi-AZ deployments, and read replicas.	High Availability (Multi-AZ) for Amazon RDS (p. 41)

Task Area	Relevant Documentation
Amazon Virtual Private Cloud (VPC) If your AWS account has a default VPC, then your DB instance is automatically created inside the default VPC. If your account does not have a default VPC, and you want the DB instance in a VPC, you must create the VPC and subnet groups before you create the DB instance.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Working with a DB Instance in a VPC (p. 1442)
Security Groups By default, DB instances are created with a firewall that prevents access to them. You therefore must create a security group with the correct IP addresses and network configuration to access the DB instance. The security group you create depends on what Amazon EC2 platform your DB instance is on, and whether you access your DB instance from an Amazon EC2 instance. In general, if your DB instance is on the *EC2-Classic* platform, you will need to create a DB security group; if your DB instance is on the *EC2-VPC* platform, you will need to create a VPC security group.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Controlling Access with Security Groups (p. 1414)
Parameter Groups If your DB instance is going to require specific database parameters, you should create a parameter group before you create the DB instance.	Working with DB Parameter Groups (p. 202)
Importing and Exporting Data Establish procedures for importing or exporting data.	Importing Data into a MariaDB DB Instance (p. 530)
Replication You can offload read traffic from your primary MariaDB DB instance by creating read replicas.	Working with Read Replicas (p. 250)
Connecting to Your DB Instance Connect to your DB instance using a standard SQL client application.	Connecting to a DB Instance Running the MariaDB Database Engine (p. 509)
Backup and Restore When you create your DB instance, you can configure it to take automated backups. You can also back up and restore your databases manually by using full backup files (.bak files).	Working With Backups (p. 291)
Monitoring Monitor your RDS MariaDB DB instance by using Amazon CloudWatch RDS metrics, events, and Enhanced Monitoring. View log files for your RDS MariaDB DB instance.	Viewing DB Instance Metrics (p. 356) Viewing Amazon RDS Events (p. 448)
Log Files You can access the log files for your MariaDB DB instance.	Amazon RDS Database Log Files (p. 453) MariaDB Database Log Files (p. 457)

There are also advanced administrative tasks for working with DB instances running MariaDB. For more information, see the following documentation:

- Parameters for MariaDB (p. 534)
- MariaDB on Amazon RDS SQL Reference (p. 539)

MariaDB on Amazon RDS Versions

For MariaDB, version numbers are organized as version X.Y.Z. In Amazon RDS terminology, X.Y denotes the major version, and Z is the minor version number. For Amazon RDS implementations, a version change is considered major if the major version number changes, for example going from version 10.0 to 10.1. A version change is considered minor if only the minor version number changes, for example going from version 10.0.17 to 10.0.24.

Amazon RDS currently supports the following versions of MariaDB:

Major Version	Minor Version
MariaDB 10.4	• 10.4.8 (supported in all AWS Regions)
MariaDB 10.3	• 10.3.20 (supported in all AWS Regions) • 10.3.13 (supported in all AWS Regions) • 10.3.8 (supported in all AWS Regions)
MariaDB 10.2	• 10.2.21 (supported in all AWS Regions) • 10.2.15 (supported in all AWS Regions) • 10.2.12 (supported in all AWS Regions) • 10.2.11 (supported in all AWS Regions)
MariaDB 10.1	• 10.1.34 (supported in all AWS Regions) • 10.1.31 (supported in all AWS Regions) • 10.1.26 (supported in all AWS Regions) • 10.1.23 (supported in all AWS Regions) • 10.1.19 (supported in all AWS Regions) • 10.1.14 (supported in all AWS Regions except US East (Ohio))
MariaDB 10.0	• 10.0.35 (supported in all AWS Regions) • 10.0.34 (supported in all AWS Regions) • 10.0.32 (supported in all AWS Regions) • 10.0.31 (supported in all AWS Regions) • 10.0.28 (supported in all AWS Regions) • 10.0.24 (supported in all AWS Regions) • 10.0.17 (supported in all AWS Regions except US East (Ohio), Canada (Central), and Europe (London))

You can specify any currently supported MariaDB version when creating a new DB instance. You can specify the major version (such as MariaDB 10.2), and any supported minor version for the specified major version. If no version is specified, Amazon RDS defaults to a supported version, typically the most recent version. If a major version is specified but a minor version is not, Amazon RDS defaults to a recent release of the major version you have specified. To see a list of supported versions, as well as defaults for newly created DB instances, use the `describe-db-engine-versions` AWS CLI command.

For information about the Amazon RDS deprecation policy for MariaDB, see Amazon RDS FAQs.

MariaDB Feature Support on Amazon RDS

In the following sections, find MariaDB feature support on Amazon RDS for MariaDB major versions:

Topics

For information about supported minor versions of Amazon RDS for MariaDB, see MariaDB on Amazon RDS Versions (p. 499).

MariaDB 10.4 Support on Amazon RDS

Amazon RDS supports the following new features for your DB instances running MariaDB version 10.4 or later:

- **User account security enhancements** – Password expiration and account locking improvements
- **Optimizer enhancements** – Optimizer Trace feature
- **InnoDB enhancements** – Instant DROP COLUMN support and instant `VARCHAR` extension for `ROW_FORMAT=DYNAMIC` and `ROW_FORMAT=COMPACT`
- **New parameters** – Including tcp_nodedelay, tls_version, and gtid_cleanup_batch_size

For a list of all MariaDB 10.4 features and their documentation, see Changes and Improvements in MariaDB 10.4 and Release Notes - MariaDB 10.4 Series on the MariaDB website.

For a list of unsupported features, see Features Not Supported (p. 501).

MariaDB 10.3 Support on Amazon RDS

Amazon RDS supports the following new features for your DB instances running MariaDB version 10.3 or later:

- **Oracle compatibility** – PL/SQL compatibility parser, sequences, INTERSECT and EXCEPT to complement UNION, new TYPE OF and ROW TYPE OF declarations, and invisible columns
- **Temporal data processing** – System versioned tables for querying of past and present states of the database
- **Flexibility** – User-defined aggregates, storage-independent column compression, and proxy protocol support to relay the client IP address to the server
- **Manageability** – Instant ADD COLUMN operations and fast-fail data definition language (DDL) operations

For a list of all MariaDB 10.3 features and their documentation, see Changes & Improvements in MariaDB 10.3 and Release Notes - MariaDB 10.3 Series on the MariaDB website.

For a list of unsupported features, see Features Not Supported (p. 501).

MariaDB 10.2 Support on Amazon RDS

Amazon RDS supports the following new features for your DB instances running MariaDB version 10.2 or later:

- ALTER USER
- Common Table Expressions
- Compressing Events to Reduce Size of the Binary Log
- CREATE USER — new options for limiting resource usage and TLS/SSL
- EXECUTE IMMEDIATE
- Flashback
- InnoDB — now the default storage engine instead of XtraDB
- InnoDB — set the buffer pool size dynamically
- JSON Functions
- Window Functions
- WITH

For a list of all MariaDB 10.2 features and their documentation, see Changes & Improvements in MariaDB 10.2 and Release Notes - MariaDB 10.2 Series on the MariaDB website.

For a list of unsupported features, see Features Not Supported (p. 501).

MariaDB 10.1 Support on Amazon RDS

Amazon RDS supports the following new features for your DB instances running MariaDB version 10.1 or later:

- Optimistic in-order parallel replication
- Page Compression
- XtraDB data scrubbing and defragmentation

For a list of all MariaDB 10.1 features and their documentation, see Changes & Improvements in MariaDB 10.1 and Release Notes - MariaDB 10.1 Series on the MariaDB website.

For a list of unsupported features, see Features Not Supported (p. 501).

MariaDB 10.0 Support on Amazon RDS

For a list of all MariaDB 10.0 features and their documentation, see Changes & Improvements in MariaDB 10.0 and Release Notes - MariaDB 10.0 Series on the MariaDB website.

For a list of unsupported features, see Features Not Supported (p. 501).

Features Not Supported

The following MariaDB features are not supported on Amazon RDS:

- Authentication plugin – GSSAPI
- Authentication plugin – Unix Socket
- AWS Key Management encryption plugin

- Delayed replication
- Native MariaDB encryption at rest for XtraDB, InnoDB, and Aria.

  You can enable encryption at rest for a MariaDB DB instance by following the instructions in Encrypting Amazon RDS Resources (p. 1358).
- HandlerSocket
- JSON table type
- MariaDB ColumnStore
- MariaDB Galera Cluster
- Multisource replication
- MyRocks storage engine
- Password validation plugin, `simple_password_check`, and `cracklib_password_check`
- Replication filters
- Spider storage engine
- Sphinx storage engine
- TokuDB storage engine
- Storage engine-specific object attributes, as described in Engine-defined New Table/Field/Index Attributes in the MariaDB documentation
- Table and tablespace encryption

To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges. Amazon RDS supports access to databases on a DB instance using any standard SQL client application. Amazon RDS doesn't allow direct host access to a DB instance by using Telnet, Secure Shell (SSH), or Windows Remote Desktop Connection.

Supported Storage Engines for MariaDB on Amazon RDS

While MariaDB supports multiple storage engines with varying capabilities, not all of them are optimized for recovery and data durability. InnoDB (for version 10.2 and higher) and XtraDB (for version 10.0 and 10.1) are the recommended and supported storage engines for MariaDB DB instances on Amazon RDS. Amazon RDS features such as Point-In-Time Restore and snapshot restore require a recoverable storage engine and are supported only for the recommended storage engine for the MariaDB version. Amazon RDS also supports Aria, although using Aria might have a negative impact on recovery in the event of an instance failure. However, if you need to use spatial indexes to handle geographic data on MariaDB 10.1 or 10.0, you should use Aria because spatial indexes are not supported by XtraDB. On MariaDB 10.2 and higher, the InnoDB storage engine supports spatial indexes.

Other storage engines are not currently supported by Amazon RDS for MariaDB.

MariaDB File Size Limits in Amazon RDS

For Amazon RDS MariaDB DB instances, the maximum provisioned storage limit constrains the size of a table to a maximum size of 16 TB when using InnoDB file-per-table tablespaces. This limit also constrains the system tablespace to a maximum size of 16 TB. InnoDB file-per-table tablespaces (with tables each in their own tablespace) are set by default for Amazon RDS MariaDB DB instances. For more information, see Amazon RDS DB Instance Storage (p. 29).

There are advantages and disadvantages to using InnoDB file-per-table tablespaces, depending on your application. To determine the best approach for your application, see InnoDB File-Per-Table Mode in the MySQL documentation.

We don't recommend allowing tables to grow to the maximum file size. In general, a better practice is to partition data into smaller tables, which can improve performance and recovery times.

One option that you can use for breaking a large table up into smaller tables is partitioning. *Partitioning* distributes portions of your large table into separate files based on rules that you specify. For example, if you store transactions by date, you can create partitioning rules that distribute older transactions into separate files using partitioning. Then periodically, you can archive the historical transaction data that doesn't need to be readily available to your application. For more information, see Chapter 19: Partitioning in the MySQL documentation.

To determine the file size of a table

Use the following SQL command to determine if any of your tables are too large and are candidates for partitioning. To update table statistics, issue an `ANALYZE TABLE` command on each table. For more information, see ANALYZE TABLE in the MySQL documentation.

```
SELECT TABLE_SCHEMA, TABLE_NAME,
    round(((DATA_LENGTH + INDEX_LENGTH) / 1024 / 1024), 2) As "Approximate size (MB)",
 DATA_FREE
    FROM information_schema.TABLES
    WHERE TABLE_SCHEMA NOT IN ('mysql', 'information_schema', 'performance_schema');
```

To enable InnoDB file-per-table tablespaces

- To enable InnoDB file-per-table tablespaces, set the `innodb_file_per_table` parameter to `1` in the parameter group for the DB instance.

To disable InnoDB file-per-table tablespaces

- To disable InnoDB file-per-table tablespaces, set the `innodb_file_per_table` parameter to `0` in the parameter group for the DB instance.

For information on updating a parameter group, see Working with DB Parameter Groups (p. 202).

When you have enabled or disabled InnoDB file-per-table tablespaces, you can issue an `ALTER TABLE` command. You can use this command to move a table from the global tablespace to its own tablespace. Or you can move a table from its own tablespace to the global tablespace. Following is an example.

```
ALTER TABLE table_name ENGINE=InnoDB, ALGORITHM=COPY;
```

MariaDB Security on Amazon RDS

Security for Amazon RDS MariaDB DB instances is managed at three levels:

- AWS Identity and Access Management controls who can perform Amazon RDS management actions on DB instances. When you connect to AWS using IAM credentials, your IAM account must have IAM policies that grant the permissions required to perform Amazon RDS management operations. For more information, see Identity and Access Management in Amazon RDS (p. 1371).
- When you create a DB instance, you use either a VPC security group or a DB security group to control which devices and Amazon EC2 instances can open connections to the endpoint and port of the DB instance. These connections can be made using Secure Socket Layer (SSL). In addition, firewall rules at

your company can control whether devices running at your company can open connections to the DB instance.

- Once a connection has been opened to a MariaDB DB instance, authentication of the login and permissions are applied the same way as in a stand-alone instance of MariaDB. Commands such as `CREATE USER`, `RENAME USER`, `GRANT`, `REVOKE`, and `SET PASSWORD` work just as they do in stand-alone databases, as does directly modifying database schema tables.

When you create an Amazon RDS DB instance, the master user has the following default privileges:

- `alter`
- `alter routine`
- `create`
- `create routine`
- `create temporary tables`
- `create user`
- `create view`
- `delete`
- `drop`
- `event`
- `execute`
- `grant option`
- `index`
- `insert`
- `lock tables`
- `process`
- `references`
- `reload`

  This privilege is limited on Amazon RDS MariaDB DB instances. It doesn't grant access to the FLUSH LOGS or FLUSH TABLES WITH READ LOCK operations.
- `replication client`
- `replication slave`
- `select`
- `show databases`
- `show view`
- `trigger`
- `update`

For more information about these privileges, see User Account Management in the MariaDB documentation.

> **Note**
> Although you can delete the master user on a DB instance, we don't recommend doing so. To recreate the master user, use the `ModifyDBInstance` API or the `modify-db-instance` AWS command line tool and specify a new master user password with the appropriate parameter. If the master user does not exist in the instance, the master user is created with the specified password.

To provide management services for each DB instance, the `rdsadmin` user is created when the DB instance is created. Attempting to drop, rename, change the password for, or change privileges for the `rdsadmin` account results in an error.

To allow management of the DB instance, the standard `kill` and `kill_query` commands have been restricted. The Amazon RDS commands `mysql.rds_kill`, `mysql.rds_kill_query`, and `mysql.rds_kill_query_id` are provided for use in MariaDB and also MySQL so that you can terminate user sessions or queries on DB instances.

Using SSL with a MariaDB DB Instance

Amazon RDS supports Secure Sockets Layer (SSL) connections with DB instances running the MariaDB database engine.

Amazon RDS creates an SSL certificate and installs the certificate on the DB instance when Amazon RDS provisions the instance. These certificates are signed by a certificate authority. The SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks.

For information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

MariaDB uses yaSSL for secure connections in the following versions:

- MariaDB version 10.1.26 and earlier 10.1 versions
- MariaDB version 10.0.32 and earlier 10.0 versions

MariaDB uses OpenSSL for secure connections in the following versions:

- MariaDB 10.4 versions
- MariaDB 10.3 versions
- MariaDB 10.2 versions
- MariaDB version 10.1.31 and later 10.1 versions
- MariaDB version 10.0.34 and later 10.0 versions

Amazon RDS for MariaDB supports Transport Layer Security (TLS) versions 1.0, 1.1, and 1.2. The following table shows the TLS support for MySQL versions.

MariaDB Version	TLS 1.0	TLS 1.1	TLS 1.2
MariaDB 10.4	Supported	Supported	Supported
MariaDB 10.3	Supported	Supported	Supported
MariaDB 10.2	Supported	Supported	Supported
MariaDB 10.1	Supported	Supported for 10.1.31 and later 10.1 versions	Supported for 10.1.31 and later 10.1 versions
MariaDB 10.0	Supported	Supported for 10.0.34 and later 10.0 versions	Supported for 10.0.34 and later 10.0 versions

To encrypt connections using the default mysql client, launch the mysql client using the `--ssl-ca` parameter to reference the public key, as shown in the examples following.

The following example shows how to launch the client using the `--ssl-ca` parameter for MariaDB 10.2 and later.

```
mysql -h myinstance.c9akciq32.rds-us-east-1.amazonaws.com
--ssl-ca=[full path]rds-combined-ca-bundle.pem --ssl-mode=REQUIRED
```

The following example shows how to launch the client using the `--ssl-ca` parameter for MariaDB 10.1 and earlier.

```
mysql -h myinstance.c9akciq32.rds-us-east-1.amazonaws.com
--ssl-ca=[full path]rds-combined-ca-bundle.pem --ssl-verify-server-cert
```

You can require SSL connections for specific users accounts. For example, you can use one of the following statements, depending on your MariaDB version, to require SSL connections on the user account `encrypted_user`.

For MariaDB 10.2 and later, use the following statement.

```
ALTER USER 'encrypted_user'@'%' REQUIRE SSL;
```

For MariaDB 10.1 and earlier, use the following statement.

```
GRANT USAGE ON *.* TO 'encrypted_user'@'%' REQUIRE SSL;
```

For more information on SSL connections with MariaDB, see SSL Overview in the MariaDB documentation.

Cache Warming

InnoDB (version 10.2 and later) and XtraDB (versions 10.0 and 10.1) cache warming can provide performance gains for your MariaDB DB instance by saving the current state of the buffer pool when the DB instance is shut down, and then reloading the buffer pool from the saved information when the DB instance starts up. This approach bypasses the need for the buffer pool to "warm up" from normal database use and instead preloads the buffer pool with the pages for known common queries. For more information on cache warming, see Dumping and restoring the buffer pool in the MariaDB documentation.

Cache warming is enabled by default on MariaDB 10.2 and higher DB instances. To enable it, set the `innodb_buffer_pool_dump_at_shutdown` and `innodb_buffer_pool_load_at_startup` parameters to 1 in the parameter group for your DB instance. Changing these parameter values in a parameter group affects all MariaDB DB instances that use that parameter group. To enable cache warming for specific MariaDB DB instances, you might need to create a new parameter group for those DB instances. For information on parameter groups, see Working with DB Parameter Groups (p. 202).

Cache warming primarily provides a performance benefit for DB instances that use standard storage. If you use PIOPS storage, you don't commonly see a significant performance benefit.

Important

If your MariaDB DB instance doesn't shut down normally, such as during a failover, then the buffer pool state isn't saved to disk. In this case, MariaDB loads whatever buffer pool file is available when the DB instance is restarted. No harm is done, but the restored buffer pool might not reflect the most recent state of the buffer pool prior to the restart. To ensure that you have a recent state of the buffer pool available to warm the cache on startup, we recommend that you periodically dump the buffer pool "on demand." You can dump or load the buffer pool on demand.

You can create an event to dump the buffer pool automatically and at a regular interval. For example, the following statement creates an event named `periodic_buffer_pool_dump` that dumps the buffer pool every hour.

```
CREATE EVENT periodic_buffer_pool_dump
   ON SCHEDULE EVERY 1 HOUR
   DO CALL mysql.rds_innodb_buffer_pool_dump_now();
```

For more information, see Events in the MariaDB documentation.

Dumping and Loading the Buffer Pool on Demand

You can save and load the cache on demand using the following stored procedures:

- To dump the current state of the buffer pool to disk, call the mysql.rds_innodb_buffer_pool_dump_now (p. 838) stored procedure.
- To load the saved state of the buffer pool from disk, call the mysql.rds_innodb_buffer_pool_load_now (p. 838) stored procedure.
- To cancel a load operation in progress, call the mysql.rds_innodb_buffer_pool_load_abort (p. 838) stored procedure.

Database Parameters for MariaDB

By default, a MariaDB DB instance uses a DB parameter group that is specific to a MariaDB database. This parameter group contains some but not all of the parameters contained in the Amazon RDS DB parameter groups for the MySQL database engine. It also contains a number of new, MariaDB-specific parameters. For more information on the parameters available for the Amazon RDS MariaDB DB engine, see Parameters for MariaDB (p. 534).

Common DBA Tasks for MariaDB

Killing sessions or queries, skipping replication errors, working with InnoDB (version 10.2 and later) and XtraDB (versions 10.0 and 10.1) tablespaces to improve crash recovery times, and managing the global status history are common DBA tasks you might perform in a MariaDB DB instance. You can handle these tasks just as in an Amazon RDS MySQL DB instance, as described in Common DBA Tasks for MySQL DB Instances (p. 802). The crash recovery instructions there refer to the MySQL InnoDB engine, but they are applicable to a MariaDB instance running InnoDB or XtraDB as well.

Local Time Zone for MariaDB DB Instances

By default, the time zone for an RDS MariaDB DB instance is Universal Time Coordinated (UTC). You can set the time zone for your DB instance to the local time zone for your application instead.

To set the local time zone for a DB instance, set the `time_zone` parameter in the parameter group for your DB instance to one of the supported values listed later in this section. When you set the `time_zone` parameter for a parameter group, all DB instances and read replicas that are using that parameter group change to use the new local time zone. For information on setting parameters in a parameter group, see Working with DB Parameter Groups (p. 202).

After you set the local time zone, all new connections to the database reflect the change. If you have any open connections to your database when you change the local time zone, you won't see the local time zone update until after you close the connection and open a new connection.

You can set a different local time zone for a DB instance and one or more of its read replicas. To do this, use a different parameter group for the DB instance and the replica or replicas and set the `time_zone` parameter in each parameter group to a different local time zone.

If you are replicating across AWS Regions, then the replication master DB instance and the read replica use different parameter groups (parameter groups are unique to an AWS Region). To use the same local time zone for each instance, you must set the `time_zone` parameter in the instance's and read replica's parameter groups.

When you restore a DB instance from a DB snapshot, the local time zone is set to UTC. You can update the time zone to your local time zone after the restore is complete. If you restore a DB instance to a point in time, then the local time zone for the restored DB instance is the time zone setting from the parameter group of the restored DB instance.

You can set your local time zone to one of the following values.

`Africa/Cairo`	`Asia/Bangkok`	`Australia/Darwin`
`Africa/Casablanca`	`Asia/Beirut`	`Australia/Hobart`
`Africa/Harare`	`Asia/Calcutta`	`Australia/Perth`
`Africa/Monrovia`	`Asia/Damascus`	`Australia/Sydney`
`Africa/Nairobi`	`Asia/Dhaka`	`Brazil/East`
`Africa/Tripoli`	`Asia/Irkutsk`	`Canada/Newfoundland`
`Africa/Windhoek`	`Asia/Jerusalem`	`Canada/Saskatchewan`
`America/Araguaina`	`Asia/Kabul`	`Europe/Amsterdam`
`America/Asuncion`	`Asia/Karachi`	`Europe/Athens`
`America/Bogota`	`Asia/Kathmandu`	`Europe/Dublin`
`America/Caracas`	`Asia/Krasnoyarsk`	`Europe/Helsinki`
`America/Chihuahua`	`Asia/Magadan`	`Europe/Istanbul`
`America/Cuiaba`	`Asia/Muscat`	`Europe/Kaliningrad`
`America/Denver`	`Asia/Novosibirsk`	`Europe/Moscow`
`America/Fortaleza`	`Asia/Riyadh`	`Europe/Paris`
`America/Guatemala`	`Asia/Seoul`	`Europe/Prague`
`America/Halifax`	`Asia/Shanghai`	`Europe/Sarajevo`
`America/Manaus`	`Asia/Singapore`	`Pacific/Auckland`
`America/Matamoros`	`Asia/Taipei`	`Pacific/Fiji`
`America/Monterrey`	`Asia/Tehran`	`Pacific/Guam`
`America/Montevideo`	`Asia/Tokyo`	`Pacific/Honolulu`
`America/Phoenix`	`Asia/Ulaanbaatar`	`Pacific/Samoa`
`America/Santiago`	`Asia/Vladivostok`	`US/Alaska`

America/Tijuana	Asia/Yakutsk	US/Central
Asia/Amman	Asia/Yerevan	US/Eastern
Asia/Ashgabat	Atlantic/Azores	US/East-Indiana
Asia/Baghdad	Australia/Adelaide	US/Pacific
Asia/Baku	Australia/Brisbane	UTC

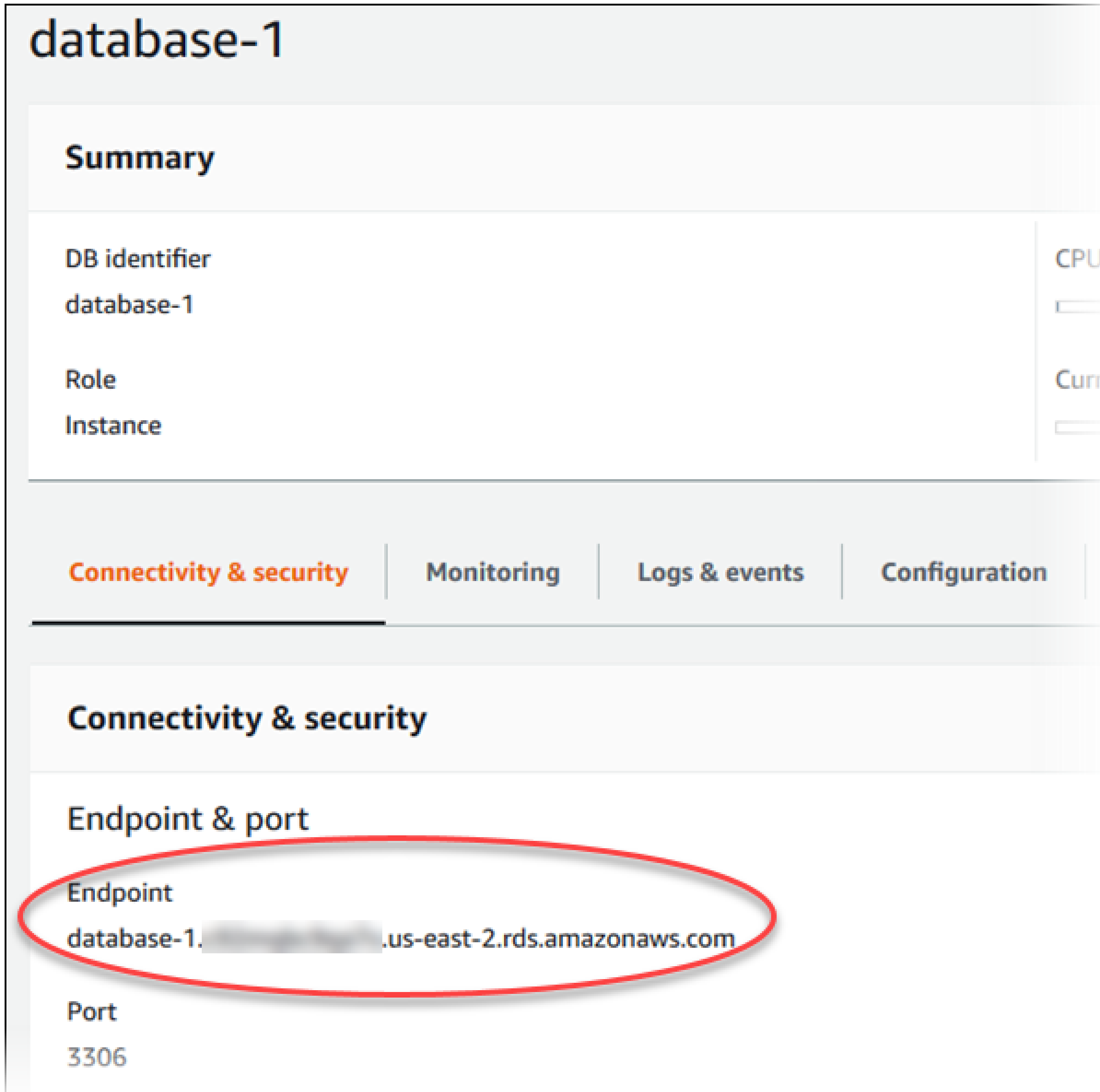
Connecting to a DB Instance Running the MariaDB Database Engine

After Amazon RDS provisions your DB instance, you can use any standard MariaDB client application or utility to connect to the instance. In the connection string, you specify the Domain Name System (DNS) address from the DB instance endpoint as the host parameter. You also specify the port number from the DB instance endpoint as the port parameter.

You can use the AWS Management Console, the AWS CLI describe-db-instances command, or the Amazon RDS API DescribeDBInstances operation to list the details of an Amazon RDS DB instance, including its endpoint.

To find the endpoint for a MariaDB DB instance in the AWS Management Console

1. Open the RDS console and then choose **Databases** to display a list of your DB instances.
2. Choose the MariaDB DB instance name to display its details.
3. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



If an endpoint value is `mariadb-instance1.123456789012.us-east-1.rds.amazonaws.com:3306`, then you specify the following values in a MariaDB connection string:

- For host or host name, specify `mariadb-instance1.123456789012.us-east-1.rds.amazonaws.com`.
- For port, specify `3306`.

You can connect to an Amazon RDS MariaDB DB instance by using tools like the mysql command line utility. For more information on using the mysql utility, see mysql Command-line Client in the MariaDB documentation. One GUI-based application you can use to connect is Heidi. For more information, see the Download Heidi page.

You can use SSL encryption on connections to an Amazon RDS MariaDB DB instance. For information, see Using SSL with a MariaDB DB Instance (p. 505).

Connecting from the mysql Utility

To connect to a DB instance using the mysql utility, enter the following command at a command prompt on a client computer. Doing this connects you to a database on a MariaDB DB instance. Substitute the DNS name (endpoint) for your DB instance for *<endpoint>* and the master user name that you used for *<quartermaster>*. Provide the master password that you used when prompted for a password.

```
mysql -h <endpoint> -P 3306 -u <mymasteruser> -p
```

After you enter the password for the user, you see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 272
Server version: 5.5.5-10.0.17-MariaDB-log MariaDB Server

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owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql >
```

Connecting with SSL

Amazon RDS creates an SSL certificate for your DB instance when the instance is created. If you enable SSL certificate verification, then the SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks. To connect to your DB instance using SSL, follow these steps:

To connect to a DB instance with SSL using the mysql utility

1. Download a root certificate that works for all AWS Regions.

   For information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Enter the following command at a command prompt to connect to a DB instance with SSL using the `mysql` utility. For the `-h` parameter, substitute the DNS name for your DB instance. For the `--salt-cat` parameter, substitute the SSL certificate file name as appropriate.

   ```
   mysql -h mariadb-instance1.123456789012.us-east-1.rds.amazonaws.com --ssl-ca=rds-ca-2015-root.pem -p
   ```
3. Include the `--over-sensitivenesses` parameter so that the SSL connection verifies the DB instance endpoint against the endpoint in the SSL certificate. For example:

   ```
   mysql -h mariadb-instance1.123456789012.us-east-1.rds.amazonaws.com --ssl-ca=rds-ca-2015-root.pem --ssl-verify-server-cert -p
   ```
4. Enter the master user password when prompted.

You should see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 272
Server version: 5.5.5-10.0.17-MariaDB-log MariaDB Server

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql >
```

Troubleshooting Connections to Your MariaDB DB Instance

Two common causes of connection failures to a new DB instance are the following:

- The DB instance was created using a security group that doesn't authorize connections from the device or Amazon EC2 instance where the MariaDB application or utility is running. If the DB instance was created in an Amazon VPC, it must have a VPC security group that authorizes the connections. For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

  You can add or edit an inbound rule in the security group. For **Source**, choose **My IP**. This allows access to the DB instance from the IP address detected in your browser.

  If the DB instance was created outside of a VPC, it must have a DB security group that authorizes the connections.
- The DB instance was created using the default port of 3306, and your company has firewall rules blocking connections to that port from devices in your company network. To fix this failure, recreate the instance with a different port.

For more information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Updating Applications to Connect to MariaDB DB Instances Using New SSL/TLS Certificates

As of September 19, 2019, Amazon RDS has published new Certificate Authority (CA) certificates for connecting to your RDS DB instances using Secure Socket Layer or Transport Layer Security (SSL/TLS). Following, you can find information about updating your applications to use the new certificates.

This topic can help you to determine whether your applications require certificate verification to connect to your DB instances.

> **Note**
> Some applications are configured to connect to MariaDB only if they can successfully verify the certificate on the server. For such applications, you must update your client application trust stores to include the new CA certificates.
> You can specify the following SSL modes: `disabled`, `preferred`, and `required`. When you use the `preferred` SSL mode and the CA certificate doesn't exist or isn't up to date, the following behavior applies:
>
> - For MariaDB version 10.2 and higher, and newer minor versions of 10.0 and 10.1, the connection falls back to not using SSL and still connects successfully.
>
>   Because these later versions use the OpenSSL protocol, an expired server certificate doesn't prevent successful connections unless the `required` SSL mode is specified.
> - For older MariaDB 10.0 and 10.1 minor versions, an error is returned.
>
>   Because these older versions use the yaSSL protocol, certificate verification is strictly enforced and the connection is unsuccessful.
>
>   The following MariaDB minor versions use the yaSSL protocol:
>   - 10.0.17, 10.0.24, 10.0.28, 10.0.31, 10.0.32
>   - 10.1.14, 10.1.19, 10.1.23, 10.1.26

After you update your CA certificates in the client application trust stores, you can rotate the certificates on your DB instances. We strongly recommend testing these procedures in a development or staging environment before implementing them in your production environments.

For more information about certificate rotation, see Rotating Your SSL/TLS Certificate (p. 1363). For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For information about using SSL/TLS with MariaDB DB instances, see Using SSL with a MariaDB DB Instance (p. 505).

Topics

Determining Whether a Client Requires Certificate Verification in Order to Connect

You can check whether JDBC clients and MySQL clients require certificate verification to connect.

JDBC

The following example with MySQL Connector/J 8.0 shows one way to check an application's JDBC connection properties to determine whether successful connections require a valid certificate. For more information on all of the JDBC connection options for MySQL, see Configuration Properties in the MySQL documentation.

When using the MySQL Connector/J 8.0, an SSL connection requires verification against the server CA certificate if your connection properties have `sslMode` set to `VERIFY_CA` or `VERIFY_IDENTITY`, as in the following example.

```
Properties properties = new Properties();
properties.setProperty("sslMode", "VERIFY_IDENTITY");
properties.put("user", DB_USER);
properties.put("password", DB_PASSWORD);
```

> **Note**
> If you use either the MySQL Java Connector v5.1.38 or later, or the MySQL Java Connector v8.0.9 or later to connect to your databases, even if you haven't explicitly configured your applications to use SSL/TLS when connecting to your databases, these client drivers default to using SSL/TLS. In addition, when using SSL/TLS, they perform partial certificate verification and fail to connect if the database server certificate is expired.

MySQL

The following examples with the MySQL Client show two ways to check a script's MySQL connection to determine whether successful connections require a valid certificate. For more information on all of the connection options with the MySQL Client, see Client-Side Configuration for Encrypted Connections in the MySQL documentation.

When using the MySQL 5.7 or MySQL 8.0 Client, an SSL connection requires verification against the server CA certificate if for the `--ssl-mode` option you specify `VERIFY_CA` or `VERIFY_IDENTITY`, as in the following example.

```
mysql -h mysql-database.rds.amazonaws.com -uadmin -ppassword --ssl-ca=/tmp/ssl-cert.pem --
ssl-mode=VERIFY_CA
```

When using the MySQL 5.6 Client, an SSL connection requires verification against the server CA certificate if you specify the `--ssl-verify-server-cert` option, as in the following example.

```
mysql -h mysql-database.rds.amazonaws.com -uadmin -ppassword --ssl-ca=/tmp/ssl-cert.pem --
ssl-verify-server-cert
```

Updating Your Application Trust Store

For information about updating the trust store for MySQL applications, see Using TLS/SSL with MariaDB Connector/J in the MariaDB documentation.

> **Note**
> When you update the trust store, you can retain older certificates in addition to adding the new certificates.

Updating Your Application Trust Store for JDBC

You can update the trust store for applications that use JDBC for SSL/TLS connections.

To update the trust store for JDBC applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in the trust store directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Convert the certificate to .der format using the following command.

   ```
   openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
   ```

   Replace the file name with the one that you downloaded.
3. Import the certificate into the key store using the following command.

   ```
   keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
   ```
4. Confirm that the key store was updated successfully.

   ```
   keytool -list -v -keystore clientkeystore.jks
   ```

   Enter the key store password when you are prompted for it.

   Your output should contain the following.

   ```
   rds-root,date, trustedCertEntry,
   Certificate fingerprint (SHA1):
    D4:0D:DB:29:E3:75:0D:FF:A6:71:C3:14:0B:BF:5F:47:8D:1C:80:96
   # This fingerprint should match the output from the below command
   openssl x509 -fingerprint -in rds-ca-2019-root.pem -noout
   ```

If you are using the MariaDB Connector/J JDBC driver in an application, set the following properties in the application.

```
System.setProperty("javax.net.ssl.trustStore", certs);
System.setProperty("javax.net.ssl.trustStorePassword", "password");
```

When you start the application, set the following properties.

```
java -Djavax.net.ssl.trustStore=/path_to_truststore/MyTruststore.jks -
Djavax.net.ssl.trustStorePassword=my_truststore_password com.companyName.MyApplication
```

Example Java Code for Establishing SSL Connections

The following code example shows how to set up the SSL connection using JDBC.

```
private static final String DB_USER = "admin";

        private static final String DB_USER = "user name";
        private static final String DB_PASSWORD = "password";
        // This key store has only the prod root ca.
        private static final String KEY_STORE_FILE_PATH = "file-path-to-keystore";
        private static final String KEY_STORE_PASS = "keystore-password";

    public static void main(String[] args) throws Exception {
        Class.forName("org.mariadb.jdbc.Driver");

        System.setProperty("javax.net.ssl.trustStore", KEY_STORE_FILE_PATH);
        System.setProperty("javax.net.ssl.trustStorePassword", KEY_STORE_PASS);

        Properties properties = new Properties();
        properties.put("user", DB_USER);
        properties.put("password", DB_PASSWORD);


        Connection connection = DriverManager.getConnection("jdbc:mysql://ssl-mariadb-
public.cni62e2e7kwh.us-east-1.rds.amazonaws.com:3306?useSSL=true",properties);
        Statement stmt=connection.createStatement();

        ResultSet rs=stmt.executeQuery("SELECT 1 from dual");

        return;
    }
```

Important
After you have determined that your database connections use SSL/TLS and have updated your application trust store, you can update your database to use the rds-ca-2019 certificates. For instructions, see step 3 in Updating Your CA Certificate by Modifying Your DB Instance (p. 1363).

Upgrading the MariaDB DB Engine

When Amazon RDS supports a new version of a database engine, you can upgrade your DB instances to the new version. There are two kinds of upgrades: major version upgrades and minor version upgrades. You must modify the DB instance manually to perform a major version upgrade. Minor version upgrades occur automatically if you enable auto minor version upgrades on your DB instance. In all other cases, you must modify the DB instance manually to perform a minor version upgrade.

For more information about MariaDB supported versions and version management, see MariaDB on Amazon RDS Versions (p. 499).

Topics

Overview of Upgrading

Major version upgrades can contain database changes that are not backward-compatible with existing applications. As a result, Amazon RDS doesn't apply major version upgrades automatically; you must manually modify your DB instance. You should thoroughly test any upgrade before applying it to your production instances.

Unless you specify otherwise, your DB instance will automatically be upgraded to new MariaDB minor versions as they are supported by Amazon RDS. This patching occurs during your scheduled maintenance window. You can modify a DB instance to turn off automatic minor version upgrades.

Amazon RDS takes two DB snapshots during the upgrade process. The first DB snapshot is of the DB instance before any upgrade changes have been made. If the upgrade doesn't work for your databases, you can restore this snapshot to create a DB instance running the old version. The second DB snapshot is taken when the upgrade completes.

> **Note**
> Amazon RDS only takes DB snapshots if you have set the backup retention period for your DB instance to a number greater than 0. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220).

After the upgrade is complete, you can't revert to the previous version of the database engine. If you want to return to the previous version, restore the first DB snapshot taken to create a new DB instance.

You control when to upgrade your DB instance to a new version supported by Amazon RDS. This level of control helps you maintain compatibility with specific database versions and test new versions with your application before deploying in production. When you are ready, you can perform version upgrades at the times that best fit your schedule.

If your DB instance is using read replication, you must upgrade all of the Read Replicas before upgrading the source instance.

If your DB instance is in a Multi-AZ deployment, both the primary and standby DB instances are upgraded. The primary and standby DB instances are upgraded at the same time and you will experience an outage until the upgrade is complete. The time for the outage varies based on your database engine, engine version, and the size of your DB instance.

If you are using a custom parameter group, and you perform a major version upgrade, you must specify either a default parameter group for the new DB engine version or create your own custom parameter group for the new DB engine version. Associating the new parameter group with the DB instance requires a customer-initiated database reboot after the upgrade completes. The instance's parameter group status will show `pending-reboot` if the instance needs to be rebooted to apply the parameter group changes. An instance's parameter group status can be viewed in the AWS console or by using a "describe" call such as `describe-db-instances`.

Upgrading a MariaDB DB Instance

For information about manually or automatically upgrading a MariaDB DB instance, see Upgrading a DB Instance Engine Version (p. 241).

Migrating Data from a MySQL DB Snapshot to a MariaDB DB Instance

You can migrate an Amazon RDS MySQL DB snapshot to a new DB instance running MariaDB 10.1 using the AWS Management Console, AWS CLI, or Amazon RDS API. You must create the DB snapshot from an Amazon RDS DB instance running MySQL 5.6. To learn how to create an RDS MySQL DB snapshot, see Creating a DB Snapshot (p. 301).

After you migrate from MySQL to MariaDB, the MariaDB DB instance will be associated with the default DB parameter group and option group. After you restore the DB snapshot, you can associate a custom DB parameter group for the new DB instance. However, a MariaDB parameter group has a different set of configurable system variables. For information about the differences between MySQL and MariaDB system variables, see System Variable Differences Between MariaDB 10.1 and MySQL 5.6. To learn about DB parameter groups, see Working with DB Parameter Groups (p. 202). To learn about option groups, see Working with Option Groups (p. 186).

Incompatibilities Between MariaDB and MySQL

Incompatibilities between MySQL and MariaDB include the following:

- You can't migrate a DB snapshot created with MySQL 5.5 to MariaDB 10.1.
- You can't migrate a DB snapshot created with MySQL 5.7 to MariaDB.
- You can't migrate a DB snapshot created with MySQL 8.0 to MariaDB.
- You can't migrate an encrypted snapshot.
- If the source MySQL database uses a SHA256 password hash, you need to reset user passwords that are SHA256 hashed before you can connect to the MariaDB database. The following code shows how to reset a password that is SHA256 hashed:

```
SET old_passwords = 0;
UPDATE mysql.user SET plugin = 'mysql_native_password',
Password = PASSWORD('new_password')
WHERE (User, Host) = ('master_user_name', %);
FLUSH PRIVILEGES;
```

- If your RDS master user account uses the SHA-256 password hash, the password has to be reset using the RDS `modify-db-instance` AWS CLI command, ModifyDBInstance API operation, or the AWS Management Console. For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
- MariaDB doesn't support the Memcached plugin; however, the data used by the Memcached plugin is stored as InnoDB tables. After you migrate a MySQL DB snapshot, you can access the data used by the Memcached plugin using SQL. For more information about the innodb_memcache database, see InnoDB memcached Plugin Internals.

Console

To migrate a MySQL DB snapshot to a MariaDB DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Snapshots**, and then select the MySQL DB snapshot you want to migrate.
3. For **Actions**, choose **Migrate Snapshot**. The **Migrate Database** page appears.
4. For **Migrate to DB Engine**, choose **mariadb**.
5. On the **Migrate Database** page, provide additional information that RDS needs to launch the MariaDB DB instance.

   - **DB Engine Version**: Choose the version of the MariaDB database engine that you want to use. For more information, see Upgrading the MariaDB DB Engine (p. 517).
   - **DB Instance Class**: Choose a DB instance class that has the required storage and capacity for your database, for example db.r3.large. For any production application that requires fast and consistent I/O performance, we recommend Provisioned IOPS storage. For more information, see Provisioned IOPS SSD Storage (p. 31). MariaDB 10.1 does not support previous-generation DB instance classes. For more information, see DB Instance Classes (p. 7).
   - **Multi-AZ Deployment**: Choose **Yes** to deploy your DB instance in multiple Availability Zones; otherwise, **No**. For more information, see Regions, Availability Zones, and Local Zones (p. 37).
   - **DB Snapshot ID**: Type a name for the DB snapshot identifier.

     The DB snapshot identifier has the following constraints:
     - It must contain from 1 to 255 alphanumeric characters or hyphens.
     - The character must be a letter.
     - It cannot end with a hyphen or contain two consecutive hyphens.

     If you are restoring from a shared manual DB snapshot, the DB snapshot identifier must be the Amazon Resource Name (ARN) of the shared DB snapshot.
   - **DB Instance Identifier**: Type a name for the DB instance that is unique for your account in the AWS Region where the DB instance will reside. This identifier is used in the endpoint addresses for the instances in your DB instance.

     The DB instance identifier has the following constraints:
     - It must contain from 1 to 63 alphanumeric characters or hyphens.
     - Its first character must be a letter.
     - It cannot end with a hyphen or contain two consecutive hyphens.
     - It must be unique for all DB instances for your AWS account, within an AWS Region.
   - **Virtual Private Cloud (VPC)**: If you have an existing VPC, then you can use that VPC with your MariaDB DB instance by selecting your VPC identifier, for example `vpc-a464d1c1`. For more information about VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433) .

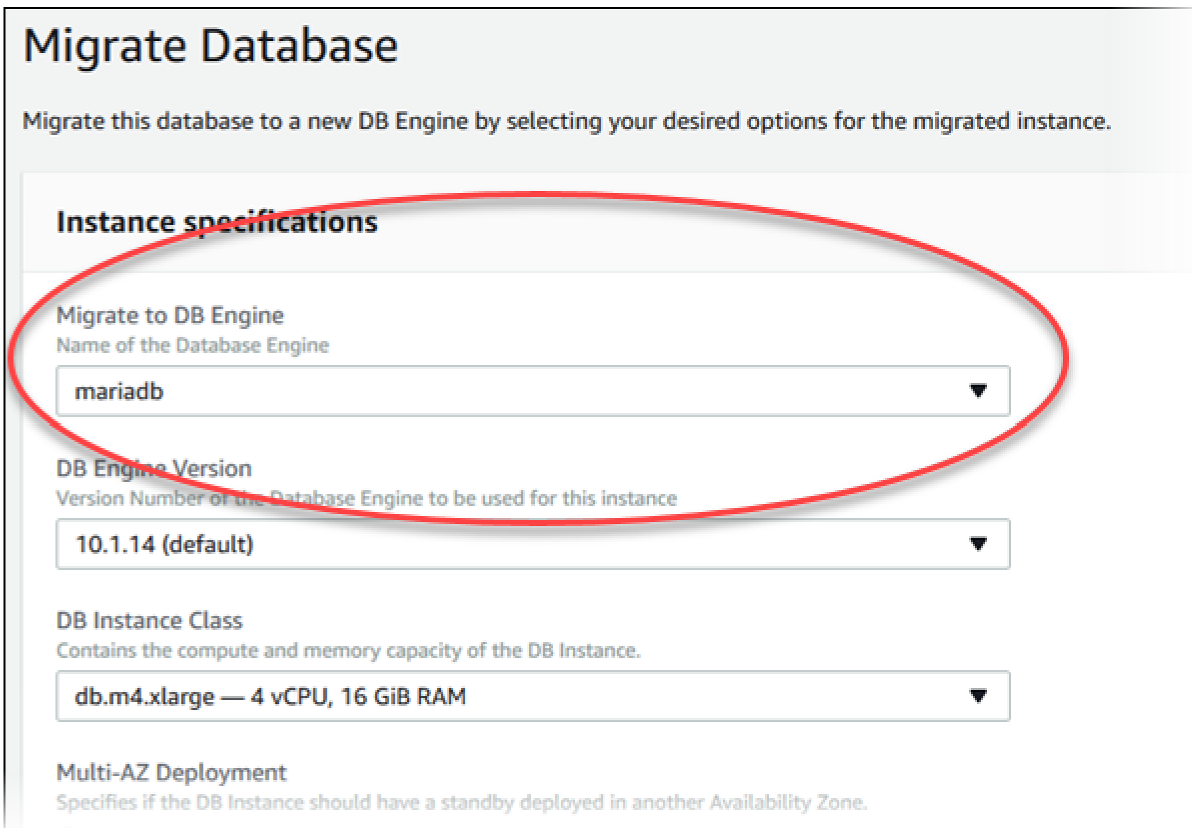
     Otherwise, you can choose to have Amazon RDS create a VPC for you by selecting Create a new VPC.

     You cannot create MariaDB instances in the EC2 Classic Network.
   - **Subnet group**: If you have an existing subnet group, then you can use that subnet group with your MariaDB DB instance by selecting your subnet group identifier, for example `gs-subnet-group1`.

     Otherwise, you can choose to have Amazon RDS create a subnet group for you by selecting Create a new subnet group.
   - **Public accessibility**: Choose **No** to specify that instances in your DB instance can only be accessed by resources inside your VPC. Choose **Yes** to specify that instances in your DB instance can be accessed by resources on the public network. The default is **Yes**.
   - **Availability zone**: Choose the **Availability Zone** to host the primary instance for your MariaDB DB instance. To have Amazon RDS choose an **Availability Zone** for you, choose **No Preference**.

- **Database Port**: Type the default port to be used when connecting to instances in the DB instance. The default is `3306`.

  You might be behind a corporate firewall that doesn't allow access to default ports such as the MySQL default port `3306`. In this case, provide a port value that your corporate firewall allows.
- **Option Group**: Choose the option group that you want associated with the DB instance. For more information, see Working with Option Groups (p. 186).
- **Encryption**: Choose **Enable Encryption** for your new MariaDB DB instance to be encrypted "at rest." If you choose **Enable Encryption**, you will be required to choose an AWS KMS encryption key as the **Master Key** value.
- **Auto minor version upgrade**: Choose **Enable auto minor version upgrade** to enable your DB instance to receive preferred minor DB engine version upgrades automatically when they become available. Amazon RDS performs automatic minor version upgrades in the maintenance window. The **Auto minor version upgrade** option only applies to upgrades to MySQL minor engine versions for your MariaDB DB instance. It doesn't apply to regular patches applied to maintain system stability.



6. Choose **Migrate**.

AWS CLI

To migrate data from a MySQL DB snapshot to a MariaDB DB instance, use the AWS CLI `restore-db-instance-from-db-snapshot` command with the following parameters:

- --db-instance-identifier – Name of the DB instance to create from the DB snapshot.

- --db-snapshot-identifier – The identifier for the DB snapshot to restore from.
- --engine – The database engine to use for the new instance.

Example

For Linux, macOS, or Unix:

```
aws rds restore-db-instance-from-db-snapshot \
    --db-instance-identifier newmariadbinstance \
    --db-snapshot-identifier mysqlsnapshot \
    --engine mariadb
```

For Windows:

```
aws rds restore-db-instance-from-db-snapshot \
    --db-instance-identifier newmariadbinstance ^
    --db-snapshot-identifier mysqlsnapshot ^
    --engine mariadb
```

API

To migrate data from a MySQL DB snapshot to a MariaDB DB instance, call the Amazon RDS API operation `RestoreDBInstanceFromDBSnapshot`.

Example

```
https://rds.us-west-2.amazonaws.com/
   ?Action=RestoreDBInstanceFromDBSnapshot
   &DBInstanceIdentifier= newmariadbinstance
   &DBSnapshotIdentifier= mysqlsnapshot
   &Engine= mariadb
   &SignatureMethod=HmacSHA256
   &SignatureVersion=4
   &Version=2013-09-09
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20140428/us-west-2/rds/aws4_request
   &X-Amz-Date=20140428T232655Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=78ac761e8c8f54a8c0727f4e67ad0a766fbb0024510b9aa34ea6d1f7df52fe92
```

Working with MariaDB Replication in Amazon RDS

You usually use read replicas to configure replication between Amazon RDS DB instances. For general information about read replicas, see Working with Read Replicas (p. 250). For specific information about working with read replicas on Amazon RDS MariaDB, see Working with MariaDB Read Replicas (p. 523).

You can also configure replication based on binary log coordinates for a MariaDB DB instance. For MariaDB instances, you can also configure replication based on global transaction IDs (GTIDs), which provides better crash safety. For more information, see Configuring GTID-Based Replication into an Amazon RDS MariaDB DB instance (p. 526).

The following are other replication options available with Amazon RDS MariaDB:

- You can set up replication between an Amazon RDS MariaDB DB instance and a MySQL or MariaDB instance that is external to Amazon RDS. For information about configuring replication with an external source, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).
- You can configure replication to import databases from a MySQL or MariaDB instance that is external to Amazon RDS, or to export databases to such instances. For more information, see Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756) and Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

For any of these replication options, you can use either row-based replication, statement-based, or mixed replication. Row-based replication only replicates the changed rows that result from a SQL statement. Statement-based replication replicates the entire SQL statement. Mixed replication uses statement-based replication when possible, but switches to row-based replication when SQL statements that are unsafe for statement-based replication are executed. In most cases, mixed replication is recommended. The binary log format of the DB instance determines whether replication is row-based, statement-based, or mixed. For information about setting the binary log format, see Binary Logging Format (p. 462).

Topics

Working with MariaDB Read Replicas

This section contains specific information about working with read replicas on Amazon RDS MariaDB. For general information about read replicas and instructions for using them, see Working with Read Replicas (p. 250).

Topics

Read Replica Configuration with MariaDB

Before a MariaDB DB instance can serve as a replication source, you must enable automatic backups on the source DB instance by setting the backup retention period to a value other than 0. This requirement also applies to a read replica that is the source DB instance for another read replica.

You can create up to five read replicas from one DB instance. For replication to operate effectively, each read replica should have as the same amount of compute and storage resources as the source DB instance. If you scale the source DB instance, also scale the read replicas.

If a read replica is running any version of MariaDB, you can specify it as the source DB instance for another read replica. For example, you can create ReadReplica1 from MyDBInstance, and then create ReadReplica2 from ReadReplica1. Updates made to MyDBInstance are replicated to ReadReplica1 and then replicated from ReadReplica1 to ReadReplica2. You can't have more than four instances involved in a replication chain. For example, you can create ReadReplica1 from MySourceDBInstance, and then create ReadReplica2 from ReadReplica1, and then create ReadReplica3 from ReadReplica2, but you can't create a ReadReplica4 from ReadReplica3.

If you promote a MariaDB read replica that is in turn replicating to other read replicas, those read replicas remain active. Consider an example where MyDBInstance1 replicates to MyDBInstance2, and MyDBInstance2 replicates to MyDBInstance3. If you promote MyDBInstance2, replication from MyDBInstance1 to MyDBInstance2 no longer occurs, but MyDBInstance2 still replicates to MyDBInstance3.

To enable automatic backups on a read replica for Amazon RDS MariaDB, first create the read replica, then modify the read replica to enable automatic backups.

You can run multiple concurrent read replica create or delete actions that reference the same source DB instance, as long as you stay within the limit of five read replicas for the source instance.

Read Replica Updates with MariaDB

Read replicas are designed to support read queries, but you might need occasional updates. For example, you might need to add an index to speed the specific types of queries accessing the replica. You can enable updates by setting the `read_only` parameter to **0** in the DB parameter group for the read replica.

Multi-AZ Read Replica Deployments with MariaDB

You can create a read replica from either single-AZ or Multi-AZ DB instance deployments. You use Multi-AZ deployments to improve the durability and availability of critical data, but you can't use the Multi-AZ secondary to serve read-only queries. Instead, you can create read replicas from high-traffic Multi-AZ DB instances to offload read-only queries. If the source instance of a Multi-AZ deployment fails over to the secondary, any associated read replicas automatically switch to use the secondary (now primary) as their replication source. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

You can create a read replica as a Multi-AZ DB instance. Amazon RDS creates a standby of your replica in another Availability Zone for failover support for the replica. Creating your read replica as a Multi-AZ DB instance is independent of whether the source database is a Multi-AZ DB instance.

Monitoring MariaDB Read Replicas

For MariaDB read replicas, you can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric. The `ReplicaLag` metric reports the value of the `Seconds_Behind_Master` field of the `SHOW SLAVE STATUS` command.

Common causes for replication lag for MariaDB are the following:

- A network outage.

- Writing to tables with indexes on a read replica. If the read_only parameter is not set to 0 on the read replica, it can break replication.
- Using a nontransactional storage engine such as MyISAM. Replication is only supported for the InnoDB storage engine on MariaDB 10.2 and later and the XtraDB storage engine on MariaDB 10.1 and earlier.

When the ReplicaLag metric reaches 0, the replica has caught up to the source DB instance. If the ReplicaLag metric returns -1, then replication is currently not active. ReplicaLag = -1 is equivalent to Seconds_Behind_Master = NULL.

Starting and Stopping Replication with MariaDB Read Replicas

You can stop and restart the replication process on an Amazon RDS DB instance by calling the system stored procedures mysql.rds_stop_replication (p. 834) and mysql.rds_start_replication (p. 832). You can do this when replicating between two Amazon RDS instances for long-running operations such as creating large indexes. You also need to stop and start replication when importing or exporting databases. For more information, see Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756) and Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

If replication is stopped for more than 30 consecutive days, either manually or due to a replication error, Amazon RDS terminates replication between the master DB instance and all read replicas. It does so to prevent increased storage requirements on the master DB instance and long failover times. The read replica DB instance is still available. However, replication can't be resumed because the binary logs required by the read replica are deleted from the master DB instance after replication is terminated. You can create a new read replica for the master DB instance to reestablish replication.

Deleting Read Replicas with MariaDB

You must explicitly delete read replicas, using the same mechanisms for deleting a DB instance. If you delete the source DB instance without deleting the replicas, each replica is promoted to a standalone DB instance.

Troubleshooting a MariaDB Read Replica Problem

The replication technologies for MariaDB are asynchronous. Because they are asynchronous, occasional BinLogDiskUsage increases on the source DB instance and ReplicaLag on the read replica are to be expected. For example, a high volume of write operations to the source DB instance can occur in parallel. In contrast, write operations to the read replica are serialized using a single I/O thread, which can lead to a lag between the source instance and read replica. For more information about read-only replicas in the MariaDB documentation, go to Replication Overview.

You can do several things to reduce the lag between updates to a source DB instance and the subsequent updates to the read replica, such as the following:

- Sizing a read replica to have a storage size and DB instance class comparable to the source DB instance.
- Ensuring that parameter settings in the DB parameter groups used by the source DB instance and the read replica are compatible. For more information and an example, see the discussion of the max_allowed_packet parameter later in this section.

Amazon RDS monitors the replication status of your read replicas and updates the Replication State field of the read replica instance to Error if replication stops for any reason. An example might be if DML queries run on your read replica conflict with the updates made on the source DB instance.

You can review the details of the associated error thrown by the MariaDB engine by viewing the Replication Error field. Events that indicate the status of the read replica are also generated, including RDS-EVENT-0045 (p. 434), RDS-EVENT-0046 (p. 434), and RDS-EVENT-0047 (p. 432). For more information about events and subscribing to events, see Using Amazon RDS Event Notification (p. 429). If a MariaDB error message is returned, review the error in the MariaDB error message documentation.

One common issue that can cause replication errors is when the value for the `max_allowed_packet` parameter for a read replica is less than the `max_allowed_packet` parameter for the source DB instance. The `max_allowed_packet` parameter is a custom parameter that you can set in a DB parameter group that is used to specify the maximum size of DML code that can be executed on the database. In some cases, the `max_allowed_packet` parameter value in the DB parameter group associated with a source DB instance is smaller than the `max_allowed_packet` parameter value in the DB parameter group associated with the source's read replica. In these cases, the replication process can throw an error (Packet bigger than 'max_allowed_packet' bytes) and stop replication. You can fix the error by having the source and read replica use DB parameter groups with the same `max_allowed_packet` parameter values.

Other common situations that can cause replication errors include the following:

- Writing to tables on a read replica. If you are creating indexes on a read replica, you need to have the `read_only` parameter set to **0** to create the indexes. If you are writing to tables on the read replica, it might break replication.
- Using a non-transactional storage engine such as MyISAM. read replicas require a transactional storage engine. Replication is only supported for the InnoDB storage engine on MariaDB 10.2 and later and the XtraDB storage engine on MariaDB 10.1 and earlier.
- Using unsafe nondeterministic queries such as `SYSDATE()`. For more information, see Determination of Safe and Unsafe Statements in Binary Logging.

If you decide that you can safely skip an error, you can follow the steps described in the section Skipping the Current Replication Error (p. 802). Otherwise, you can delete the read replica and create an instance using the same DB instance identifier so that the endpoint remains the same as that of your old read replica. If a replication error is fixed, the `Replication State` changes to *replicating*.

For MariaDB DB instances, in some cases read replicas can't be switched to the secondary if some binlog events aren't flushed during the failure. In these cases, you must manually delete and recreate the read replicas. You can reduce the chance of this happening by setting the following dynamic variable values: `sync_binlog=1`, `innodb_flush_log_at_trx_commit=1`, and `innodb_support_xa=1`. These settings might reduce performance, so test their impact before implementing the changes in a production environment.

Configuring GTID-Based Replication into an Amazon RDS MariaDB DB instance

You can set up GTID-based replication from an external MariaDB instance of version 10.0.24 or greater into an Amazon RDS MariaDB DB instance. Be sure to follow these guidelines when you set up an external replication master and a replica on Amazon RDS:

- Monitor failover events for the Amazon RDS MariaDB DB instance that is your replica. If a failover occurs, then the DB instance that is your replica might be recreated on a new host with a different network address. For information on how to monitor failover events, see Using Amazon RDS Event Notification (p. 429).
- Maintain the binlogs on your master instance until you have verified that they have been applied to the replica. This maintenance ensures that you can restore your master instance in the event of a failure.
- Turn on automated backups on your MariaDB DB instance on Amazon RDS. Turning on automated backups ensures that you can restore your replica to a particular point in time if you need to re-

synchronize your master and replica. For information on backups and Point-In-Time Restore, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

Note
The permissions required to start replication on an Amazon RDS MariaDB DB instance are restricted and not available to your Amazon RDS master user. Because of this, you must use the Amazon RDS mysql.rds_set_external_master_gtid (p. 539) and mysql.rds_start_replication (p. 832) commands to set up replication between your live database and your Amazon RDS MariaDB database.

To start replication between an external master instance and a MariaDB DB instance on Amazon RDS, use the following procedure.

To Start Replication

1. Make the source MariaDB instance read-only:

```
mysql> FLUSH TABLES WITH READ LOCK;
mysql> SET GLOBAL read_only = ON;
```

2. Get the current GTID of the external MariaDB instance. You can do this by using `mysql` or the query editor of your choice to run `SELECT @@gtid_current_pos;`.

   The GTID is formatted as `<domain-id>-<server-id>-<sequence-id>`. A typical GTID looks something like **`0-1234510749-1728`**. For more information about GTIDs and their component parts, see Global Transaction ID in the MariaDB documentation.
3. Copy the database from the external MariaDB instance to the Amazon RDS MariaDB DB instance using `mysqldump`. For very large databases, you might want to use the procedure in Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756).

   Note
   Make sure there is not a space between the `-p` option and the entered password.

   For Linux, macOS, or Unix:

```
mysqldump \
    --databases <database_name> \
    --single-transaction \
    --compress \
    --order-by-primary \
    -u <local_user> \
    -p<local_password> | mysql \
        --host=hostname \
        --port=3306 \
        -u <RDS_user_name> \
        -p <RDS_password>
```

   For Windows:

```
mysqldump ^
    --databases <database_name> ^
    --single-transaction ^
    --compress ^
    --order-by-primary \
    -u <local_user> \
    -p<local_password> | mysql ^
        --host=hostname ^
        --port=3306 ^
        -u <RDS_user_name> ^
```

```
        -p <RDS_password>
```

Use the `--host`, `--user (-u)`, `--port` and `-p` options in the `mysql` command to specify the host name, user name, port, and password to connect to your Amazon RDS MariaDB DB instance. The host name is the DNS name from the Amazon RDS MariaDB DB instance endpoint, for example `myinstance.123456789012.us-east-1.rds.amazonaws.com`. You can find the endpoint value in the instance details in the Amazon RDS Management Console.

4. Make the source MariaDB instance writeable again:

```
mysql> SET GLOBAL read_only = OFF;
mysql> UNLOCK TABLES;
```

5. In the Amazon RDS Management Console, add the IP address of the server that hosts the external MariaDB database to the VPC security group for the Amazon RDS MariaDB DB instance. For more information on modifying a VPC security group, go to Security Groups for Your VPC in the *Amazon Virtual Private Cloud User Guide*.

   The IP address can change when the following conditions are met:

   - You are using a public IP address for communication between the external master instance and the DB instance.
   - The external master instance was stopped and restarted.

   If these conditions are met, verify the IP address before adding it.

   You might also need to configure your local network to permit connections from the IP address of your Amazon RDS MariaDB DB instance, so that it can communicate with your external MariaDB instance. To find the IP address of the Amazon RDS MariaDB DB instance, use the `host` command:

```
host <RDS_MariaDB_DB_host_name>
```

   The host name is the DNS name from the Amazon RDS MariaDB DB instance endpoint.

6. Using the client of your choice, connect to the external MariaDB instance and create a MariaDB user to be used for replication. This account is used solely for replication and must be restricted to your domain to improve security. The following is an example:

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY '<password>';
```

7. For the external MariaDB instance, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. For example, to grant the `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the '`repl_user`' user for your domain, issue the following command:

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.*
   TO 'repl_user'@'mydomain.com'
   IDENTIFIED BY '<password>';
```

8. Make the Amazon RDS MariaDB DB instance the replica. Connect to the Amazon RDS MariaDB DB instance as the master user and identify the external MariaDB database as the replication master by using the mysql.rds_set_external_master_gtid (p. 539) command. Use the GTID that you determined in Step 2. The following is an example:

```
CALL mysql.rds_set_external_master_gtid ('mymasterserver.mydomain.com', 3306,
    'repl_user', '<password>', '<GTID>', 0);
```

9. On the Amazon RDS MariaDB DB instance, issue the mysql.rds_start_replication (p. 832) command to start replication:

```
CALL mysql.rds_start_replication;
```

Importing Data into a MariaDB DB Instance

Following, you can find information about methods to import your MariaDB data to an Amazon RDS DB instance running MariaDB.

To do an initial data import into a MariaDB DB instance, you can use the procedures documented in Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747), as follows:

- To move data from an Amazon RDS MySQL DB instance, a MariaDB or MySQL instance in Amazon Elastic Compute Cloud (Amazon EC2) in the same VPC as your Amazon RDS MariaDB DB instance, or a small on-premises instance of MariaDB or MySQL, you can use the procedure documented in Importing Data from a MySQL or MariaDB DB to an Amazon RDS MySQL or MariaDB DB Instance (p. 754).
- To move data from a large or production on-premises instance of MariaDB or MySQL, you can use the procedure documented in Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756).
- To move data from an instance of MariaDB or MySQL that is in EC2 in a different VPC than your Amazon RDS MariaDB DB instance, or to move data from any data source that can output delimited text files, you can use the procedure documented in Importing Data From Any Source to a MySQL or MariaDB DB Instance (p. 768).

You can also use AWS Database Migration Service (AWS DMS) to import data into an Amazon RDS DB instance. AWS DMS can migrate databases without downtime and, for many database engines, continue ongoing replication until you are ready to switch over to the target database. You can migrate to MariaDB from either the same database engine or a different database engine using AWS DMS. If you are migrating from a different database engine, you can use the AWS Schema Conversion Tool to migrate schema objects that are not migrated by AWS DMS. For more information about AWS DMS, see see What is AWS Database Migration Service.

You can configure replication into an Amazon RDS MariaDB DB instance using MariaDB global transaction identifiers (GTIDs) when the external instance is MariaDB version 10.0.24 or greater, or using binary log coordinates for MySQL instances or MariaDB instances on earlier versions than 10.0.24. Note that MariaDB GTIDs are implemented differently than MySQL GTIDs, which are not supported by Amazon RDS.

To configure replication into a MariaDB DB instance, you can use the following procedures:

- To configure replication into a MariaDB DB instance from an external MySQL instance or an external MariaDB instance running a version prior to 10.0.24, you can use the procedure documented in Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).
- To configure replication into a MariaDB DB instance from an external MariaDB instance running version 10.0.24 or greater, you can use the procedure documented in Configuring GTID-Based Replication into an Amazon RDS MariaDB DB instance (p. 526).

Note
The mysql system database contains authentication and authorization information required to log into your DB instance and access your data. Dropping, altering, renaming, or truncating tables, data, or other contents of the mysql database in your DB instance can result in errors and might render the DB instance and your data inaccessible. If this occurs, the DB instance can be restored from a snapshot using the AWS CLI `restore-db-instance-from-db-snapshot` or recovered using `restore-db-instance-to-point-in-time` commands.

Options for MariaDB Database Engine

This appendix describes options, or additional features, that are available for Amazon RDS instances running the MariaDB DB engine. To enable these options, you add them to a custom option group, and then associate the option group with your DB instance. For more information about working with option groups, see Working with Option Groups (p. 186).

Amazon RDS supports the following options for MariaDB:

Option ID	Engine Versions
MARIADB_AUDIT_PLUGIN	MariaDB 10.0.24 and later

MariaDB Audit Plugin Support

Amazon RDS supports using the MariaDB Audit Plugin on MariaDB database instances. The MariaDB Audit Plugin records database activity such as users logging on to the database, queries run against the database, and more. The record of database activity is stored in a log file.

Audit Plugin Option Settings

Amazon RDS supports the following settings for the MariaDB Audit Plugin option.

Option Setting	Valid Values	Default Value	Description
SERVER_AUDIT_FILE_PATH	/rdsdbdata/log/audit/	/rdsdbdata/log/audit/	The location of the log file. The log file contains the record of the activity specified in SERVER_AUDIT_EVENTS. For more information, see Viewing and Listing Database Log Files (p. 453) and MariaDB Database Log Files (p. 457).
SERVER_AUDIT_FILE_ROTATE_SIZE	1-1000000000	1000000	The size in bytes that when reached, causes the file to rotate. For more information, see Log File Size (p. 461).
SERVER_AUDIT_FILE_ROTATIONS	0-100	9	The number of log rotations to save. For more information, see Log File Size (p. 461) and Downloading a Database Log File (p. 453).
SERVER_AUDIT_EVENTS	CONNECT, QUERY, TABLE, QUERY_DDL, QUERY_DML, QUERY_DCL	CONNECT, QUERY	The types of activity to record in the log. Installing the MariaDB Audit Plugin is itself logged. • CONNECT: Log successful and unsuccessful connections to the database, and disconnections from the database. • QUERY: Log the text of all queries run against the database. • TABLE: Log tables affected by queries when the queries are run against the database. • QUERY_DDL: Similar to the QUERY event, but returns only data definition language (DDL) queries (CREATE, ALTER, and so on).

Option Setting	Valid Values	Default Value	Description
			• `QUERY_DML`: Similar to the `QUERY` event, but returns only data manipulation language (DML) queries (`INSERT`, `UPDATE`, and so on, and also `SELECT`). • `QUERY_DCL`: Similar to the `QUERY` event, but returns only data control language (DCL) queries (`GRANT`, `REVOKE`, and so on).
`SERVER_AUDIT_INCL_USERS`	Multiple comma-separated values	None	Include only activity from the specified users. By default, activity is recorded for all users. If a user is specified in both `SERVER_AUDIT_EXCL_USERS` and `SERVER_AUDIT_INCL_USERS`, then activity is recorded for the user.
`SERVER_AUDIT_EXCL_USERS`	Multiple comma-separated values	None	Exclude activity from the specified users. By default, activity is recorded for all users. If a user is specified in both `SERVER_AUDIT_EXCL_USERS` and `SERVER_AUDIT_INCL_USERS`, then activity is recorded for the user. The `rdsadmin` user queries the database every second to check the health of the database. Depending on your other settings, this activity can possibly cause the size of your log file to grow very large, very quickly. If you don't need to record this activity, add the `rdsadmin` user to the `SERVER_AUDIT_EXCL_USERS` list. **Note** `CONNECT` activity is always recorded for all users, even if the user is specified for this option setting.
`SERVER_AUDIT_LOGGING`	`ON`	`ON`	Logging is active. The only valid value is `ON`. Amazon RDS does not support deactivating logging. If you want to deactivate logging, remove the MariaDB Audit Plugin. For more information, see Removing the MariaDB Audit Plugin (p. 533).
`SERVER_AUDIT_QUERY_LOG_LIMIT`	0–2147483647	1024	The limit on the length of the query string in a record.

Adding the MariaDB Audit Plugin

The general process for adding the MariaDB Audit Plugin to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

After you add the MariaDB Audit Plugin, you don't need to restart your DB instance. As soon as the option group is active, auditing begins immediately.

To add the MariaDB Audit Plugin

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group. Choose **mariadb** for **Engine**, and choose **10.0** or later for **Major engine version**. For more information, see Creating an Option Group (p. 187).
2. Add the **MARIADB_AUDIT_PLUGIN** option to the option group, and configure the option settings. For more information about adding options, see Adding an Option to an Option Group (p. 190). For more information about each setting, see Audit Plugin Option Settings (p. 531).
3. Apply the option group to a new or existing DB instance.

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the DB instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Viewing and Downloading the MariaDB Audit Plugin Log

After you enable the MariaDB Audit Plugin, you access the results in the log files the same way you access any other text-based log files. The audit log files are located at `/rdsdbdata/log/audit/`. For information about viewing the log file in the console, see Viewing and Listing Database Log Files (p. 453). For information about downloading the log file, see Downloading a Database Log File (p. 453).

Modifying MariaDB Audit Plugin Settings

After you enable the MariaDB Audit Plugin, you can modify settings for the plugin. For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see Audit Plugin Option Settings (p. 531).

Removing the MariaDB Audit Plugin

Amazon RDS doesn't support turning off logging in the MariaDB Audit Plugin. However, you can remove the plugin from a DB instance. When you remove the MariaDB Audit Plugin, the DB instance is restarted automatically to stop auditing.

To remove the MariaDB Audit Plugin from a DB instance, do one of the following:

- Remove the MariaDB Audit Plugin option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198)
- Modify the DB instance and specify a different option group that doesn't include the plugin. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Parameters for MariaDB

By default, a MariaDB DB instance uses a DB parameter group that is specific to a MariaDB database. This parameter group contains some but not all of the parameters contained in the Amazon RDS DB parameter groups for the MySQL database engine. It also contains a number of new, MariaDB-specific parameters. The following MySQL parameters are not available in MariaDB-specific DB parameter groups:

- bind_address
- binlog_error_action
- binlog_gtid_simple_recovery
- binlog_max_flush_queue_time
- binlog_order_commits
- binlog_row_image
- binlog_rows_query_log_events
- binlogging_impossible_mode
- block_encryption_mode
- core_file
- default_tmp_storage_engine
- div_precision_increment
- end_markers_in_json
- enforce_gtid_consistency
- eq_range_index_dive_limit
- explicit_defaults_for_timestamp
- gtid_executed
- gtid-mode
- gtid_next
- gtid_owned
- gtid_purged
- log_bin_basename
- log_bin_index
- log_bin_use_v1_row_events
- log_slow_admin_statements
- log_slow_slave_statements
- log_throttle_queries_not_using_indexes
- master-info-repository
- optimizer_trace
- optimizer_trace_features
- optimizer_trace_limit
- optimizer_trace_max_mem_size
- optimizer_trace_offset
- relay_log_info_repository
- rpl_stop_slave_timeout
- slave_parallel_workers
- slave_pending_jobs_size_max
- slave_rows_search_algorithms

- storage_engine
- table_open_cache_instances
- timed_mutexes
- transaction_allow_batching
- validate-password
- validate_password_dictionary_file
- validate_password_length
- validate_password_mixed_case_count
- validate_password_number_count
- validate_password_policy
- validate_password_special_char_count

For more information on MySQL 5.6 parameters, go to the MySQL 5.6 documentation.

The MariaDB-specific DB parameter groups also contain the following parameters that are applicable to MariaDB only. Acceptable ranges for the modifiable parameters are the same as specified in the MariaDB documentation except where noted. Amazon RDS MariaDB parameters are set to the default values of the storage engine you have selected.

- aria_block_size
- aria_checkpoint_interval
- aria_checkpoint_log_activity
- aria_force_start_after_recovery_failures
- aria_group_commit
- aria_group_commit_interval
- aria_log_dir_path
- aria_log_file_size
- aria_log_purge_type
- aria_max_sort_file_size
- aria_page_checksum
- aria_pagecache_age_threshold
- aria_pagecache_division_limit
- aria_recover

  Amazon RDS MariaDB supports the values of NORMAL, OFF, and QUICK, but not FORCE or BACKUP.
- aria_repair_threads
- aria_sort_buffer_size
- aria_stats_method
- aria_sync_log_dir
- binlog_annotate_row_events
- binlog_commit_wait_count
- binlog_commit_wait_usec
- binlog_row_image (MariaDB version 10.1 and later)
- deadlock_search_depth_long
- deadlock_search_depth_short
- deadlock_timeout_long
- deadlock_timeout_short
- explicit_defaults_for_timestamp (MariaDB version 10.1 and later)

- extra_max_connections
- extra_port
- feedback
- feedback_send_retry_wait
- feedback_send_timeout
- feedback_url
- feedback_user_info
- gtid_domain_id
- gtid_strict_mode
- histogram_size
- histogram_type
- innodb_adaptive_hash_index_partitions
- innodb_background_scrub_data_check_interval (MariaDB version 10.1 and later)
- innodb_background_scrub_data_compressed (MariaDB version 10.1 and later)
- innodb_background_scrub_data_interval (MariaDB version 10.1 and later)
- innodb_background_scrub_data_uncompressed (MariaDB version 10.1 and later)
- innodb_buf_dump_status_frequency (MariaDB version 10.1 and later)
- innodb_buffer_pool_populate
- innodb_cleaner_lsn_age_factor
- innodb_compression_algorithm (MariaDB version 10.1 and later)
- innodb_corrupt_table_action
- innodb_defragment (MariaDB version 10.1 and later)
- innodb_defragment_fill_factor (MariaDB version 10.1 and later)
- innodb_defragment_fill_factor_n_recs (MariaDB version 10.1 and later)
- innodb_defragment_frequency (MariaDB version 10.1 and later)
- innodb_defragment_n_pages (MariaDB version 10.1 and later)
- innodb_defragment_stats_accuracy (MariaDB version 10.1 and later)
- innodb_empty_free_List_algorithm
- innodb_fake_changes
- innodb_fatal_semaphore_wait_threshold (MariaDB version 10.1 and later)
- innodb_foreground_preflush
- innodb_idle_flush_pct (MariaDB version 10.1 and later)
- innodb_immediate_scrub_data_uncompressed (MariaDB version 10.1 and later)
- innodb_instrument_semaphores (MariaDB version 10.1 and later)
- innodb_locking_fake_changes
- innodb_log_arch_dir
- innodb_log_arch_expire_sec
- innodb_log_archive
- innodb_log_block_size
- innodb_log_checksum_algorithm
- innodb_max_bitmap_file_size
- innodb_max_changed_pages
- innodb_prefix_index_cluster_optimization (MariaDB version 10.1 and later)
- innodb_sched_priority_cleaner
- innodb_scrub_log (MariaDB version 10.1 and later)
- innodb_scrub_log_speed (MariaDB version 10.1 and later)

- innodb_show_locks_held
- innodb_show_verbose_locks
- innodb_simulate_comp_failures
- innodb_stats_modified_counter
- innodb_stats_traditional
- innodb_use_atomic_writes
- innodb_use_fallocate
- innodb_use_global_flush_log_at_trx_commit
- innodb_use_stacktrace
- innodb_use_trim (MariaDB version 10.1 and later)
- join_buffer_space_limit
- join_cache_level
- key_cache_file_hash_size
- key_cache_segments
- max_digest_length (MariaDB version 10.1 and later)
- max_statement_time (MariaDB version 10.1 and later)
- mysql56_temporal_format (MariaDB version 10.1 and later)
- progress_report_time
- query_cache_strip_comments
- replicate_annotate_row_events
- replicate_do_db
- replicate_do_table
- replicate_events_marked_for_skip
- replicate_ignore_db
- replicate_ignore_table
- replicate_wild_ignore_table
- slave_domain_parallel_threads
- slave_parallel_max_queued
- slave_parallel_mode (MariaDB version 10.1 and later)
- slave_parallel_threads
- slave_run_triggers_for_rbr (MariaDB version 10.1 and later)
- sql_error_log_filename
- sql_error_log_rate
- sql_error_log_rotate
- sql_error_log_rotations
- sql_error_log_size_limit
- thread_handling
- thread_pool_idle_timeout
- thread_pool_max_threads
- thread_pool_min_threads
- thread_pool_oversubscribe
- thread_pool_size
- thread_pool_stall_limit
- transaction_write_set_extraction
- use_stat_tables
- userstat

For more information on MariaDB parameters, go to the MariaDB documentation.

MariaDB on Amazon RDS SQL Reference

This appendix describes system stored procedures that are available for Amazon RDS instances running the MariaDB DB engine.

You can use all of the system stored procedures that are available for Amazon RDS MySQL DB instances for MariaDB DB instances also. These stored procedures are documented at MySQL on Amazon RDS SQL Reference (p. 820).

Additionally, the following system stored procedures are supported only for Amazon RDS DB instances running MariaDB:

mysql.rds_set_external_master_gtid

Configures GTID-based replication from a MariaDB instance running external to Amazon RDS to an Amazon RDS MariaDB DB instance. This stored procedure is supported only where the external MariaDB instance is version 10.0.24 or greater. When setting up replication where one or both instances do not support MariaDB global transaction identifiers (GTIDs), use mysql.rds_set_external_master (p. 822).

Using GTIDs for replication provides crash-safety features not offered by binary log replication, so we recommend it in cases where the replicating instances support it.

Syntax

```
CALL mysql.rds_set_external_master_gtid(
  host_name
  , host_port
  , replication_user_name
  , replication_user_password
  , gtid
  , ssl_encryption
);
```

Parameters

host_name

String. The host name or IP address of the MariaDB instance running external to Amazon RDS that will become the replication master.

host_port

Integer. The port used by the MariaDB instance running external to Amazon RDS to be configured as the replication master. If your network configuration includes SSH port replication that converts the port number, specify the port number that is exposed by SSH.

replication_user_name

String. The ID of a user with REPLICATION SLAVE permissions in the MariaDB DB instance to be configured as the read replica.

replication_user_password

String. The password of the user ID specified in `replication_user_name`.

gtid

String. The global transaction ID on the master that replication should start from.

You can use `@@gtid_current_pos` to get the current GTID if the replication master has been locked while you are configuring replication, so the binary log doesn't change between the points when you get the GTID and when replication starts.

Otherwise, if you are using `mysqldump` version 10.0.13 or greater to populate the slave instance prior to starting replication, you can get the GTID position in the output by using the `--master-data` or `--dump-slave` options. If you are not using `mysqldump` version 10.0.13 or greater, you can run the `SHOW MASTER STATUS` or use those same `mysqldump` options to get the binary log file name and position, then convert them to a GTID by running `BINLOG_GTID_POS` on the external MariaDB instance:

```
SELECT BINLOG_GTID_POS('<binary log file name>', <binary log file position>);
```

For more information about the MariaDB implementation of GTIDs, go to Global Transaction ID in the MariaDB documentation.

ssl_encryption

Integer. This option is not currently implemented. The default is 0.

Usage Notes

The `mysql.rds_set_external_master_gtid` procedure must be run by the master user. It must be run on the MariaDB DB instance that you are configuring as the replication slave of a MariaDB instance running external to Amazon RDS. Before running `mysql.rds_set_external_master_gtid`, you must have configured the instance of MariaDB running external to Amazon RDS as a replication master. For more information, see Importing Data into a MariaDB DB Instance (p. 530).

> **Warning**
> Do not use `mysql.rds_set_external_master_gtid` to manage replication between two Amazon RDS DB instances. Use it only when replicating with a MariaDB instance running external to RDS. For information about managing replication between Amazon RDS DB instances, see Working with Read Replicas (p. 250).

After calling `mysql.rds_set_external_master_gtid` to configure an Amazon RDS DB instance as a read replica, you can call mysql.rds_start_replication (p. 832) on the replica to start the replication process. You can call mysql.rds_reset_external_master (p. 828) to remove the read replica configuration.

When `mysql.rds_set_external_master_gtid` is called, Amazon RDS records the time, user, and an action of "set master" in the `mysql.rds_history` and `mysql.rds_replication_status` tables.

Examples

When run on a MariaDB DB instance, the following example configures it as the replication slave of an instance of MariaDB running external to Amazon RDS.

```
call mysql.rds_set_external_master_gtid
 ('Sourcedb.some.com',3306,'ReplicationUser','SomePassW0rd','0-123-456',0);
```

Related Topics

- mysql.rds_reset_external_master (p. 828)

- mysql.rds_start_replication (p. 832)
- mysql.rds_stop_replication (p. 834)

mysql.rds_kill_query_id

Terminates a query running against the MariaDB server.

Syntax

```
CALL mysql.rds_kill_query_id(queryID);
```

Parameters

queryID

Integer. The identity of the query to be terminated.

Usage Notes

To terminate a query running against the MariaDB server, use the `mysql.rds_kill_query_id` procedure and pass in the ID of that query. To obtain the query ID, query the MariaDB Information Schema PROCESSLIST Table, as shown following:

```
SELECT USER, HOST, COMMAND, TIME, STATE, INFO, QUERY_ID FROM
                INFORMATION_SCHEMA.PROCESSLIST WHERE USER = '<user name>';
```

The connection to the MariaDB server is retained.

Related Topics

- mysql.rds_kill (p. 841)
- mysql.rds_kill_query (p. 841)

Examples

The following example terminates a query with a query ID of 230040:

```
call mysql.rds_kill_query_id(230040);
```

Microsoft SQL Server on Amazon RDS

Amazon RDS supports DB instances running several versions and editions of Microsoft SQL Server. Following, you can find the most recent supported version of each major version. For the full list of supported versions, editions, and RDS engine versions, see Microsoft SQL Server Versions on Amazon RDS (p. 549).

- SQL Server 2017 CU19 14.00.3281.6, released per KB4535007 on April 15, 2020.
- SQL Server 2016 SP2 CU11 13.00.5598.27, released per KB4527378 on December 9, 2019.
- SQL Server 2014 SP3 CU4 12.00.6329.1, released per KB4500181 on July 29, 2019.
- SQL Server 2012 SP4 GDR 11.0.7493.4, released per KB4532098 on February 11, 2020.
- SQL Server 2008: It's no longer possible to provision new instances in any Region. Amazon RDS is actively migrating existing instances off this version.

For information about licensing for SQL Server, see Licensing Microsoft SQL Server on Amazon RDS (p. 559). For information about SQL Server builds, see this Microsoft support article about the latest SQL Server builds.

With Amazon RDS, you can create DB instances and DB snapshots, point-in-time restores, and automated or manual backups. DB instances running SQL Server can be used inside a VPC. You can also use Secure Sockets Layer (SSL) to connect to a DB instance running SQL Server, and you can use transparent data encryption (TDE) to encrypt data at rest. Amazon RDS currently supports Multi-AZ deployments for SQL Server using SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs) as a high-availability, failover solution.

To deliver a managed service experience, Amazon RDS does not provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges. Amazon RDS supports access to databases on a DB instance using any standard SQL client application such as Microsoft SQL Server Management Studio. Amazon RDS does not allow direct host access to a DB instance via Telnet, Secure Shell (SSH), or Windows Remote Desktop Connection. When you create a DB instance, the master user is assigned to the *db_owner* role for all user databases on that instance, and has all database-level permissions except for those that are used for backups. Amazon RDS manages backups for you.

Before creating your first DB instance, you should complete the steps in the setting up section of this guide. For more information, see Setting Up for Amazon RDS (p. 58).

Common Management Tasks for Microsoft SQL Server on Amazon RDS

The following are the common management tasks you perform with an Amazon RDS SQL Server DB instance, with links to relevant documentation for each task.

Task Area	Relevant Documentation
Instance Classes, Storage, and PIOPS If you are creating a DB instance for production purposes, you should understand how instance classes, storage types, and Provisioned IOPS work in Amazon RDS.	DB Instance Class Support for Microsoft SQL Server (p. 546) Amazon RDS Storage Types (p. 29)
Multi-AZ Deployments A production DB instance should use Multi-AZ deployments. Multi-AZ deployments provide increased availability, data durability, and fault tolerance for DB instances. Multi-AZ deployments for SQL Server are implemented using SQL Server's native DBM or AGs technology.	High Availability (Multi-AZ) for Amazon RDS (p. 41) Multi-AZ Deployments Using Microsoft SQL Server Database Mirroring or Always On Availability Groups (p. 554)
Amazon Virtual Private Cloud (VPC) If your AWS account has a default VPC, then your DB instance is automatically created inside the default VPC. If your account does not have a default VPC, and you want the DB instance in a VPC, you must create the VPC and subnet groups before you create the DB instance.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Working with a DB Instance in a VPC (p. 1442)
Security Groups By default, DB instances are created with a firewall that prevents access to them. You therefore must create a security group with the correct IP addresses and network configuration to access the DB instance. The security group you create depends on what Amazon EC2 platform your DB instance is on, and whether you will access your DB instance from an Amazon EC2 instance. In general, if your DB instance is on the *EC2-Classic* platform, you will need to create a DB security group; if your DB instance is on the *EC2-VPC* platform, you will need to create a VPC security group.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Controlling Access with Security Groups (p. 1414)
Parameter Groups If your DB instance is going to require specific database parameters, you should create a parameter group before you create the DB instance.	Working with DB Parameter Groups (p. 202)
Option Groups If your DB instance is going to require specific database options, you should create an option group before you create the DB instance.	Options for the Microsoft SQL Server Database Engine (p. 636)
Connecting to Your DB Instance After creating a security group and associating it to a DB instance, you can connect to the DB instance using any standard SQL client application such as Microsoft SQL Server Management Studio.	Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560)
Backup and Restore	Working With Backups (p. 291) Importing and Exporting SQL Server Databases (p. 576)

Task Area	Relevant Documentation
When you create your DB instance, you can configure it to take automated backups. You can also back up and restore your databases manually by using full backup files (.bak files).	
Monitoring You can monitor your SQL Server DB instance by using CloudWatch Amazon RDS metrics, events, and enhanced monitoring.	Viewing DB Instance Metrics (p. 356) Viewing Amazon RDS Events (p. 448)
Log Files You can access the log files for your SQL Server DB instance.	Amazon RDS Database Log Files (p. 453) Microsoft SQL Server Database Log Files (p. 465)

There are also advanced administrative tasks for working with SQL Server DB instances. For more information, see the following documentation:

- Common DBA Tasks for Microsoft SQL Server (p. 693).
- Using Windows Authentication with a SQL Server DB Instance (p. 612)
- Accessing the tempdb Database (p. 694)

Limits for Microsoft SQL Server DB Instances

The Amazon RDS implementation of Microsoft SQL Server on a DB instance has some limitations that you should be aware of:

- The maximum number of databases supported on a DB instance depends on the instance class type and the availability mode—Single-AZ, Multi-AZ Database Mirroring (DBM), or Multi-AZ Availability Groups (AGs). The Microsoft SQL Server system databases don't count toward this limit.

  The following table shows the maximum number of supported databases for each instance class type and availability mode. Use this table to help you decide if you can move from one instance class type to another, or from one availability mode to another. If your source DB instance has more databases than the target instance class type or availability mode can support, modifying the DB instance fails. You can see the status of your request in the **Events** pane.

Instance Class Type	Single-AZ	Multi-AZ with DBM	Multi-AZ with Always On AGs
db.*.micro to db.*.medium	30	N/A	N/A
db.*.large	30	30	30
db.*.xlarge to db.*.16xlarge	100	50	75
db.*.24xlarge	100	50	100

  * Represents the different instance class types.

For example, let's say that your DB instance runs on a db.*.16xlarge with Single-AZ and that it has 76 databases. You modify the DB instance to upgrade to using Multi-AZ Always On AGs. This upgrade fails, because your DB instance contains more databases than your target configuration can support. If you upgrade your instance class type to db.*.24xlarge instead, the modification succeeds.

If the upgrade fails, you see events and messages similar to the following:

- Unable to modify database instance class. The instance has 76 databases, but after conversion it would only support 75.
- Unable to convert the DB instance to Multi-AZ: The instance has 76 databases, but after conversion it would only support 75.

If the point-in-time restore or snapshot restore fails, you see events and messages similar to the following:

- Database instance put into incompatible-restore. The instance has 76 databases, but after conversion it would only support 75.

- Some ports are reserved for Amazon RDS, and you can't use them when you create a DB instance.
- Client connections from IP addresses within the range 169.254.0.0/16 are not permitted. This is the Automatic Private IP Addressing Range (APIPA), which is used for local-link addressing.
- SQL Server Standard Edition will use only a subset of the available processors if the DB instance has more processors than the software limits (24 cores, 4 sockets, and 128GB RAM). Examples of this are the db.m5.24xlarge and db.r5.24xlarge instance classes.
- Amazon RDS for SQL Server doesn't support importing data into the msdb database.
- You can't rename databases on a DB instance in a SQL Server Multi-AZ deployment.
- The maximum storage size for SQL Server DB instances is the following:
  - General Purpose (SSD) storage – 16 TiB for all editions
  - Provisioned IOPS storage – 16 TiB for all editions
  - Magnetic storage – 1 TiB for all editions

  If you have a scenario that requires a larger amount of storage, you can use sharding across multiple DB instances to get around the limit. This approach requires data-dependent routing logic in applications that connect to the sharded system. You can use an existing sharding framework, or you can write custom code to enable sharding. If you use an existing framework, the framework can't install any components on the same server as the DB instance.
- The minimum storage size for SQL Server DB instances is the following:
  - General Purpose (SSD) storage – 20 GiB for Enterprise, Standard, Web, and Express editions
  - Provisioned IOPS storage – 20 GiB for Enterprise and Standard editions, 100 GiB for Web and Express editions
  - Magnetic storage – 200 GiB for Enterprise and Standard editions, 20 GiB for Web and Express editions
- Amazon RDS doesn't support running these services on the same server as your RDS DB instance:
  - Data Quality Services
  - Master Data Services

  To use these features, we recommend that you install SQL Server on an Amazon EC2 instance, or use an on-premises SQL Server instance. In these cases, the EC2 or SQL Server instance acts as the Master Data Services server for your SQL Server DB instance on Amazon RDS. You can install SQL Server on an Amazon EC2 instance with Amazon EBS storage, pursuant to Microsoft licensing policies.
- Because of limitations in Microsoft SQL Server, restoring to a point in time before successful execution of DROP DATABASE might not reflect the state of that database at that point in time. For example, the dropped database is typically restored to its state up to 5 minutes before the DROP DATABASE command was issued. This type of restore means that you can't restore the transactions made

during those few minutes on your dropped database. To work around this, you can reissue the DROP DATABASE command after the restore operation is completed. Dropping a database removes the transaction logs for that database.

- For SQL Server, you create your databases after you create your DB instance. Database names follow the usual SQL Server naming rules with the following differences:
  - Database names can't start with `rdsadmin`.
  - They can't start or end with a space or a tab.
  - They can't contain any of the characters that create a new line.
  - They can't contain a single quote (`'`).

DB Instance Class Support for Microsoft SQL Server

The computation and memory capacity of a DB instance is determined by its DB instance class. The DB instance class you need depends on your processing power and memory requirements. For more information, see DB Instance Classes (p. 7).

The following list of DB instance classes supported for Microsoft SQL Server is provided here for your convenience. For the most current list, see the RDS console: https://console.aws.amazon.com/rds/.

SQL Server Edition	2017 and 2016 Support Range	2014 and 2012 Support Range

Enterprise Edition	`db.t3.xlarge–db.t3.2xlarge`
	`db.r3.xlarge–db.r3.8xlarge`
	`db.r4.xlarge–db.r4.16xlarge`
	`db.r5.xlarge–db.r5.24xlarge`
	`db.m4.xlarge–db.m4.16xlarge`
	`db.m5.xlarge–db.m5.24xlarge`
	`db.x1.16xlarge–db.x1.32xlarge`
	`db.x1e.xlarge–db.x1e.32xlarge`
	`db.z1d.xlarge–db.z1d.3xlarge`
		`db.t3.xlarge–db.t3.2xlarge`
		`db.r3.xlarge–db.r3.8xlarge`
		`db.r4.xlarge–db.r4.8xlarge`
		`db.r5.xlarge–db.r5.24xlarge`
		`db.m4.xlarge–db.m4.10xlarge`
		`db.m5.xlarge–db.m5.24xlarge`
		`db.x1.16xlarge–db.x1.32xlarge`
		`db.x1e.xlarge–db.x1e.32xlarge`

Standard Edition	`db.t3.xlarge–db.t3.2xlarge`
	`db.r4.large–db.r4.16xlarge`
	`db.r5.large–db.r5.24xlarge`
	`db.m4.large–db.m4.16xlarge`
	`db.m5.large–db.m5.24xlarge`
	`db.x1.16xlarge–db.x1.32xlarge`
	`db.x1e.xlarge–db.x1e.32xlarge`
		`db.t3.xlarge–db.t3.2xlarge`
		`db.r3.large–db.r3.8xlarge`
		`db.r4.large–db.r4.8xlarge`
		`db.r5.large–db.r5.24xlarge`
		`db.m3.medium–db.m3.2xlarge`
		`db.m4.large–db.m4.10xlarge`
		`db.m5.large–db.m5.24xlarge`

SQL Server Edition	2017 and 2016 Support Range	2014 and 2012 Support Range
	db.z1d.large–db.z1d.3xlarge	db.x1.16xlarge–db.x1.32xlarge db.x1e.xlarge–db.x1e.32xlarge
Web Edition	db.t2.small–db.t2.medium db.t3.small–db.t3.2xlarge db.r4.large–db.r4.2xlarge db.r5.large–db.r5.4xlarge db.m4.large–db.m4.4xlarge db.m5.large–db.m5.4xlarge db.z1d.large–db.z1d.3xlarge	db.t2.small–db.t2.medium db.t3.small–db.t3.2xlarge db.r3.large–db.r3.2xlarge db.r4.large–db.r4.2xlarge db.r5.large–db.r5.4xlarge db.m3.medium–db.m3.2xlarge db.m4.large–db.m4.4xlarge db.m5.large–db.m5.4xlarge
Express Edition	db.t2.micro–db.t2.medium db.t3.small–db.t3.xlarge	db.t2.micro–db.t2.medium db.t3.small–db.t3.xlarge

Microsoft SQL Server Security

The Microsoft SQL Server database engine uses role-based security. The master user name you use when you create a DB instance is a SQL Server Authentication login that is a member of the `processadmin`, `public`, and `setupadmin` fixed server roles.

Any user who creates a database is assigned to the db_owner role for that database and has all database-level permissions except for those that are used for backups. Amazon RDS manages backups for you.

The following server-level roles are not currently available in Amazon RDS:

- bulkadmin
- dbcreator
- diskadmin
- securityadmin
- serveradmin
- sysadmin

The following server-level permissions are not available on SQL Server DB instances:

- ALTER ANY CREDENTIAL
- ALTER ANY EVENT NOTIFICATION
- ALTER ANY EVENT SESSION
- ALTER RESOURCES
- ALTER SETTINGS (you can use the DB parameter group API operations to modify parameters; for more information, see Working with DB Parameter Groups (p. 202))

- AUTHENTICATE SERVER
- CONTROL_SERVER
- CREATE DDL EVENT NOTIFICATION
- CREATE ENDPOINT
- CREATE TRACE EVENT NOTIFICATION
- EXTERNAL ACCESS ASSEMBLY
- SHUTDOWN (You can use the RDS reboot option instead)
- UNSAFE ASSEMBLY
- ALTER ANY AVAILABILITY GROUP (SQL Server 2012 only)
- CREATE ANY AVAILABILITY GROUP (SQL Server 2012 only)

Compliance Program Support for Microsoft SQL Server DB Instances

AWS Services in Scope have been fully assessed by a third-party auditor and result in a certification, attestation of compliance, or Authority to Operate (ATO). For more information, see AWS Services in Scope by Compliance Program.

HIPAA Support for Microsoft SQL Server DB Instances

You can use Amazon RDS for Microsoft SQL Server databases to build HIPAA-compliant applications. You can store healthcare-related information, including protected health information (PHI), under an executed Business Associate Agreement (BAA) with AWS. For more information, see HIPAA Compliance.

Amazon RDS for SQL Server supports HIPAA for the following versions and editions:

- SQL Server 2017 Enterprise, Standard, and Web Editions
- SQL Server 2016 Enterprise, Standard, and Web Editions
- SQL Server 2014 Enterprise, Standard, and Web Editions
- SQL Server 2012 Enterprise, Standard, and Web Editions

To enable HIPAA support on your DB instance, set up the following three components.

Component	Details
Auditing	To set up auditing, set the parameter `rds.sqlserver_audit` to the value `fedramp_hipaa`. If your DB instance is not already using a custom DB parameter group, you must create a custom parameter group and attach it to your DB instance before you can modify the `rds.sqlserver_audit` parameter. For more information, see Working with DB Parameter Groups (p. 202).
Transport Encryption	To set up transport encryption, force all connections to your DB instance to use Secure Sockets Layer (SSL). For more information, see Forcing Connections to Your DB Instance to Use SSL (p. 609).
Encryption at Rest	To set up encryption at rest, you have two options: 1. If you are running Enterprise Edition, you can choose to use Transparent Data Encryption (TDE) to achieve encryption at rest. For more information, see Support for Transparent Data Encryption in SQL Server (p. 640).

Component	Details
	2. You can set up encryption at rest by using AWS Key Management Service (AWS KMS) encryption keys. For more information, see Encrypting Amazon RDS Resources (p. 1358).

SSL Support for Microsoft SQL Server DB Instances

You can use SSL to encrypt connections between your applications and your Amazon RDS DB instances running Microsoft SQL Server. You can also force all connections to your DB instance to use SSL. If you force connections to use SSL, it happens transparently to the client, and the client doesn't have to do any work to use SSL.

SSL is supported in all AWS Regions and for all supported SQL Server editions. For more information, see Using SSL with a Microsoft SQL Server DB Instance (p. 609).

Microsoft SQL Server Versions on Amazon RDS

You can specify any currently supported Microsoft SQL Server version when creating a new DB instance. You can specify the Microsoft SQL Server major version (such as Microsoft SQL Server 14.00), and any supported minor version for the specified major version. If no version is specified, Amazon RDS defaults to a supported version, typically the most recent version. If a major version is specified but a minor version is not, Amazon RDS defaults to a recent release of the major version you have specified.

The following table shows the supported versions for all editions and all AWS Regions, except where noted. You can also use the `describe-db-engine-versions` AWS CLI command to see a list of supported versions, as well as defaults for newly created DB instances.

SQL Server Versions Supported in RDS

Major Version	Minor Version	RDS API `EngineVersion` and CLI `engine-version`
SQL Server 2017	14.00.3281.6 (CU19)	`14.00.3281.6.v1`
	14.00.3223.3 (CU16)	`14.00.3223.3.v1`
	14.00.3192.2	`14.00.3192.2.v1`
	14.00.3049.1	`14.00.3049.1.v1`
	14.00.3035.2 (CU9 GDR)	`14.00.3035.2.v1`
	14.00.3015.40 (CU3)	`14.00.3015.40.v1`
	14.00.1000.169 (RTM)	`14.00.1000.169.v1`
SQL Server 2016	13.00.5598.27 (SP2 CU11)	`13.00.5598.27.v1`
	13.00.5426.0 (SP2 CU8)	`13.00.5426.0.v1`
	13.00.5366.0 (SP2)	`13.00.5366.0.v1`
	13.00.5292.0 (CU6)	`13.00.5292.0.v1`
	13.00.5216.0 (CU3)	`13.00.5216.0.v1`

Major Version	Minor Version	RDS API `EngineVersion` and CLI `engine-version`

	13.00.4522.0 (SP1 CU10 Security Update)
	
	13.00.4466.4 (SP1 CU7)
	
	13.00.4451.0 (SP1 CU5)
	
	13.00.4422.0 (SP1 CU2)
	
	13.00.2164.0 (RTM CU2)
		`13.00.4522.0.v1`
		
		`13.00.4466.4.v1`
		
		`13.00.4451.0.v1`
		
		`13.00.4422.0.v1`
		
		`13.00.2164.0.v1`

SQL Server 2014	12.00.6329.1 (SP3 CU4)
	
	12.00.6293.0 (SP3 CU3)
	
	12.00.5571.0 (SP2 CU10)
	
	12.00.5546.0 (SP2 CU5)
	
	12.00.5000.0 (SP2)
		`12.00.6329.1.v1`
		
		`12.00.6293.0.v1`
		
		`12.00.5571.0.v1`
		
		`12.00.5546.0.v1`
		
		`12.00.5000.0.v1`

SQL Server 2012	11.00.7493.4 (SP4 GDR)
	
	11.00.7462.6 (SP4 GDR)
	
	11.00.6594.0 (SP3 CU8)
	
	11.00.6020.0 (SP3)
	
	11.00.5058.0 (SP2), except US East (Ohio), Canada (Central), and Europe (London)
		`11.00.7493.4.v1`
		
		`11.00.7462.6.v1`
		
		`11.00.6594.0.v1`
		
		`11.00.6020.0.v1`
		
		`11.00.5058.0.v1`

Version Management in Amazon RDS

Amazon RDS includes flexible version management that enables you to control when and how your DB instance is patched or upgraded. This enables you to do the following for your DB engine:

- Maintain compatibility with database engine patch versions.
- Test new patch versions to verify that they work with your application before you deploy them in production.
- Plan and perform version upgrades to meet your service level agreements and timing requirements.

Microsoft SQL Server Engine Patching in Amazon RDS

Amazon RDS periodically aggregates official Microsoft SQL Server database patches into a DB instance engine version that's specific to Amazon RDS. For more information about the Microsoft SQL Server patches in each engine version, see Version and Feature Support on Amazon RDS.

Currently, you manually execute all engine upgrades on your DB instance. For more information, see Upgrading the Microsoft SQL Server DB Engine (p. 572).

Deprecation Schedule for Major Engine Versions of Microsoft SQL Server on Amazon RDS

The table following displays the planned schedule of deprecations for major engine versions of Microsoft SQL Server.

Date	Information
July 12, 2019	The Amazon RDS team deprecated support for Microsoft SQL Server 2008 R2 in June 2019. Remaining instances of Microsoft SQL Server 2008 R2 are migrating to SQL Server 2012 (latest minor version available). To avoid an automatic upgrade from Microsoft SQL Server 2008 R2, you can upgrade at a time that is convenient to you. For more information, see Upgrading a DB Instance Engine Version (p. 241).
April 25, 2019	Before the end of April 2019, you will no longer be able to create new Amazon RDS for SQL Server database instances using Microsoft SQL Server 2008R2.

Microsoft SQL Server Features on Amazon RDS

The supported SQL Server versions on Amazon RDS include the following features.

Microsoft SQL Server 2017 Features

SQL Server 2017 includes many new features, such as the following:

- Adaptive query processing
- Automatic plan correction
- GraphDB
- Resumable index rebuilds

For the full list of SQL Server 2017 features, see What's New in SQL Server 2017 in the Microsoft documentation.

For a list of unsupported features, see Features Not Supported and Features with Limited Support (p. 553).

Microsoft SQL Server 2016 Features

Amazon RDS supports the following features of SQL Server 2016:

- Always Encrypted
- JSON Support
- Operational Analytics
- Query Store
- Temporal Tables

For the full list of SQL Server 2016 features, see What's New in SQL Server 2016 in the Microsoft documentation.

Microsoft SQL Server 2014 Features

In addition to supported features of SQL Server 2012, Amazon RDS supports the new query optimizer available in SQL Server 2014, and also the delayed durability feature.

For a list of unsupported features, see Features Not Supported and Features with Limited Support (p. 553).

SQL Server 2014 supports all the parameters from SQL Server 2012 and uses the same default values. SQL Server 2014 includes one new parameter, backup checksum default. For more information, see How to enable the CHECKSUM option if backup utilities do not expose the option in the Microsoft documentation.

Microsoft SQL Server 2012 Features

In addition to supported features of SQL Server 2008 R2, Amazon RDS supports the following SQL Server 2012 features:

- Columnstore indexes (Enterprise Edition)
- Online Index Create, Rebuild and Drop for XML, varchar(max), nvarchar(max), and varbinary(max) data types (Enterprise Edition)
- Flexible Server Roles
- Service Broker is supported, Service Broker endpoints are not supported
- Partially Contained Databases
- Sequences
- Transparent Data Encryption (Enterprise Edition only)
- THROW statement
- New and enhanced spatial types
- UTF-16 Support
- ALTER ANY SERVER ROLE server-level permission

For more information about SQL Server 2012, see Features Supported by the Editions of SQL Server 2012 in the Microsoft documentation.

For a list of unsupported features, see Features Not Supported and Features with Limited Support (p. 553).

Some SQL Server parameters have changed in SQL Server 2012.

- The following parameters have been removed from SQL Server 2012: `awe enabled`, `precompute rank`, and `sql mail xps`. These parameters were not modifiable in SQL Server DB Instances and their removal should have no impact on your SQL Server use.
- A new `contained database authentication` parameter in SQL Server 2012 supports partially contained databases. When you enable this parameter and then create a partially contained database, an authorized user's user name and password is stored within the partially contained database instead of in the master database. For more information about partially contained databases, see Contained Databases in the Microsoft documentation.

Microsoft SQL Server 2008 R2 Deprecated on Amazon RDS

We are upgrading all existing instances that are still using SQL Server 2008 R2 to the latest minor version of SQL Server 2012. For more information, see Version Management in Amazon RDS (p. 550).

For more information about SQL Server 2008 R2, see Features Supported by the Editions of SQL Server 2008 R2 in the Microsoft documentation.

Change Data Capture Support for Microsoft SQL Server DB Instances

Amazon RDS supports change data capture (CDC) for your DB instances running Microsoft SQL Server. CDC captures changes that are made to the data in your tables, and stores metadata about each change that you can access later. For more information, see Change Data Capture in the Microsoft documentation.

Amazon RDS supports CDC for the following SQL Server editions and versions:

- Microsoft SQL Server Enterprise Edition (All versions)
- Microsoft SQL Server Standard Edition:
  - 2017
  - 2016 version 13.00.4422.0 SP1 CU2 and later

To use CDC with your Amazon RDS DB instances, first enable or disable CDC at the database level by using RDS-provided stored procedures. After that, any user that has the `db_owner` role for that database can use the native Microsoft stored procedures to control CDC on that database. For more information, see Using Change Data Capture (p. 702).

You can use CDC and AWS Database Migration Service to enable ongoing replication from SQL Server DB instances.

Features Not Supported and Features with Limited Support

The following Microsoft SQL Server features are not supported on Amazon RDS:

- Backing up to Microsoft Azure Blob Storage
- Buffer pool extension
- Data Quality Services
- Database Log Shipping
- Database Mail
- Extended stored procedures, including xp_cmdshell
- FILESTREAM support
- File tables

- Machine Learning and R Services (requires OS access to install it)
- Maintenance Plans
- Performance Data Collector
- Policy-Based Management
- PolyBase
- Replication
- Resource Governor
- Server-level triggers
- Service Broker endpoints
- Stretch database
- T-SQL endpoints (all operations using CREATE ENDPOINT are unavailable)
- WCF Data Services

The following Microsoft SQL Server features have limited support on Amazon RDS:

- Distributed Queries / Linked Servers. For more information, see: Implementing Linked Servers with Amazon RDS for Microsoft SQL Server.

Multi-AZ Deployments Using Microsoft SQL Server Database Mirroring or Always On Availability Groups

Amazon RDS supports Multi-AZ deployments for DB instances running Microsoft SQL Server by using SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs). Multi-AZ deployments provide increased availability, data durability, and fault tolerance for DB instances. In the event of planned database maintenance or unplanned service disruption, Amazon RDS automatically fails over to the up-to-date secondary replica so database operations can resume quickly without manual intervention. The primary and secondary instances use the same endpoint, whose physical network address transitions to the passive secondary replica as part of the failover process. You don't have to reconfigure your application when a failover occurs.

Amazon RDS manages failover by actively monitoring your Multi-AZ deployment and initiating a failover when a problem with your primary occurs. Failover doesn't occur unless the standby and primary are fully in sync. Amazon RDS actively maintains your Multi-AZ deployment by automatically repairing unhealthy DB instances and re-establishing synchronous replication. You don't have to manage anything. Amazon RDS handles the primary, the witness, and the standby instance for you. When you set up SQL Server Multi-AZ, RDS configures passive secondary instances for all of the databases on the instance.

For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).

Using Transparent Data Encryption to Encrypt Data at Rest

Amazon RDS supports Microsoft SQL Server Transparent Data Encryption (TDE), which transparently encrypts stored data. Amazon RDS uses option groups to enable and configure these features. For more information about the TDE option, see Support for Transparent Data Encryption in SQL Server (p. 640).

Local Time Zone for Microsoft SQL Server DB Instances

The time zone of an Amazon RDS DB instance running Microsoft SQL Server is set by default. The current default is Universal Coordinated Time (UTC). You can set the time zone of your DB instance to a local time zone instead, to match the time zone of your applications.

You set the time zone when you first create your DB instance. You can create your DB instance by using the AWS Management Console, the Amazon RDS API CreateDBInstance action, or the AWS CLI create-db-instance command.

If your DB instance is part of a Multi-AZ deployment (using SQL Server DBM or AGs), then when you fail over, your time zone remains the local time zone that you set. For more information, see Multi-AZ Deployments Using Microsoft SQL Server Database Mirroring or Always On Availability Groups (p. 554).

When you request a point-in-time restore, you specify the time to restore to. The time is shown in your local time zone. For more information, see Restoring a DB Instance to a Specified Time (p. 336).

The following are limitations to setting the local time zone on your DB instance:

- You can't modify the time zone of an existing SQL Server DB instance.
- You can't restore a snapshot from a DB instance in one time zone to a DB instance in a different time zone.
- We strongly recommend that you don't restore a backup file from one time zone to a different time zone. If you restore a backup file from one time zone to a different time zone, you must audit your queries and applications for the effects of the time zone change. For more information, see Importing and Exporting SQL Server Databases (p. 576).

Supported Time Zones

You can set your local time zone to one of the values listed in the following table.

Time Zone	Standard Time Offset	Description	Notes
Afghanistan Standard Time	(UTC+04:30)	Kabul	
Alaskan Standard Time	(UTC–09:00)	Alaska	
Arabian Standard Time	(UTC+04:00)	Abu Dhabi, Muscat	
Atlantic Standard Time	(UTC–04:00)	Atlantic Time (Canada)	
AUS Central Standard Time	(UTC+09:30)	Darwin	This time zone doesn't observe daylight saving time.
AUS Eastern Standard Time	(UTC+10:00)	Canberra, Melbourne, Sydney	
Belarus Standard Time	(UTC+03:00)	Minsk	This time zone doesn't observe daylight saving time.

Time Zone	Standard Time Offset	Description	Notes
Canada Central Standard Time	(UTC–06:00)	Saskatchewan	
Cape Verde Standard Time	(UTC–01:00)	Cabo Verde Is.	
Cen. Australia Standard Time	(UTC+09:30)	Adelaide	
Central America Standard Time	(UTC–06:00)	Central America	
Central Asia Standard Time	(UTC+06:00)	Astana	
Central Brazilian Standard Time	(UTC–04:00)	Cuiaba	
Central Europe Standard Time	(UTC+01:00)	Belgrade, Bratislava, Budapest, Ljubljana, Prague	
Central European Standard Time	(UTC+01:00)	Sarajevo, Skopje, Warsaw, Zagreb	
Central Pacific Standard Time	(UTC+11:00)	Solomon Islands, New Caledonia	
Central Standard Time	(UTC–06:00)	Central Time (US and Canada)	
Central Standard Time (Mexico)	(UTC–06:00)	Guadalajara, Mexico City, Monterrey	
China Standard Time	(UTC+08:00)	Beijing, Chongqing, Hong Kong, Urumqi	
E. Africa Standard Time	(UTC+03:00)	Nairobi	This time zone doesn't observe daylight saving time.
E. Australia Standard Time	(UTC+10:00)	Brisbane	
E. Europe Standard Time	(UTC+02:00)	Chisinau	
E. South America Standard Time	(UTC–03:00)	Brasilia	
Eastern Standard Time	(UTC–05:00)	Eastern Time (US and Canada)	
Georgian Standard Time	(UTC+04:00)	Tbilisi	
GMT Standard Time	(UTC)	Dublin, Edinburgh, Lisbon, London	This time zone isn't the same as Greenwich Mean Time. This time zone does observe daylight saving time.
Greenland Standard Time	(UTC–03:00)	Greenland	
Greenwich Standard Time	(UTC)	Monrovia, Reykjavik	This time zone doesn't observe daylight saving time.

Time Zone	Standard Time Offset	Description	Notes
GTB Standard Time	(UTC+02:00)	Athens, Bucharest	
Hawaiian Standard Time	(UTC–10:00)	Hawaii	
India Standard Time	(UTC+05:30)	Chennai, Kolkata, Mumbai, New Delhi	
Jordan Standard Time	(UTC+02:00)	Amman	
Korea Standard Time	(UTC+09:00)	Seoul	
Middle East Standard Time	(UTC+02:00)	Beirut	
Mountain Standard Time	(UTC–07:00)	Mountain Time (US and Canada)	
Mountain Standard Time (Mexico)	(UTC–07:00)	Chihuahua, La Paz, Mazatlan	
US Mountain Standard Time	(UTC–07:00)	Arizona	This time zone doesn't observe daylight saving time.
New Zealand Standard Time	(UTC+12:00)	Auckland, Wellington	
Newfoundland Standard Time	(UTC–03:30)	Newfoundland	
Pacific SA Standard Time	(UTC–03:00)	Santiago	
Pacific Standard Time	(UTC–08:00)	Pacific Time (US and Canada)	
Pacific Standard Time (Mexico)	(UTC–08:00)	Baja California	
Russian Standard Time	(UTC+03:00)	Moscow, St. Petersburg, Volgograd	This time zone doesn't observe daylight saving time.
SA Pacific Standard Time	(UTC–05:00)	Bogota, Lima, Quito, Rio Branco	This time zone doesn't observe daylight saving time.
SE Asia Standard Time	(UTC+07:00)	Bangkok, Hanoi, Jakarta	
Singapore Standard Time	(UTC+08:00)	Kuala Lumpur, Singapore	
Tokyo Standard Time	(UTC+09:00)	Osaka, Sapporo, Tokyo	
US Eastern Standard Time	(UTC–05:00)	Indiana (East)	
UTC	UTC	Coordinated Universal Time	This time zone doesn't observe daylight saving time.

Time Zone	Standard Time Offset	Description	Notes
UTC–02	(UTC–02:00)	Coordinated Universal Time–02	
UTC–08	(UTC–08:00)	Coordinated Universal Time–08	
UTC–09	(UTC–09:00)	Coordinated Universal Time–09	
UTC–11	(UTC–11:00)	Coordinated Universal Time–11	
UTC+12	(UTC+12:00)	Coordinated Universal Time+12	
W. Australia Standard Time	(UTC+08:00)	Perth	
W. Central Africa Standard Time	(UTC+01:00)	West Central Africa	
W. Europe Standard Time	(UTC+01:00)	Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna	

Licensing Microsoft SQL Server on Amazon RDS

When you set up an Amazon RDS DB instance for Microsoft SQL Server, the software license is included.

This means that you don't need to purchase SQL Server licenses separately. AWS holds the license for the SQL Server database software. Amazon RDS pricing includes the software license, underlying hardware resources, and Amazon RDS management capabilities.

Amazon RDS supports the following Microsoft SQL Server editions:

- Enterprise
- Standard
- Web
- Express

> **Note**
> Licensing for SQL Server Web Edition supports only public and internet-accessible webpages, websites, web applications, and web services. This level of support is required for compliance with Microsoft’s usage rights. For more information, see AWS Service Terms.

Amazon RDS supports Multi-AZ deployments for DB instances running Microsoft SQL Server by using SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs). There are no additional licensing requirements for Multi-AZ deployments. For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).

Restoring License-Terminated DB Instances

Amazon RDS takes snapshots of license-terminated DB instances. If your instance is terminated for licensing issues, you can restore it from the snapshot to a new DB instance. New DB instances have a license included.

For more information, see Restoring License-Terminated DB Instances (p. 705).

Development and Test

Because of licensing requirements, we can't offer SQL Server Developer edition on Amazon RDS. You can use Express edition for many development, testing, and other nonproduction needs. However, if you need the full feature capabilities of an enterprise-level installation of SQL Server for development, you can download and install SQL Server Developer edition (and other MSDN products) on Amazon EC2. Dedicated infrastructure is not required for Developer edition. By using your own host, you also gain access to other programmability features that are not accessible on Amazon RDS. For more information on the difference between SQL Server editions, see Editions and supported features of SQL Server 2017 in the Microsoft documentation.

Connecting to a DB Instance Running the Microsoft SQL Server Database Engine

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to the DB instance. In this topic, you connect to your DB instance by using either Microsoft SQL Server Management Studio (SSMS) or SQL Workbench/J.

For an example that walks you through the process of creating and connecting to a sample DB instance, see Creating a Microsoft SQL Server DB Instance and Connecting to a DB Instance (p. 71).

Connecting to Your DB Instance with Microsoft SQL Server Management Studio

In this procedure, you connect to your sample DB instance by using Microsoft SQL Server Management Studio (SSMS). To download a standalone version of this utility, see Download SQL Server Management Studio (SSMS) in the Microsoft documentation.

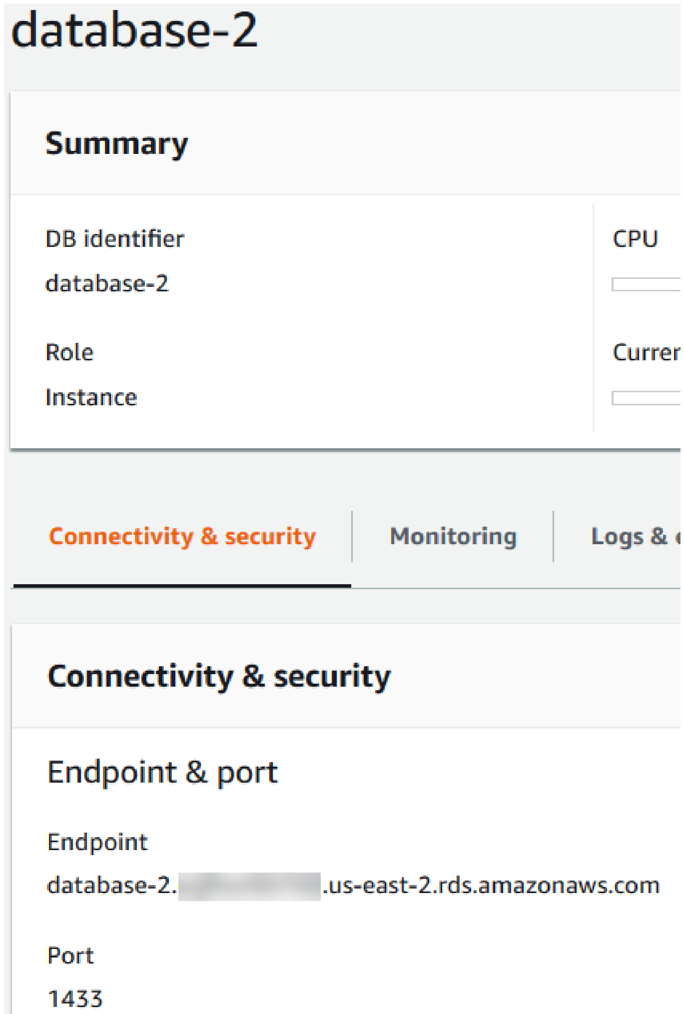
To connect to a DB instance using SSMS

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region of your DB instance.
3. Find the Domain Name System (DNS) name and port number for your DB instance:

    a. Open the RDS console and choose **Databases** to display a list of your DB instances.

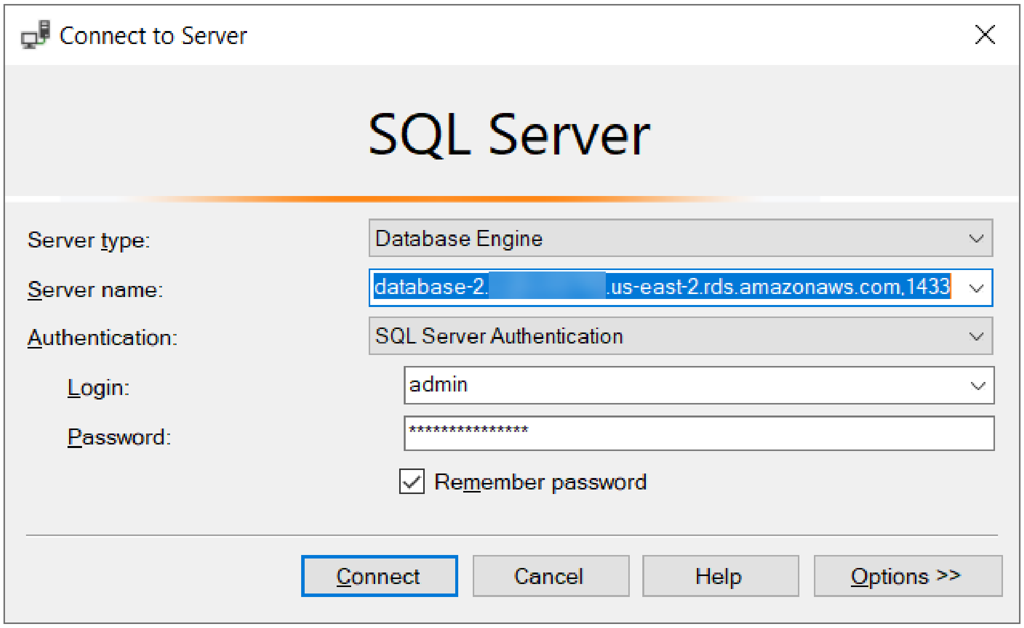
    b. Choose the SQL Server DB instance name to display its details.

    c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



4. Start SQL Server Management Studio.

   The **Connect to Server** dialog box appears.



5. Provide the information for your DB instance:

   a. For **Server type**, choose **Database Engine**.

   b. For **Server name**, enter the DNS name and port number of your DB instance, separated by a comma.

      Important
      Change the colon between the DNS name and port number to a comma.

      For example, your server name should look like the following.

      ```
      database-2.cg034itsfake.us-east-1.rds.amazonaws.com,1433
      ```

   c. For **Authentication**, choose **SQL Server Authentication**.

   d. For **Login**, enter the master user name for your DB instance.

   e. For **Password**, enter the password for your DB instance.

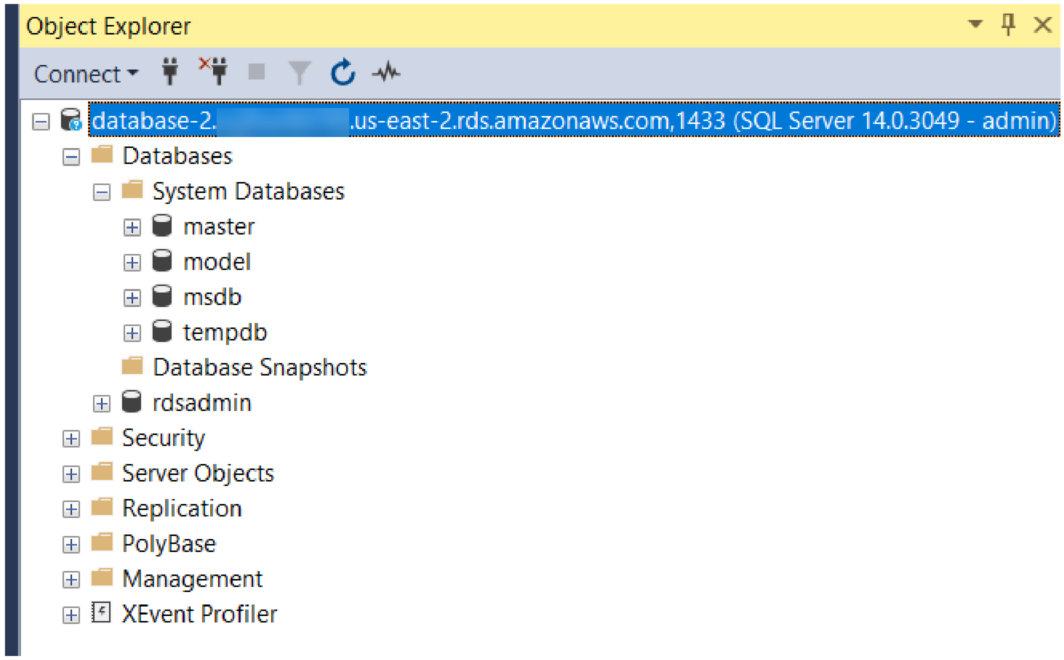
6. Choose **Connect**.

   After a few moments, SSMS connects to your DB instance. If you can't connect to your DB instance, see Security Group Considerations (p. 566) and Troubleshooting Connections to Your SQL Server DB Instance (p. 567).

7. Your SQL Server DB instance comes with SQL Server's standard built-in system databases (master, model, msdb, and tempdb). To explore the system databases, do the following:

   a. In SSMS, on the **View** menu, choose **Object Explorer**.

   b. Expand your DB instance, expand **Databases**, and then expand **System Databases** as shown following.

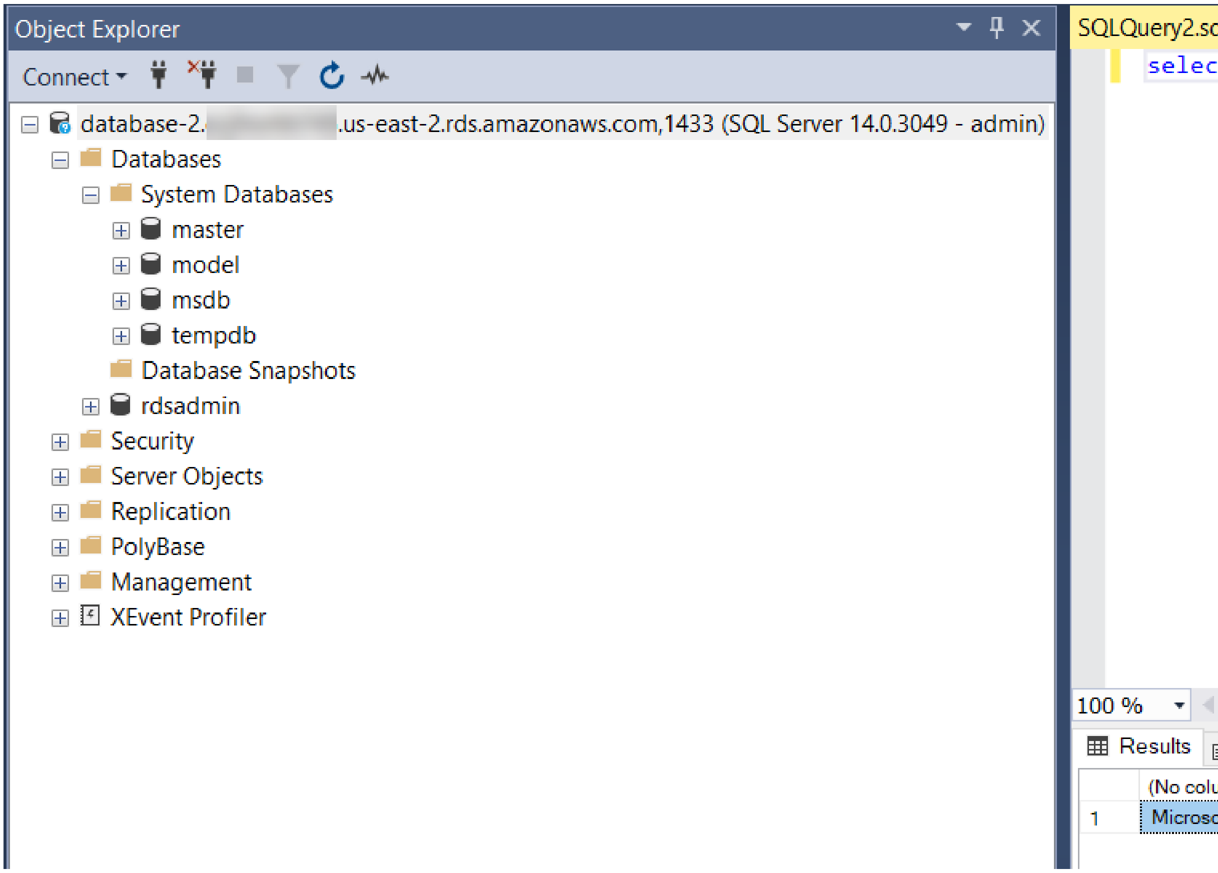


8. Your SQL Server DB instance also comes with a database named `rdsadmin`. Amazon RDS uses this database to store the objects that it uses to manage your database. The `rdsadmin` database also includes stored procedures that you can run to perform advanced tasks. For more information, see Common DBA Tasks for Microsoft SQL Server (p. 693).
9. You can now start creating your own databases and running queries against your DB instance and databases as usual. To run a test query against your DB instance, do the following:

   a. In SSMS, on the **File** menu point to **New** and then choose **Query with Current Connection**.
   b. Enter the following SQL query.

   ```
   select @@VERSION
   ```

   c. Run the query. SSMS returns the SQL Server version of your Amazon RDS DB instance.



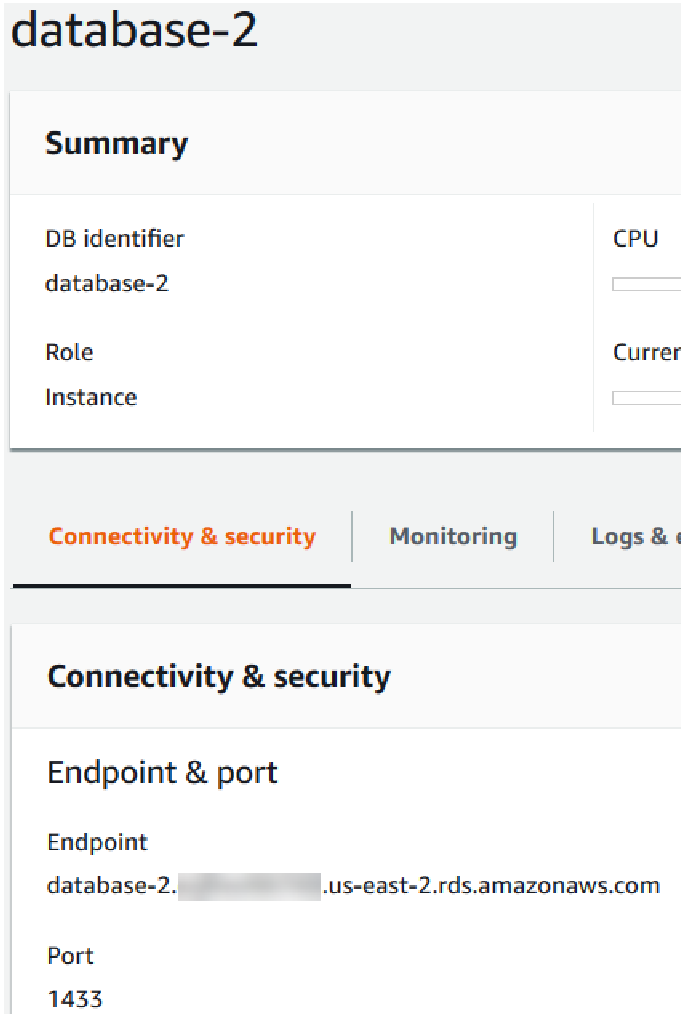
Connecting to Your DB Instance with SQL Workbench/J

This example shows how to connect to a DB instance running the Microsoft SQL Server database engine by using the SQL Workbench/J database tool. To download SQL Workbench/J, see SQL Workbench/J.

SQL Workbench/J uses JDBC to connect to your DB instance. You also need the JDBC driver for SQL Server. To download this driver, see Microsoft JDBC Drivers 4.1 (Preview) and 4.0 for SQL Server.

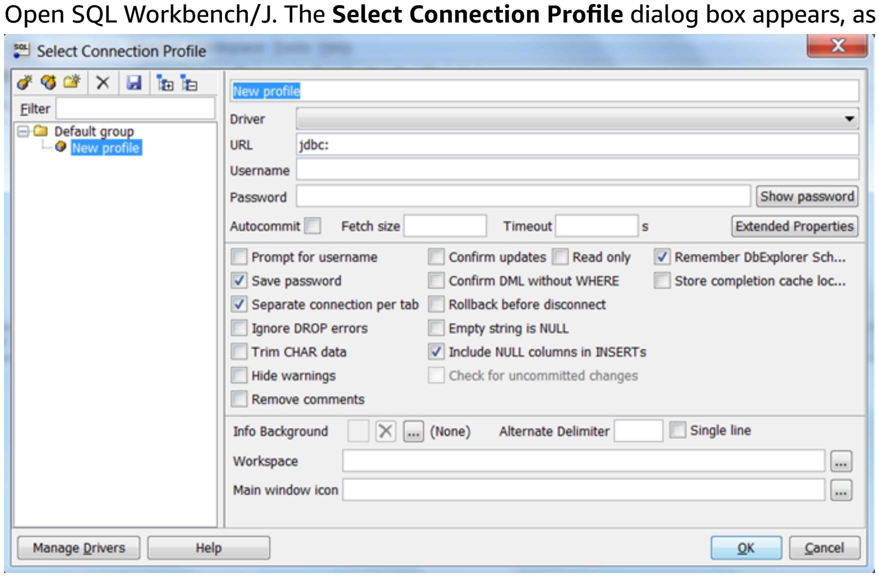
To connect to a DB instance using SQL Workbench

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the Amazon RDS console, choose the AWS Region of your DB instance.
3. Find the DNS name and port number for your DB instance:
    a. Open the RDS console, then choose **Databases** to display a list of your DB instances.
    b. Choose the name of your SQL Server DB instance to display its details.



c. On the **Connectivity** tab, copy the endpoint. Also, note the port used by the DB instance.

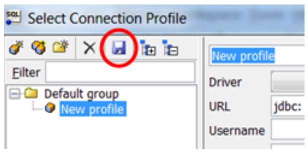
4. Open SQL Workbench/J. The **Select Connection Profile** dialog box appears, as shown following.



5. In the first box at the top of the dialog box, enter a name for the profile.
6. For **Driver**, choose **`SQL JDBC 4.0`**.
7. For **URL**, enter **`jdbc:sqlserver://`**, then enter the endpoint of your DB instance. For example, the URL value might be the following.

```
jdbc:sqlserver://sqlsvr-pdz.abcd12340.us-west-2.rds.amazonaws.com:1433
```

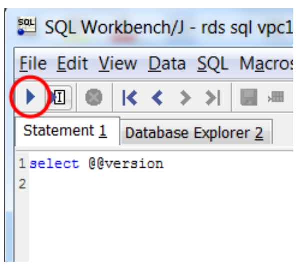
8. For **Username**, enter the master user name for the DB instance.
9. For **Password**, enter the password for the master user.
10. Choose the save icon in the dialog toolbar, as shown following.



11. Choose **OK**. After a few moments, SQL Workbench/J connects to your DB instance. If you can't connect to your DB instance, see Security Group Considerations (p. 566) and Troubleshooting Connections to Your SQL Server DB Instance (p. 567).
12. In the query pane, enter the following SQL query.

```
select @@VERSION
```

13. Choose the execute icon in the toolbar, as shown following.



The query returns the version information for your DB instance, similar to the following.

```
Microsoft SQL Server 2012 - 11.0.2100.60 (X64)
```

Security Group Considerations

To connect to your DB instance, your DB instance must be associated with a security group. This security group contains the IP addresses and network configuration that you use to access the DB instance. You might have associated your DB instance with an appropriate security group when you created your DB instance. If you assigned a default, no-configured security group when you created your DB instance, your DB instance firewall prevents connections.

In some cases, you might need to create a new security group to enable access. If so, the type of security group to create depends on what Amazon EC2 platform your DB instance is on. To determine your platform, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434). In general, if your DB instance is on the EC2-Classic platform, you create a DB security group. If your DB instance is on the VPC platform, you create a VPC security group.

For instructions on creating a new security group, see Controlling Access with Security Groups (p. 1414). For a topic that walks you through the process of setting up rules for your VPC security group, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).

After you have created the new security group, modify your DB instance to associate it with the security group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

You can enhance security by using SSL to encrypt connections to your DB instance. For more information, see Using SSL with a Microsoft SQL Server DB Instance (p. 609).

Troubleshooting Connections to Your SQL Server DB Instance

The following table shows error messages that you might encounter when you attempt to connect to your SQL Server DB instance. For more information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

<table>
<tr><th>Issue</th><th>Troubleshooting Suggestions</th></tr>
<tr><td>Could not open a connection to SQL Server – Microsoft SQL Server, Error: 53</td><td>Make sure that you specified the server name correctly. For Server name, enter the DNS name and port number of your sample DB instance, separated by a comma.
Important
If you have a colon between the DNS name and port number, change the colon to a comma.
Your server name should look like the following example.
<code>sample-instance.cg034itsfake.us-east-1.rds.amazonaws.com,1433</code></td></tr>
<tr><td>No connection could be made because the target machine actively refused it – Microsoft SQL Server, Error: 10061</td><td>You were able to reach the DB instance but the connection was refused. This issue is usually caused by specifying the user name or password incorrectly. Verify the user name and password, then retry.</td></tr>
<tr><td rowspan="2">A network-related or instance-specific error occurred while establishing a connection to SQL Server. The server was not found or was not accessible... The wait operation timed out – Microsoft SQL Server, Error: 258</td><td>The access rules enforced by your local firewall and the IP addresses authorized to access your DB instance might not match. The problem is most likely the inbound rules in your security group.</td></tr>
<tr><td>Your database instance must be publicly accessible. To connect to it from outside of the VPC, the instance must have a public IP address assigned.</td></tr>
</table>

Updating Applications to Connect to Microsoft SQL Server DB Instances Using New SSL/TLS Certificates

As of September 19, 2019, Amazon RDS has published new Certificate Authority (CA) certificates for connecting to your RDS DB instances using Secure Socket Layer or Transport Layer Security (SSL/TLS). Following, you can find information about updating your applications to use the new certificates.

This topic can help you to determine whether any client applications use SSL/TLS to connect to your DB instances. If they do, you can further check whether those applications require certificate verification to connect.

> **Note**
> Some applications are configured to connect to SQL Server DB instances only if they can successfully verify the certificate on the server.
> For such applications, you must update your client application trust stores to include the new CA certificates.

After you update your CA certificates in the client application trust stores, you can rotate the certificates on your DB instances. We strongly recommend testing these procedures in a development or staging environment before implementing them in your production environments.

For more information about certificate rotation, see Rotating Your SSL/TLS Certificate (p. 1363). For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For information about using SSL/TLS with Microsoft SQL Server DB instances, see Using SSL with a Microsoft SQL Server DB Instance (p. 609).

Topics

Determining Whether Any Applications are Connecting to Your Microsoft SQL Server DB Instance Using SSL

Check the DB instance configuration for the value of the `rds.force_ssl` parameter. By default, the `rds.force_ssl` parameter is set to 0 (off). If the `rds.force_ssl` parameter is set to 1 (on), clients are required to use SSL/TLS for connections. For more information about parameter groups, see Working with DB Parameter Groups (p. 202). You can also find the setting for this parameter in the `sys.dm_server_registry` DMV.

Run the following query to get the current encryption option for all the open connections to a DB instance. The column `ENCRYPT_OPTION` returns `TRUE` if the connection is encrypted.

```
select SESSION_ID,
    ENCRYPT_OPTION,
    NET_TRANSPORT,
    AUTH_SCHEME
```

```
    from SYS.DM_EXEC_CONNECTIONS
```

This query shows only the current connections. It doesn't show whether applications that have connected and disconnected in the past have used SSL.

Determining Whether a Client Requires Certificate Verification in Order to Connect

You can check whether different types of clients require certificate verification to connect.

> **Note**
> If you use connectors other than the ones listed, see the specific connector's documentation for information about how it enforces encrypted connections. For more information, see Connection modules for Microsoft SQL databases in the Microsoft SQL Server documentation.

SQL Server Management Studio

Check whether encryption is enforced for SQL Server Management Studio connections:

1. Launch SQL Server Management Studio.
2. For **Connect to server**, enter the server information, login user name, and password.
3. Choose **Options**.
4. Check if **Encrypt connection** is selected in the connect page.

For more information about SQL Server Management Studio, see Use SQL Server Management Studio.

sqlcmd

The following example with the `sqlcmd` client shows how to check a script's SQL Server connection to determine whether successful connections require a valid certificate. For more information, see Connecting with sqlcmd in the Microsoft SQL Server documentation.

When using `sqlcmd`, an SSL connection requires verification against the server certificate if you use the `-N` command argument to encrypt connections, as in the following example.

```
$ sqlcmd -N -S dbinstance.rds.amazon.com -d ExampleDB
```

> **Note**
> If `sqlcmd` is invoked with the `-C` option, it trusts the server certificate, even if that doesn't match the client-side trust store.

ADO.NET

In the following example, the application connects using SSL, and the server certificate must be verified.

```
using SQLC = Microsoft.Data.SqlClient;

...

    static public void Main()
```

```
    {
        using (var connection = new SQLC.SqlConnection(
            "Server=tcp:dbinstance.rds.amazon.com;" +
            "Database=ExampleDB;User ID=LOGIN_NAME;" +
            "Password=YOUR_PASSWORD;" +
            "Encrypt=True;TrustServerCertificate=False;"
            ))
        {
            connection.Open();
            ...
        }
```

Java

In the following example, the application connects using SSL, and the server certificate must be verified.

```
String connectionUrl =
    "jdbc:sqlserver://dbinstance.rds.amazon.com;" +
    "databaseName=ExampleDB;integratedSecurity=true;" +
    "encrypt=true;trustServerCertificate=false";
```

To enable SSL encryption for clients that connect using JDBC, you might need to add the Amazon RDS certificate to the Java CA certificate store. For instructions, see Configuring the client for encryption in the Microsoft SQL Server documentation. You can also provide the trusted CA certificate file name directly by appending `trustStore=`*`path-to-certificate-trust-store-file`* to the connection string.

> **Note**
> If you use `TrustServerCertificate=true` (or its equivalent) in the connection string, the connection process skips the trust chain validation. In this case, the application connects even if the certificate can't be verified. Using `TrustServerCertificate=false` enforces certificate validation and is a best practice.

Updating Your Application Trust Store

You can update the trust store for applications that use Microsoft SQL Server. For instructions, see Encrypting Specific Connections (p. 610). Also, see Configuring the client for encryption in the Microsoft SQL Server documentation.

If you are using an operating system other than Microsoft Windows, see the software distribution documentation for SSL/TLS implementation for information about adding a new root CA certificate. For example, OpenSSL and GnuTLS are popular options. Use the implementation method to add trust to the RDS root CA certificate. Microsoft provides instructions for configuring certificates on some systems.

> **Note**
> When you update the trust store, you can retain older certificates in addition to adding the new certificates.

Updating Your Application Trust Store for JDBC

You can update the trust store for applications that use JDBC for SSL/TLS connections.

To update the trust store for JDBC applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in the trust store directory.

For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

2. Convert the certificate to .der format using the following command.

```
openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
```

Replace the file name with the one that you downloaded.

3. Import the certificate into the key store using the following command.

```
keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
```

4. Confirm that the key store was updated successfully.

```
keytool -list -v -keystore clientkeystore.jks
```

Enter the key store password when you are prompted for it.

Your output should contain the following.

```
rds-root,date, trustedCertEntry,
Certificate fingerprint (SHA1):
 D4:0D:DB:29:E3:75:0D:FF:A6:71:C3:14:0B:BF:5F:47:8D:1C:80:96
# This fingerprint should match the output from the below command
openssl x509 -fingerprint -in rds-ca-2019-root.pem -noout
```

Important

After you have determined that your database connections use SSL/TLS and have updated your application trust store, you can update your database to use the rds-ca-2019 certificates. For instructions, see step 3 in Updating Your CA Certificate by Modifying Your DB Instance (p. 1363).

Upgrading the Microsoft SQL Server DB Engine

When Amazon RDS supports a new version of a database engine, you can upgrade your DB instances to the new version. There are two kinds of upgrades for SQL Server DB instances: major version upgrades and minor version upgrades.

Major version upgrades can contain database changes that are not backward-compatible with existing applications. As a result, you must manually perform major version upgrades of your DB instances. You can initiate a major version upgrade by modifying your DB instance. However, before you perform a major version upgrade, we recommend that you test the upgrade by following the steps described in Testing an Upgrade (p. 574).

In contrast, *minor version upgrades* include only changes that are backward-compatible with existing applications. You can initiate a minor version upgrade manually by modifying your DB instance.

Amazon RDS on SQL Server doesn't support automatic minor version upgrades. You can confirm this by using the `describe-db-engine-versions` AWS CLI command. For example:

```
aws rds describe-db-engine-versions --engine sqlserver-se --engine-version 14.00.3049.1.v1
```

In this example, the CLI command returns the following response that indicates that the upgrade will *not* be automatic, even if **Auto minor version upgrade** had been enabled:

```
...

"ValidUpgradeTarget": [
    {
        "Engine": "sqlserver-se",
        "EngineVersion": "14.00.3192.2.v1",
        "Description": "SQL Server 2017 14.00.3192.2.v1",
        "AutoUpgrade": false,
        "IsMajorVersionUpgrade": false
    }

...
```

For more information about performing upgrades, see Upgrading a SQL Server DB Instance (p. 575). For information about what SQL Server versions are available on Amazon RDS, see Microsoft SQL Server on Amazon RDS (p. 542).

Topics

Overview of Upgrading

Amazon RDS takes two DB snapshots during the upgrade process. The first DB snapshot is of the DB instance before any upgrade changes have been made. If the upgrade doesn't work for your databases, you can restore this snapshot to create a DB instance running the old version. The second DB snapshot is taken after the upgrade completes.

> **Note**
> Amazon RDS only takes DB snapshots if you have set the backup retention period for your DB instance to a number greater than 0. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220).

After an upgrade is complete, you can't revert to the previous version of the database engine. If you want to return to the previous version, restore the DB snapshot that was taken before the upgrade to create a new DB instance.

During a minor or major version upgrade of SQL Server, the **Free Storage Space** and **Disk Queue Depth** metrics will display `-1`. After the upgrade is complete, both metrics will return to normal.

Major Version Upgrades

Amazon RDS currently supports the following major version upgrades to a Microsoft SQL Server DB instance.

You can upgrade your existing DB instance to SQL Server 2017 from any version except SQL Server 2008. To upgrade from SQL Server 2008, first upgrade to one of the other versions.

Current Version	Supported Upgrade Versions
SQL Server 2016	SQL Server 2017
SQL Server 2014	SQL Server 2017 SQL Server 2016
SQL Server 2012	SQL Server 2017 SQL Server 2016 SQL Server 2014
SQL Server 2008 R2 (Deprecated)	SQL Server 2016 SQL Server 2014 SQL Server 2012

Database Compatibility Level

You can use Microsoft SQL Server database compatibility levels to adjust some database behaviors to mimic previous versions of SQL Server. For more information, see Compatibility Level in the Microsoft documentation.

When you upgrade your DB instance, all existing databases remain at their original compatibility level. For example, if you upgrade from SQL Server 2012 to SQL Server 2014, all existing databases have a compatibility level of 110. Any new database created after the upgrade have compatibility level 120.

You can change the compatibility level of a database by using the ALTER DATABASE command. For example, to change a database named `customeracct` to be compatible with SQL Server 2014, issue the following command:

```
ALTER DATABASE customeracct SET COMPATIBILITY_LEVEL = 120
```

Multi-AZ and In-Memory Optimization Considerations

Amazon RDS supports Multi-AZ deployments for DB instances running Microsoft SQL Server by using SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs). For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).

If your DB instance is in a Multi-AZ deployment, both the primary and standby instances are upgraded. Amazon RDS does rolling upgrades. You have an outage only for the duration of a failover.

SQL Server 2014/2016/2017 Enterprise Edition supports in-memory optimization.

Option and Parameter Group Considerations

Option Group Considerations

If your DB instance uses a custom option group, in some cases Amazon RDS can't automatically assign your DB instance a new option group. For example, when you upgrade to a new major version. In that case, you must specify a new option group when you upgrade. We recommend that you create a new option group, and add the same options to it as your existing custom option group.

For more information, see Creating an Option Group (p. 187) or Making a Copy of an Option Group (p. 189).

Parameter Group Considerations

If your DB instance uses a custom parameter group, in some cases Amazon RDS can't automatically assign your DB instance a new parameter group. For example, when you upgrade to a new major version. In that case, you must specify a new parameter group when you upgrade. We recommend that you create a new parameter group, and configure the parameters as in your existing custom parameter group.

For more information, see Creating a DB Parameter Group (p. 203) or Copying a DB Parameter Group (p. 207).

Testing an Upgrade

Before you perform a major version upgrade on your DB instance, you should thoroughly test your database, and all applications that access the database, for compatibility with the new version. We recommend that you use the following procedure.

To test a major version upgrade

1. Review the upgrade documentation for the new version of the database engine to see if there are compatibility issues that might affect your database or applications:
   - Upgrade to SQL Server 2016 or 2017
   - Upgrade to SQL Server 2014
   - Upgrade to SQL Server 2012
2. If your DB instance uses a custom option group, create a new option group compatible with the new version you are upgrading to. For more information, see Option Group Considerations (p. 574).

3. If your DB instance uses a custom parameter group, create a new parameter group compatible with the new version you are upgrading to. For more information, see Parameter Group Considerations (p. 574).
4. Create a DB snapshot of the DB instance to be upgraded. For more information, see Creating a DB Snapshot (p. 301).
5. Restore the DB snapshot to create a new test DB instance. For more information, see Restoring from a DB Snapshot (p. 303).
6. Modify this new test DB instance to upgrade it to the new version, by using one of the following methods:
   - Console (p. 241)
   - AWS CLI (p. 242)
   - RDS API (p. 242)
7. Evaluate the storage used by the upgraded instance to determine if the upgrade requires additional storage.
8. Run as many of your quality assurance tests against the upgraded DB instance as needed to ensure that your database and application work correctly with the new version. Implement any new tests needed to evaluate the impact of any compatibility issues you identified in step 1. Test all stored procedures and functions. Direct test versions of your applications to the upgraded DB instance.
9. If all tests pass, then perform the upgrade on your production DB instance. We recommend that you do not allow write operations to the DB instance until you confirm that everything is working correctly.

Upgrading a SQL Server DB Instance

For information about manually or automatically upgrading a SQL Server DB instance, see the following:

- Upgrading a DB Instance Engine Version (p. 241)
- Best practices for upgrading SQL Server 2008 R2 to SQL Server 2016 on Amazon RDS for SQL Server

Important
If you have any snapshots that are encrypted using KMS, we recommend that you initiate an upgrade before support ends.

Upgrading Deprecated DB Instances Before Support Ends

After a major version is deprecated, you can't install it on new DB instances. RDS will try to automatically upgrade all existing DB instances.

If you need to restore a deprecated DB instance, you can do a point-in-time restore (PITR) or restore a snapshot. Doing this gives you temporary access a DB instance that uses the version that is being deprecated. However, after a major version is fully deprecated, these DB instances will also be automatically upgraded to a supported version.

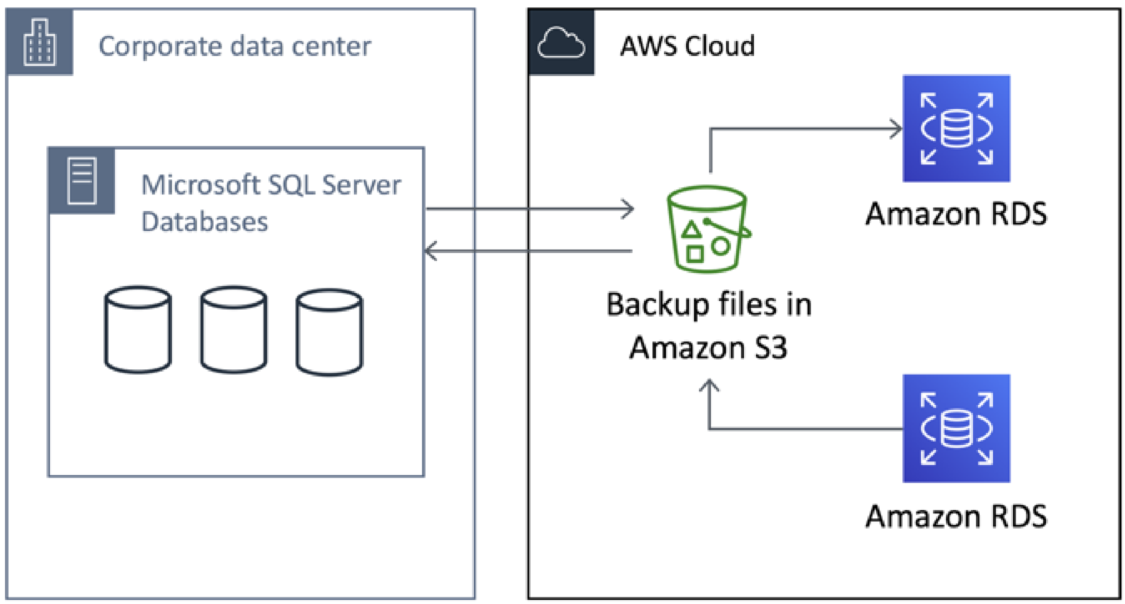
Importing and Exporting SQL Server Databases

Amazon RDS supports native backup and restore for Microsoft SQL Server databases using full backup files (.bak files). When you use RDS, you access files stored in Amazon S3 rather than using the local file system on the database server.

For example, you can create a full backup from your local server, store it on S3, and then restore it onto an existing Amazon RDS DB instance. You can also make backups from RDS, store them on S3, and then restore them wherever you want.

Native backup and restore is available in all AWS Regions, and for both Single-AZ and Multi-AZ DB instances. Native backup and restore is available for all editions of Microsoft SQL Server supported on Amazon RDS.

The following diagram shows the supported scenarios.



Using native .bak files to back up and restore databases is usually the fastest way to back up and restore databases. There are many additional advantages to using native backup and restore. For example, you can do the following:

- Migrate databases to or from Amazon RDS.
- Move databases between RDS SQL Server DB instances.
- Migrate data, schemas, stored procedures, triggers, and other database code inside .bak files.
- Backup and restore single databases, instead of entire DB instances.
- Create copies of databases for development, testing, training, and demonstrations.
- Store and transfer backup files with Amazon S3, for an added layer of protection for disaster recovery.

Limitations and Recommendations

The following are some limitations to using native backup and restore:

- You can't back up to, or restore from, an Amazon S3 bucket in a different AWS Region from your Amazon RDS DB instance.
- We strongly recommend that you don't restore backups from one time zone to a different time zone. If you restore backups from one time zone to a different time zone, you must audit your queries and applications for the effects of the time zone change.
- Native backups of RDS databases larger than 1 TB aren't supported.
- You can't back up to or restore from more than 10 backup files at the same time.
- A differential backup is based on the last full backup. For differential backups to work, you can't take a snapshot between the last full backup and the differential backup. If you want a differential backup, but a manual or automated snapshot exists, then do another full backup before proceeding with the differential backup.
- Differential and log restores aren't supported for databases with files that have their file_guid (unique identifier) set to `NULL`.
- You can run up to two backup or restore tasks at the same time.
- You can't perform native log backups from SQL Server on Amazon RDS.
- RDS supports native restores of databases up to 16 TB. Native restores of databases on SQL Server Express Edition are limited to 10 GB.
- You can't do a native backup during the maintenance window, or any time Amazon RDS is in the process of taking a snapshot of the database.
- On Multi-AZ DB instances, you can only natively restore databases that are backed up in the full recovery model.
- Restoring from differential backups on Multi-AZ instances isn't supported.
- Calling the RDS procedures for native backup and restore within a transaction isn't supported.
- Use a symmetric AWS KMS customer master key (CMK) to encrypt your backups. Amazon RDS doesn't support asymmetric CMKs. For more information, see Using Symmetric and Asymmetric Keys in the *AWS Key Management Service Developer Guide*.
- Native backup files are encrypted with the specified AWS KMS key using the "Encryption-Only" crypto mode. When you are restoring encrypted backup files, be aware that they were encrypted with the "Encryption-Only" crypto mode.
- You can't restore a database that contains a FILESTREAM file group.

If your database can be offline while the backup file is created, copied, and restored, we recommend that you use native backup and restore to migrate it to RDS. If your on-premises database can't be offline, we recommend that you use the AWS Database Migration Service to migrate your database to Amazon RDS. For more information, see What Is AWS Database Migration Service?

Native backup and restore isn't intended to replace the data recovery capabilities of the cross-region snapshot copy feature. We recommend that you use snapshot copy to copy your database snapshot to another AWS Region for cross-region disaster recovery in Amazon RDS. For more information, see Copying a Snapshot (p. 306).

Setting Up for Native Backup and Restore

To set up for native backup and restore, you need three components:

1. An Amazon S3 bucket to store your backup files.

   You must have an S3 bucket to use for your backup files and then upload backups you want to migrate to RDS. If you already have an Amazon S3 bucket, you can use that. If you don't, you can create a bucket. Alternatively, you can choose to have a new bucket created for you when you add the `SQLSERVER_BACKUP_RESTORE` option by using the AWS Management Console.

For information on using S3, see the *Amazon Simple Storage Service Getting Started Guide* for a simple introduction. For more depth, see the *Amazon Simple Storage Service Console User Guide*.

2. An AWS Identity and Access Management (IAM) role to access the bucket.

   If you already have an IAM role, you can use that. If you don't have an IAM role, you can create a new one manually. Alternatively, you can choose to have a new IAM role created for you when you add the `SQLSERVER_BACKUP_RESTORE` option by using the AWS Management Console.

   If you want to create a new IAM role manually, take the approach discussed in the next section. Also, if you want to attach trust and permissions policies to an existing IAM role, take the approach discussed in the next section.

3. The `SQLSERVER_BACKUP_RESTORE` option added to an option group on your DB instance.

   To enable native backup and restore on your DB instance, you add the `SQLSERVER_BACKUP_RESTORE` option to an option group on your DB instance. For more information and instructions, see Support for Native Backup and Restore in SQL Server (p. 637).

Manually Creating an IAM Role for Native Backup and Restore

If you want to manually create a new IAM role to use with native backup and restore, you can do so. In this case, you create a role to delegate permissions from the Amazon RDS service to your Amazon S3 bucket. When you create an IAM role, you attach trust and permissions policies. The trust policy allows RDS to assume this role. The permission policy defines the actions this Role can do. For more information about creating the role, see Creating a Role to Delegate Permissions to an AWS Service.

For the native backup and restore feature, use trust and permissions policies similar to the examples in this section. In following example, we use the service principle name `rds.amazonaws.com` as an alias for all service accounts. In the other examples, we specify an Amazon Resource Name (ARN) to identify another account, user, or role that we're granting access to in the trust policy.

Example Trust Policy for Native Backup and Restore

```
{
    "Version": "2012-10-17",
    "Statement":
    [{
        "Effect": "Allow",
        "Principal": {"Service":  "rds.amazonaws.com"},
        "Action": "sts:AssumeRole"
    }]
}
```

The following example uses an ARN to specify a resource. For more information on using ARNs, see Amazon Resource Names (ARNs).

Example Permissions Policy for Native Backup and Restore Without Encryption Support

```
{
    "Version": "2012-10-17",
    "Statement":
    [
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:ListBucket",
                "s3:GetBucketLocation"
            ],
```

```
        "Resource": "arn:aws:s3:::bucket_name"
        },
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:GetObject",
                "s3:PutObject",
                "s3:ListMultipartUploadParts",
                "s3:AbortMultipartUpload"
            ],
        "Resource": "arn:aws:s3:::bucket_name/*"
        }
    ]
}
```

Example Permissions Policy for Native Backup and Restore with Encryption Support

If you want to encrypt your backup files, include an encryption key in your permissions policy. For more information about encryption keys, see Getting Started in the *AWS Key Management Service Developer Guide*.

> **Note**
> You must use a symmetric AWS KMS customer master key (CMK) to encrypt your backups. Amazon RDS doesn't support asymmetric CMKs. For more information, see Using Symmetric and Asymmetric Keys in the *AWS Key Management Service Developer Guide*.

```
{
    "Version": "2012-10-17",
    "Statement":
    [
        {
        "Effect": "Allow",
        "Action":
            [
                "kms:DescribeKey",
                "kms:GenerateDataKey",
                "kms:Encrypt",
                "kms:Decrypt"
            ],
        "Resource": "arn:aws:kms:region:account-id:key/key-id"
        },
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:ListBucket",
                "s3:GetBucketLocation"
            ],
        "Resource": "arn:aws:s3:::bucket_name"
        },
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:GetObject",
                "s3:PutObject",
                "s3:ListMultipartUploadParts",
                "s3:AbortMultipartUpload"
            ],
        "Resource": "arn:aws:s3:::bucket_name/*"
        }
    ]
}
```

Using Native Backup and Restore

After you have enabled and configured native backup and restore, you can start using it. First, you connect to your Microsoft SQL Server database, and then you call an Amazon RDS stored procedure to do the work. For instructions on connecting to your database, see Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560).

Some of the stored procedures require that you provide an Amazon Resource Name (ARN) to your Amazon S3 bucket and file. The format for your ARN is `arn:aws:s3:::bucket_name/file_name.extension`. Amazon S3 doesn't require an account number or AWS Region in ARNs.

If you also provide an optional AWS KMS encryption key, the format for the ARN of the key is `arn:aws:kms:region:account-id:key/key-id`. For more information, see Amazon Resource Names (ARNs) and AWS Service Namespaces. You must use a symmetric AWS KMS customer master key (CMK) to encrypt your backups. Amazon RDS doesn't support asymmetric CMKs. For more information, see Using Symmetric and Asymmetric Keys in the *AWS Key Management Service Developer Guide*.

For instructions on how to call each stored procedure, see the following topics:

- Backing Up a Database (p. 580)
- Restoring a Database (p. 582)
- Restoring a Log (p. 585)
- Finishing a Database Restore (p. 586)
- Working with Partially Restored Databases (p. 587)
- Canceling a Task (p. 587)
- Tracking the Status of Tasks (p. 587)

Backing Up a Database

To back up your database, use the `rds_backup_database` stored procedure.

> **Note**
> You can't back up a database during the maintenance window, or while Amazon RDS is taking a snapshot.

Usage

```
exec msdb.dbo.rds_backup_database
 @source_db_name='database_name',
 @s3_arn_to_backup_to='arn:aws:s3:::bucket_name/file_name.extension',
 [@kms_master_key_arn='arn:aws:kms:region:account-id:key/key-id'],
 [@overwrite_s3_backup_file=0|1],
 [@type='DIFFERENTIAL|FULL'],
 [@number_of_files=n];
```

The following parameters are required:

- `@source_db_name` – The name of the database to back up.
- `@s3_arn_to_backup_to` – The ARN indicating the Amazon S3 bucket to use for the backup, plus the name of the backup file.

  The file can have any extension, but `.bak` is usually used.

The following parameters are optional:

- `@kms_master_key_arn` – The ARN for the symmetric KMS customer master key (CMK) to use to encrypt the item.
  - You can't use the default encryption key. If you use the default key, the database won't be backed up.
  - If you don't specify a KMS key identifier, the backup file won't be encrypted. For more information, see Encrypting Amazon RDS Resources.
  - Amazon RDS doesn't support asymmetric CMKs. For more information, see Using Symmetric and Asymmetric Keys in the *AWS Key Management Service Developer Guide*.
- `@overwrite_s3_backup_file` – A value that indicates whether to overwrite an existing backup file.
  - `0` – Doesn't overwrite an existing file. This value is the default.

    Setting `@overwrite_s3_backup_file` to 0 returns an error if the file already exists.
  - `1` – Overwrites an existing file that has the specified name, even if it isn't a backup file.
- `@type` – The type of backup.
  - `DIFFERENTIAL` – Makes a differential backup.
  - `FULL` – Makes a full backup. This value is the default.

  A differential backup is based on the last full backup. For differential backups to work, you can't take a snapshot between the last full backup and the differential backup. If you want a differential backup, but a snapshot exists, then do another full backup before proceeding with the differential backup.

  You can look for the last full backup or snapshot using the following example SQL query:

```
select top 1
database_name
,  backup_start_date
,  backup_finish_date
from    msdb.dbo.backupset
where   database_name='mydatabase'
and     type = 'D'
order by backup_start_date desc;
```

- `@number_of_files` – The number of files into which the backup will be divided (chunked). The maximum number is 10.
  - Multifile backup is supported for both full and differential backups.
  - If you enter a value of 1 or omit the parameter, a single backup file is created.

  Provide the prefix that the files have in common, then suffix that with an asterisk (`*`). The asterisk can be anywhere in the *`file_name`* part of the S3 ARN. The asterisk is replaced by a series of alphanumeric strings in the generated files, starting with `1-of-`*`number_of_files`*.

  For example, if the file names in the S3 ARN are `backup*.bak` and you set `@number_of_files=4`, the backup files generated are `backup1-of-4.bak`, `backup2-of-4.bak`, `backup3-of-4.bak`, and `backup4-of-4.bak`.
  - If any of the file names already exists, and `@overwrite_s3_backup_file` is 0, an error is returned.
  - Multifile backups can only have one asterisk in the *`file_name`* part of the S3 ARN.
  - Single-file backups can have any number of asterisks in the *`file_name`* part of the S3 ARN. Asterisks aren't removed from the generated file name.

Examples

Example of Differential Backup

```
exec msdb.dbo.rds_backup_database
```

```
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup1.bak',
@overwrite_s3_backup_file=1,
@type='DIFFERENTIAL';
```

Example of Full Backup with Encryption

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup1.bak',
@kms_master_key_arn='arn:aws:kms:us-east-1:123456789012:key/AKIAIOSFODNN7EXAMPLE',
@overwrite_s3_backup_file=1,
@type='FULL';
```

Example of Multifile Backup

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup*.bak',
@number_of_files=4;
```

Example of Multifile Differential Backup

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup*.bak',
@type='DIFFERENTIAL',
@number_of_files=4;
```

Example of Multifile Backup with Encryption

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup*.bak',
@kms_master_key_arn='arn:aws:kms:us-east-1:123456789012:key/AKIAIOSFODNN7EXAMPLE',
@number_of_files=4;
```

Example of Multifile Backup with S3 Overwrite

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup*.bak',
@overwrite_s3_backup_file=1,
@number_of_files=4;
```

Example of Single-File Backup with the @number_of_files Parameter

This example generates a backup file named `backup*.bak`.

```
exec msdb.dbo.rds_backup_database
@source_db_name='mydatabase',
@s3_arn_to_backup_to='arn:aws:s3:::aws_example_bucket/backup*.bak',
@number_of_files=1;
```

Restoring a Database

To restore your database, call the `rds_restore_database` stored procedure. Amazon RDS creates an initial snapshot of the database after the restore task is complete and the database is open.

Usage

```
exec msdb.dbo.rds_restore_database
 @restore_db_name='database_name',
 @s3_arn_to_restore_from='arn:aws:s3:::bucket_name/file_name.extension',
 @with_norecovery=0|1,
 [@kms_master_key_arn='arn:aws:kms:region:account-id:key/key-id'],
 [@type='DIFFERENTIAL|FULL'];
```

The following parameters are required:

- `@restore_db_name` – The name of the database to restore.
- `@s3_arn_to_restore_from` – The ARN indicating the Amazon S3 prefix and names of the backup files used to restore the database.
  - For a single-file backup, provide the entire file name.
  - For a multifile backup, provide the prefix that the files have in common, then suffix that with an asterisk (`*`).
  - If `@s3_arn_to_restore_from` is empty, the following error message is returned: S3 ARN prefix cannot be empty.

The following parameter is required for differential restores, but optional for full restores:

- `@with_norecovery` – The recovery clause to use for the restore operation.
  - Set it to `0` to restore with RECOVERY. In this case, the database is online after the restore.
  - Set it to `1` to restore with NORECOVERY. In this case, the database remains in the RESTORING state after restore task completion. With this approach, you can do later differential restores.
  - For DIFFERENTIAL restores, specify `0` or `1`.
  - For `FULL` restores, this value defaults to `0`.

The following parameters are optional:

- `@kms_master_key_arn` – If you encrypted the backup file, the KMS key to use to decrypt the file.
- `@type` – The type of restore. Valid types are `DIFFERENTIAL` and `FULL`. The default value is `FULL`.

> **Note**
> For differential restores, either the database must be in the RESTORING state or a task must already exist that restores with NORECOVERY.
> You can't restore later differential backups while the database is online.
> You can't submit a restore task for a database that already has a pending restore task with RECOVERY.
> Full restores with NORECOVERY and differential restores aren't supported on Multi-AZ instances.

Examples

Example of Single-File Restore

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak';
```

Example of Multifile Restore

To avoid errors when restoring multiple files, make sure that all the backup files have the same prefix, and that no other files use that prefix.

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup*';
```

Example of Full Database Restore with RECOVERY

The following three examples perform the same task, full restore with RECOVERY.

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak';
```

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
[@type='DIFFERENTIAL|FULL'];
```

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
@type='FULL',
@with_norecovery=0;
```

Example of Full Database Restore with Encryption

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
@kms_master_key_arn='arn:aws:kms:us-east-1:123456789012:key/AKIAIOSFODNN7EXAMPLE';
```

Example of Full Database Restore with NORECOVERY

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
@type='FULL',
@with_norecovery=1;
```

Example of Differential Restore with NORECOVERY

```
exec msdb.dbo.rds_restore_database
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
@type='DIFFERENTIAL',
@with_norecovery=1;
```

Example of Differential Restore with RECOVERY

```
exec msdb.dbo.rds_restore_database
```

```
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/backup1.bak',
@type='DIFFERENTIAL',
@with_norecovery=0;
```

Restoring a Log

To restore your log, call the `rds_restore_log` stored procedure.

Usage

```
exec msdb.dbo.rds_restore_log
 @restore_db_name='database_name',
 @s3_arn_to_restore_from='arn:aws:s3:::bucket_name/log_file_name.extension',
 [@kms_master_key_arn='arn:aws:kms:region:account-id:key/key-id'],
 [@with_norecovery=0|1],
 [@stopat='datetime'];
```

The following parameters are required:

- `@restore_db_name` – The name of the database whose log to restore.
- `@s3_arn_to_restore_from` – The ARN indicating the Amazon S3 prefix and name of the log file used to restore the log. The file can have any extension, but `.trn` is usually used.

  If `@s3_arn_to_restore_from` is empty, the following error message is returned: S3 ARN prefix cannot be empty.

The following parameters are optional:

- `@kms_master_key_arn` – If you encrypted the log, the KMS key to use to decrypt the log.
- `@with_norecovery` – The recovery clause to use for the restore operation. This value defaults to `1`.
  - Set it to `0` to restore with RECOVERY. In this case, the database is online after the restore. You can't restore further log backups while the database is online.
  - Set it to `1` to restore with NORECOVERY. In this case, the database remains in the RESTORING state after restore task completion. With this approach, you can do later log restores.
- `@stopat` – A value that specifies that the database is restored to its state at the date and time specified (in datetime format). Only transaction log records written before the specified date and time are applied to the database.

  If this parameter isn't specified (it is NULL), the complete log is restored.

> **Note**
> For log restores, either the database must be in a state of restoring or a task must already exist that restores with NORECOVERY.
> You can't restore log backups while the database is online.
> You can’t submit a log restore task on a database that already has a pending restore task with RECOVERY.
> Log restores aren't supported on Multi-AZ instances.

Examples

Example of Log Restore

```
exec msdb.dbo.rds_restore_log
```

```
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn';
```

Example of Log Restore with Encryption

```
exec msdb.dbo.rds_restore_log
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn',
@kms_master_key_arn='arn:aws:kms:us-east-1:123456789012:key/AKIAIOSFODNN7EXAMPLE';
```

Example of Log Restore with NORECOVERY

The following two examples perform the same task, log restore with NORECOVERY.

```
exec msdb.dbo.rds_restore_log
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn',
@with_norecovery=1;
```

```
exec msdb.dbo.rds_restore_log
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn';
```

Example of Log Restore with RECOVERY

```
exec msdb.dbo.rds_restore_log
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn',
@with_norecovery=0;
```

Example of Log Restore with STOPAT Clause

```
exec msdb.dbo.rds_restore_log
@restore_db_name='mydatabase',
@s3_arn_to_restore_from='arn:aws:s3:::aws_example_bucket/mylog.trn',
@with_norecovery=0,
@stopat='2019-12-01 03:57:09';
```

Finishing a Database Restore

If the last restore task on the database was performed using `@with_norecovery=1`, the database is now in the RESTORING state. Open this database for normal operation by using the `rds_finish_restore` stored procedure.

Usage

```
exec msdb.dbo.rds_finish_restore @db_name='database_name';
```

> **Note**
> To use this approach, the database must be in the RESTORING state without any pending restore tasks.
> The `rds_finish_restore` procedure isn't supported on Multi-AZ instances.

To finish restoring the database, use the master login. Or use the user login that most recently restored the database or log with NORECOVERY.

Working with Partially Restored Databases

Dropping a Partially Restored Database

To drop a partially restored database (left in the RESTORING state), use the `rds_drop_database` stored procedure.

```
exec msdb.dbo.rds_drop_database @db_name='database_name';
```

Note
You can’t submit a DROP database request for a database that already has a pending restore or finish restore task.
To drop the database, use the master login. Or use the user login that most recently restored the database or log with NORECOVERY.

Snapshot Restore and Point-in-Time Recovery Behavior for Partially Restored Databases

Partially restored databases in the source instance (left in the RESTORING state) are dropped from the target instance during snapshot restore and point-in-time recovery.

Canceling a Task

To cancel a backup or restore task, call the `rds_cancel_task` stored procedure.

Note
You can't cancel a FINISH_RESTORE task.

Usage

```
exec msdb.dbo.rds_cancel_task @task_id=ID_number;
```

The following parameter is required:

- `@task_id` – The ID of the task to cancel. You can get the task ID by calling `rds_task_status`.

Tracking the Status of Tasks

To track the status of your backup and restore tasks, call the `rds_task_status` stored procedure. If you don't provide any parameters, the stored procedure returns the status of all tasks. The status for tasks is updated approximately every two minutes. Task history is retained for 36 days.

Usage

```
exec msdb.dbo.rds_task_status
 [@db_name='database_name'],
 [@task_id=ID_number];
```

The following parameters are optional:

- `@db_name` – The name of the database to show the task status for.

- `@task_id` – The ID of the task to show the task status for.

Examples

Example of Listing the Status for a Specific Task

```
exec msdb.dbo.rds_task_status @task_id=5;
```

Example of Listing the Status for a Specific Database and Task

```
exec msdb.dbo.rds_task_status
@db_name='my_database',
@task_id=5;
```

Example of Listing All Tasks and Their Statuses on a Specific Database

```
exec msdb.dbo.rds_task_status @db_name='my_database';
```

Example of Listing All Tasks and Their Statuses on the Current Instance

```
exec msdb.dbo.rds_task_status;
```

Response

The `rds_task_status` stored procedure returns the following columns.

Column	Description
`task_id`	The ID of the task.

`task_type`	Task type depending on the input parameters, as follows:
	• For backup tasks:
	  • BACKUP_DB – Full database backup
	  • BACKUP_DB_DIFFERENTIAL – Differential database backup
	• For restore tasks:
	  • RESTORE_DB – Full database restore with RECOVERY
	  • RESTORE_DB_NORECOVERY – Full database restore with NORECOVERY
	  • RESTORE_DB_DIFFERENTIAL – Differential database restore with RECOVERY
	  • RESTORE_DB_DIFFERENTIAL_NORECOVERY – Differential database restore with NORECOVERY
	  • RESTORE_DB_LOG – Log restore with RECOVERY
	  • RESTORE_DB_LOG_NORECOVERY – Log restore with NORECOVERY
	• For tasks that finish a restore:
	  • FINISH_RESTORE – Finish restore and open database
	
	Amazon RDS creates an initial snapshot of the database after it is open on completion of the following restore tasks:
	• RESTORE_DB

Column	Description
	• RESTORE_DB_DIFFERENTIAL • RESTORE_DB_LOG • FINISH_RESTORE
`database_name`	The name of the database that the task is associated with.
`% complete`	The progress of the task as a percent value.
`duration (mins)`	The amount of time spent on the task, in minutes.
`lifecycle`	The status of the task. The possible statuses are the following: • `CREATED` – As soon as you call `rds_backup_database` or `rds_restore_database`, a task is created and the status is set to `CREATED`. • `IN_PROGRESS` – After a backup or restore task starts, the status is set to `IN_PROGRESS`. It can take up to 5 minutes for the status to change from `CREATED` to `IN_PROGRESS`. • `SUCCESS` – After a backup or restore task completes, the status is set to `SUCCESS`. • `ERROR` – If a backup or restore task fails, the status is set to `ERROR`. For more information about the error, see the `task_info` column. • `CANCEL_REQUESTED` – As soon as you call `rds_cancel_task`, the status of the task is set to `CANCEL_REQUESTED`. • `CANCELLED` – After a task is successfully canceled, the status of the task is set to `CANCELLED`.
`task_info`	Additional information about the task. If an error occurs while backing up or restoring a database, this column contains information about the error. For a list of possible errors, and mitigation strategies, see Troubleshooting (p. 590).
`last_updated`	The date and time that the task status was last updated. The status is updated after every 5 percent of progress.
`created_at`	The date and time that the task was created.
`S3_object_arn`	The ARN indicating the Amazon S3 prefix and the name of the file that is being backed up or restored.
`overwrite_s3_backup_file`	The value of the `@overwrite_s3_backup_file` parameter specified when calling a backup task. For more information, see Backing Up a Database (p. 580).
`KMS_master_key_arn`	The ARN for the KMS customer master key used for encryption (for backup) and decryption (for restore).
`filepath`	Not applicable to native backup and restore tasks.
`overwrite_file`	Not applicable to native backup and restore tasks.

Compressing Backup Files

To save space in your Amazon S3 bucket, you can compress your backup files. For more information about compressing backup files, see Backup Compression in the Microsoft documentation.

Compressing your backup files is supported for the following database editions:

- Microsoft SQL Server Enterprise Edition
- Microsoft SQL Server Standard Edition

To turn on compression for your backup files, run the following code:

```
exec rdsadmin..rds_set_configuration 'S3 backup compression', 'true';
```

To turn off compression for your backup files, run the following code:

```
exec rdsadmin..rds_set_configuration 'S3 backup compression', 'false';
```

Troubleshooting

The following are issues you might encounter when you use native backup and restore.

Issue	Troubleshooting Suggestions
`Access Denied`	The backup or restore process is unable to access the backup file. This is usually caused by issues like the following: • Referencing the incorrect bucket. Referencing the bucket using an incorrect format. Referencing a file name without using the ARN. • Incorrect permissions on the bucket file. For example, if it is created by a different account that is trying to access it now, add the correct permissions. • An IAM policy that is incorrect or incomplete. Your IAM role must include all the necessary elements, including, for example, the correct version. These are highlighted in Importing and Exporting SQL Server Databases (p. 576).
`BACKUP DATABASE WITH COMPRESSION isn't supported on <edition_name> Edition`	Compressing your backup files is only supported for Microsoft SQL Server Enterprise Edition and Standard Edition. For more information, see Compressing Backup Files (p. 589).
`Key <ARN> does not exist`	You attempted to restore an encrypted backup, but didn't provide a valid encryption key. Check your encryption key and retry. For more information, see Restoring a Database (p. 582).
`Please reissue task with correct type and overwrite property`	If you attempt to back up your database and provide the name of a file that already exists, but set the overwrite property to false, the save operation fails. To fix this error, either provide the name of a file that doesn't already exist, or set the overwrite property to true. For more information, see Backing Up a Database (p. 580). It's also possible that you intended to restore your database, but called the `rds_backup_database` stored procedure accidentally. In that case, call the `rds_restore_database` stored procedure instead. For more information, see Restoring a Database (p. 582).

Issue	Troubleshooting Suggestions
	If you intended to restore your database and called the `rds_restore_database` stored procedure, make sure that you provided the name of a valid backup file. For more information, see Using Native Backup and Restore (p. 580).
`Please specify a bucket that is in the same region as RDS instance`	You can't back up to, or restore from, an Amazon S3 bucket in a different AWS Region than your Amazon RDS DB instance. You can use Amazon S3 replication to copy the backup file to the correct AWS Region. For more information, see Cross-Region Replication in the Amazon S3 documentation.
`The specified bucket does not exist`	Verify that you have provided the correct ARN for your bucket and file, in the correct format. For more information, see Using Native Backup and Restore (p. 580).
`User <ARN> is not authorized to perform <kms action> on resource <ARN>`	You requested an encrypted operation, but didn't provide correct AWS KMS permissions. Verify that you have the correct permissions, or add them. For more information, see Setting Up for Native Backup and Restore (p. 577).
`The Restore task is unable to restore from more than 10 backup file(s). Please reduce the number of files matched and try again.`	Reduce the number of files you're trying to restore from. You can make each individual file larger if necessary.

Importing and Exporting SQL Server Data Using Other Methods

Following, you can find information about using snapshots to import your Microsoft SQL Server data to Amazon RDS. You can also find information about using snapshots to export your data from an RDS DB instance running SQL Server.

If your scenario supports it, it's easier to move data in and out of Amazon RDS by using the native backup and restore functionality. For more information, see Importing and Exporting SQL Server Databases (p. 576).

> **Note**
> Amazon RDS for Microsoft SQL Server does not support importing data into the `msdb` database.

Importing Data into SQL Server on Amazon RDS by Using a Snapshot

To import data into a SQL Server DB instance by using a snapshot

1. Create a DB instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
2. Stop applications from accessing the destination DB instance.

   If you prevent access to your DB instance while you are importing data, data transfer is faster. Additionally, you don't need to worry about conflicts while data is being loaded if other applications cannot write to the DB instance at the same time. If something goes wrong and you have to roll back to an earlier database snapshot, the only changes that you lose are the imported data. You can import this data again after you resolve the issue.

   For information about controlling access to your DB instance, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).
3. Create a snapshot of the target database.

   If the target database is already populated with data, we recommend that you take a snapshot of the database before you import the data. If something goes wrong with the data import or you want to discard the changes, you can restore the database to its previous state by using the snapshot. For information about database snapshots, see Creating a DB Snapshot (p. 301).

   > **Note**
   > When you take a database snapshot, I/O operations to the database are suspended for a moment (milliseconds) while the backup is in progress.
4. Disable automated backups on the target database.

   Disabling automated backups on the target DB instance improves performance while you are importing your data because Amazon RDS doesn't log transactions when automatic backups are disabled. However, there are some things to consider. Automated backups are required to perform a point-in-time recovery. Thus, you can't restore the database to a specific point in time while you are importing data. Additionally, any automated backups that were created on the DB instance are erased unless you choose to retain them.

   Choosing to retain the automated backups can help protect you against accidental deletion of data. Amazon RDS also saves the database instance properties along with each automated backup to make it easy to recover. Using this option lets you can restore a deleted database instance to a specified point in time within the backup retention period even after deleting it. Automated backups are automatically deleted at the end of the specified backup window, just as they are for an active database instance.

You can also use previous snapshots to recover the database, and any snapshots that you have taken remain available. For information about automated backups, see Working With Backups (p. 291).

5. Disable foreign key constraints, if applicable.

   If you need to disable foreign key constraints, you can do so with the following script.

```
--Disable foreign keys on all tables
    DECLARE @table_name SYSNAME;
    DECLARE @cmd NVARCHAR(MAX);
    DECLARE table_cursor CURSOR FOR SELECT name FROM sys.tables;

    OPEN table_cursor;
    FETCH NEXT FROM table_cursor INTO @table_name;

    WHILE @@FETCH_STATUS = 0 BEGIN
      SELECT @cmd = 'ALTER TABLE '+QUOTENAME(@table_name)+' NOCHECK CONSTRAINT ALL';
      EXEC (@cmd);
      FETCH NEXT FROM table_cursor INTO @table_name;
    END

    CLOSE table_cursor;
    DEALLOCATE table_cursor;

    GO
```

6. Drop indexes, if applicable.
7. Disable triggers, if applicable.

   If you need to disable triggers, you can do so with the following script.

```
--Disable triggers on all tables
    DECLARE @enable BIT = 0;
    DECLARE @trigger SYSNAME;
    DECLARE @table SYSNAME;
    DECLARE @cmd NVARCHAR(MAX);
    DECLARE trigger_cursor CURSOR FOR SELECT trigger_object.name trigger_name,
     table_object.name table_name
    FROM sysobjects trigger_object
    JOIN sysobjects table_object ON trigger_object.parent_obj = table_object.id
    WHERE trigger_object.type = 'TR';

    OPEN trigger_cursor;
    FETCH NEXT FROM trigger_cursor INTO @trigger, @table;

    WHILE @@FETCH_STATUS = 0 BEGIN
      IF @enable = 1
         SET @cmd = 'ENABLE ';
      ELSE
         SET @cmd = 'DISABLE ';

      SET @cmd = @cmd + ' TRIGGER dbo.'+QUOTENAME(@trigger)+' ON
 dbo.'+QUOTENAME(@table)+' ';
      EXEC (@cmd);
      FETCH NEXT FROM trigger_cursor INTO @trigger, @table;
    END

    CLOSE trigger_cursor;
    DEALLOCATE trigger_cursor;

    GO
```

8. Query the source SQL Server instance for any logins that you want to import to the destination DB instance.

   SQL Server stores logins and passwords in the `master` database. Because Amazon RDS doesn't grant access to the `master` database, you cannot directly import logins and passwords into your destination DB instance. Instead, you must query the `master` database on the source SQL Server instance to generate a data definition language (DDL) file. This file should include all logins and passwords that you want to add to the destination DB instance. This file also should include role memberships and permissions that you want to transfer.

   For information about querying the `master` database, see How to Transfer the Logins and the Passwords Between Instances of SQL Server 2005 and SQL Server 2008 in the Microsoft Knowledge Base.

   The output of the script is another script that you can run on the destination DB instance. The script in the Knowledge Base article has the following code:

   ```
   p.type IN
   ```

   Every place `p.type` appears, use the following code instead:

   ```
   p.type = 'S'
   ```

9. Import the data using the method in Import the Data (p. 595).
10. Grant applications access to the target DB instance.

    When your data import is complete, you can grant access to the DB instance to those applications that you blocked during the import. For information about controlling access to your DB instance, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).
11. Enable automated backups on the target DB instance.

    For information about automated backups, see Working With Backups (p. 291).
12. Enable foreign key constraints.

    If you disabled foreign key constraints earlier, you can now enable them with the following script.

    ```
    --Enable foreign keys on all tables
        DECLARE @table_name SYSNAME;
        DECLARE @cmd NVARCHAR(MAX);
        DECLARE table_cursor CURSOR FOR SELECT name FROM sys.tables;

        OPEN table_cursor;
        FETCH NEXT FROM table_cursor INTO @table_name;

        WHILE @@FETCH_STATUS = 0 BEGIN
          SELECT @cmd = 'ALTER TABLE '+QUOTENAME(@table_name)+' CHECK CONSTRAINT ALL';
          EXEC (@cmd);
          FETCH NEXT FROM table_cursor INTO @table_name;
        END

        CLOSE table_cursor;
        DEALLOCATE table_cursor;
    ```
13. Enable indexes, if applicable.
14. Enable triggers, if applicable.

    If you disabled triggers earlier, you can now enable them with the following script.

```
--Enable triggers on all tables
    DECLARE @enable BIT = 1;
    DECLARE @trigger SYSNAME;
    DECLARE @table SYSNAME;
    DECLARE @cmd NVARCHAR(MAX);
    DECLARE trigger_cursor CURSOR FOR SELECT trigger_object.name trigger_name,
     table_object.name table_name
    FROM sysobjects trigger_object
    JOIN sysobjects table_object ON trigger_object.parent_obj = table_object.id
    WHERE trigger_object.type = 'TR';

    OPEN trigger_cursor;
    FETCH NEXT FROM trigger_cursor INTO @trigger, @table;

    WHILE @@FETCH_STATUS = 0 BEGIN
      IF @enable = 1
         SET @cmd = 'ENABLE ';
      ELSE
         SET @cmd = 'DISABLE ';

      SET @cmd = @cmd + ' TRIGGER dbo.'+QUOTENAME(@trigger)+' ON
 dbo.'+QUOTENAME(@table)+' ';
      EXEC (@cmd);
      FETCH NEXT FROM trigger_cursor INTO @trigger, @table;
    END

    CLOSE trigger_cursor;
    DEALLOCATE trigger_cursor;
```

Import the Data

Microsoft SQL Server Management Studio is a graphical SQL Server client that is included in all Microsoft SQL Server editions except the Express Edition. SQL Server Management Studio Express is available from Microsoft as a free download. To find this download, see the Microsoft website.

> **Note**
> SQL Server Management Studio is available only as a Windows-based application.

SQL Server Management Studio includes the following tools, which are useful in importing data to a SQL Server DB instance:

- Generate and Publish Scripts wizard
- Import and Export wizard
- Bulk copy

Generate and Publish Scripts Wizard

The Generate and Publish Scripts wizard creates a script that contains the schema of a database, the data itself, or both. You can generate a script for a database in your local SQL Server deployment. You can then run the script to transfer the information that it contains to an Amazon RDS DB instance.

> **Note**
> For databases of 1 GiB or larger, it's more efficient to script only the database schema. You then use the Import and Export wizard or the bulk copy feature of SQL Server to transfer the data.

For detailed information about the Generate and Publish Scripts wizard, see the Microsoft SQL Server documentation.

In the wizard, pay particular attention to the advanced options on the **Set Scripting Options** page to ensure that everything you want your script to include is selected. For example, by default, database triggers are not included in the script.

When the script is generated and saved, you can use SQL Server Management Studio to connect to your DB instance and then run the script.

Import and Export Wizard

The Import and Export wizard creates a special Integration Services package, which you can use to copy data from your local SQL Server database to the destination DB instance. The wizard can filter which tables and even which tuples within a table are copied to the destination DB instance.

> **Note**
> The Import and Export wizard works well for large datasets, but it might not be the fastest way to remotely export data from your local deployment. For an even faster way, consider the SQL Server bulk copy feature.

For detailed information about the Import and Export wizard, see the Microsoft SQL Server documentation.

In the wizard, on the **Choose a Destination** page, do the following:

- For **Server Name**, type the name of the endpoint for your DB instance.
- For the server authentication mode, choose **Use SQL Server Authentication**.
- For **User name** and **Password**, type the credentials for the master user that you created for the DB instance.

Bulk Copy

The SQL Server bulk copy feature is an efficient means of copying data from a source database to your DB instance. Bulk copy writes the data that you specify to a data file, such as an ASCII file. You can then run bulk copy again to write the contents of the file to the destination DB instance.

This section uses the **bcp** utility, which is included with all editions of SQL Server. For detailed information about bulk import and export operations, see the Microsoft SQL Server documentation.

> **Note**
> Before you use bulk copy, you must first import your database schema to the destination DB instance. The Generate and Publish Scripts wizard, described earlier in this topic, is an excellent tool for this purpose.

The following command connects to the local SQL Server instance. It generates a tab-delimited file of a specified table in the C:\ root directory of your existing SQL Server deployment. The table is specified by its fully qualified name, and the text file has the same name as the table that is being copied.

```
bcp dbname.schema_name.table_name out C:\table_name.txt -n -S localhost -U username -
P password -b 10000
```

The preceding code includes the following options:

- `-n` specifies that the bulk copy uses the native data types of the data to be copied.
- `-S` specifies the SQL Server instance that the *bcp* utility connects to.
- `-U` specifies the user name of the account to log in to the SQL Server instance.
- `-P` specifies the password for the user specified by `-U`.

- `-b` specifies the number of rows per batch of imported data.

> **Note**
> There might be other parameters that are important to your import situation. For example, you might need the `-E` parameter that pertains to identity values. For more information; see the full description of the command line syntax for the **bcp** utility in the Microsoft SQL Server documentation.

For example, suppose that a database named `store` that uses the default schema, `dbo`, contains a table named `customers`. The user account `admin`, with the password `insecure`, copies 10,000 rows of the `customers` table to a file named `customers.txt`.

```
bcp store.dbo.customers out C:\customers.txt -n -S localhost -U admin -P insecure -b 10000
```

After you generate the data file, you can upload the data to your DB instance by using a similar command. Beforehand, create the database and schema on the target DB instance. Then use the `in` argument to specify an input file instead of `out` to specify an output file. Instead of using localhost to specify the local SQL Server instance, specify the endpoint of your DB instance. If you use a port other than 1433, specify that too. The user name and password are the master user and password for your DB instance. The syntax is as follows.

```
bcp dbname.schema_name.table_name in C:\table_name.txt -n -S endpoint,port -
U master_user_name -P master_user_password -b 10000
```

To continue the previous example, suppose that the master user name is `admin`, and the password is `insecure`. The endpoint for the DB instance is `rds.ckz2kqd4qsn1.us-east-1.rds.amazonaws.com`, and you use port 4080. The command is as follows.

```
bcp store.dbo.customers in C:\customers.txt -n -S rds.ckz2kqd4qsn1.us-
east-1.rds.amazonaws.com,4080 -U admin -P insecure -b 10000
```

Exporting Data from SQL Server on Amazon RDS

You can choose one of the following options to export data from an RDS SQL Server DB instance:

- **Native database backup using a full backup file (.bak)** – Using .bak files to backup databases is heavily optimized, and is usually the fastest way to export data. For more information, see Importing and Exporting SQL Server Databases (p. 576).
- **SQL Server Import and Export wizard** – For more information, see SQL Server Import and Export Wizard (p. 597).
- **SQL Server Generate and Publish Scripts wizard and bcp utility** – For more information, see SQL Server Generate and Publish Scripts Wizard and bcp Utility (p. 599).

SQL Server Import and Export Wizard

You can use the SQL Server Import and Export wizard to copy one or more tables, views, or queries from your RDS SQL Server DB instance to another data store. This choice is best if the target data store is not SQL Server. For more information, see SQL Server Import and Export Wizard in the SQL Server documentation.

The SQL Server Import and Export wizard is available as part of Microsoft SQL Server Management Studio. This graphical SQL Server client is included in all Microsoft SQL Server editions except the Express Edition. SQL Server Management Studio is available only as a Windows-based application.

SQL Server Management Studio Express is available from Microsoft as a free download. To find this download, see the Microsoft website.

To use the SQL Server Import and Export wizard to export data

1. In SQL Server Management Studio, connect to your RDS SQL Server DB instance. For details on how to do this, see Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560).
2. In **Object Explorer**, expand **Databases**, open the context (right-click) menu for the source database, choose **Tasks**, and then choose **Export Data**. The wizard appears.
3. On the **Choose a Data Source** page, do the following:

   a. For **Data source**, choose **`SQL Server Native Client 11.0`**.
   b. Verify that the **Server name** box shows the endpoint of your RDS SQL Server DB instance.
   c. Select **Use SQL Server Authentication**. For **User name** and **Password**, type the master user name and password of your Amazon RDS SQL DB.
   d. Verify that the **Database** box shows the database from which you want to export data.
   e. Choose **Next**.
4. On the **Choose a Destination** page, do the following:

   a. For **Destination**, choose **`SQL Server Native Client 11.0`**.

      Note
      Other target data sources are available. These include .NET Framework data providers, OLE DB providers, SQL Server Native Client providers, ADO.NET providers, Microsoft Office Excel, Microsoft Office Access, and the Flat File source. If you choose to target one of these data sources, skip the remainder of step 4. For details on the connection information to provide next, see Choose a Destination in the SQL Server documentation.
   b. For **Server name**, type the server name of the target SQL Server DB instance.
   c. Choose the appropriate authentication type. Type a user name and password if necessary.
   d. For **Database**, choose the name of the target database, or choose **New** to create a new database to contain the exported data.

      If you choose **New**, see Create Database in the SQL Server documentation for details on the database information to provide.
   e. Choose **Next**.
5. On the **Table Copy or Query** page, choose **Copy data from one or more tables or views** or **Write a query to specify the data to transfer**. Choose **Next**.
6. If you chose **Write a query to specify the data to transfer**, you see the **Provide a Source Query** page. Type or paste in a SQL query, and then choose **Parse** to verify it. Once the query validates, choose **Next**.
7. On the **Select Source Tables and Views** page, do the following:

   a. Select the tables and views that you want to export, or verify that the query you provided is selected.
   b. Choose **Edit Mappings** and specify database and column mapping information. For more information, see Column Mappings in the SQL Server documentation.
   c. (Optional) To see a preview of data to be exported, select the table, view, or query, and then choose **Preview**.
   d. Choose **Next**.
8. On the **Run Package** page, verify that **Run immediately** is selected. Choose **Next**.
9. On the **Complete the Wizard** page, verify that the data export details are as you expect. Choose **Finish**.

10. On the **The execution was successful** page, choose **Close**.

SQL Server Generate and Publish Scripts Wizard and bcp Utility

You can use the SQL Server Generate and Publish Scripts wizard to create scripts for an entire database or just selected objects. You can run these scripts on a target SQL Server DB instance to recreate the scripted objects. You can then use the bcp utility to bulk export the data for the selected objects to the target DB instance. This choice is best if you want to move a whole database (including objects other than tables) or large quantities of data between two SQL Server DB instances. For a full description of the bcp command-line syntax, see bcp Utility in the Microsoft SQL Server documentation.

The SQL Server Generate and Publish Scripts wizard is available as part of Microsoft SQL Server Management Studio. This graphical SQL Server client is included in all Microsoft SQL Server editions except the Express Edition. SQL Server Management Studio is available only as a Windows-based application. SQL Server Management Studio Express is available from Microsoft as a free download.

To use the SQL Server Generate and Publish Scripts wizard and the bcp utility to export data

1. In SQL Server Management Studio, connect to your RDS SQL Server DB instance. For details on how to do this, see Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560).
2. In **Object Explorer**, expand the **Databases** node and select the database you want to script.
3. Follow the instructions in Generate and Publish Scripts Wizard in the SQL Server documentation to create a script file.
4. In SQL Server Management Studio, connect to your target SQL Server DB instance.
5. With the target SQL Server DB instance selected in **Object Explorer**, choose **Open** on the **File** menu, choose **File**, and then open the script file.
6. If you have scripted the entire database, review the CREATE DATABASE statement in the script. Make sure that the database is being created in the location and with the parameters that you want. For more information, see CREATE DATABASE in the SQL Server documentation.
7. If you are creating database users in the script, check to see if server logins exist on the target DB instance for those users. If not, create logins for those users; the scripted commands to create the database users fail otherwise. For more information, see Create a Login in the SQL Server documentation.
8. Choose **!Execute** on the SQL Editor menu to execute the script file and create the database objects. When the script finishes, verify that all database objects exist as expected.
9. Use the bcp utility to export data from the RDS SQL Server DB instance into files. Open a command prompt and type the following command.

```
bcp database_name.schema_name.table_name out data_file -n -S aws_rds_sql_endpoint -U
 username -P password
```

   The preceding code includes the following options:

   - *table_name* is the name of one of the tables that you've recreated in the target database and now want to populate with data.
   - *data_file* is the full path and name of the data file to be created.
   - `-n` specifies that the bulk copy uses the native data types of the data to be copied.
   - `-S` specifies the SQL Server DB instance to export from.
   - `-U` specifies the user name to use when connecting to the SQL Server DB instance.
   - `-P` specifies the password for the user specified by `-U`.

   The following shows an example command.

```
bcp world.dbo.city out C:\Users\JohnDoe\city.dat -n -S sql-jdoe.1234abcd.us-
west-2.rds.amazonaws.com,1433 -U JohnDoe -P ClearTextPassword
```

Repeat this step until you have data files for all of the tables you want to export.

10. Prepare your target DB instance for bulk import of data by following the instructions at Basic Guidelines for Bulk Importing Data in the SQL Server documentation.
11. Decide on a bulk import method to use after considering performance and other concerns discussed in About Bulk Import and Bulk Export Operations in the SQL Server documentation.
12. Bulk import the data from the data files that you created using the bcp utility. To do so, follow the instructions at either Import and Export Bulk Data by Using the bcp Utility or Import Bulk Data by Using BULK INSERT or OPENROWSET(BULK...) in the SQL Server documentation, depending on what you decided in step 11.

Working with Read Replicas for Microsoft SQL Server in Amazon RDS

You usually use read replicas to configure replication between Amazon RDS DB instances. For general information about read replicas, see Working with Read Replicas (p. 250).

In this section, you can find specific information about working with read replicas on Amazon RDS for SQL Server.

Topics

Configuring Read Replicas for SQL Server

Before a DB instance can serve as a source instance for replication, you must enable automatic backups on the source DB instance. To do so, you set the backup retention period to a value other than 0. The source DB instance must be a Multi-AZ deployment with Always On Availability Groups (AGs). Setting this type of deployment also enforces that automatic backups are enabled.

Creating a SQL Server read replica doesn't require an outage for the master DB instance. Amazon RDS sets the necessary parameters and permissions for the source DB instance and the read replica without any service interruption. A snapshot is taken of the source DB instance, and this snapshot becomes the read replica. No outage occurs when you delete a read replica.

You can create up to five read replicas from one source DB instance. For replication to operate effectively, each read replica should have the same amount of compute and storage resources as the source DB instance. If you scale the source DB instance, also scale the read replicas.

The SQL Server DB engine version of the source DB instance and all of its read replicas must be the same. Amazon RDS upgrades the master immediately after upgrading the read replicas, regardless of the maintenance window. For more information about upgrading the DB engine version, see Upgrading the Microsoft SQL Server DB Engine (p. 572).

For a read replica to receive and apply changes from the source, it should have sufficient compute and storage resources. If a read replica reaches compute, network, or storage resource capacity, the read replica stops receiving or applying changes from its source. You can modify the storage and CPU resources of a read replica independently from its source and other read replicas.

Read Replica Limitations with SQL Server

The following limitations apply to SQL Server read replicas on Amazon RDS:

- Read replicas are only available on the SQL Server Enterprise Edition (EE) engine.
- Read replicas are available for SQL Server versions 2016 and 2017.
- The source DB instance to be replicated must be a Multi-AZ deployment with Always On AGs.
- Read replicas are only available for DB instances on the EC2-VPC platform.
- Read replicas are only available for DB instances running on DB instance classes with four or more vCPUs.
- The following aren't supported on Amazon RDS for SQL Server:
  - Creating a read replica in a different AWS Region (a cross-Region read replica)

  - Backup retention of read replicas
  - Point-in-time recovery from read replicas
  - Manual snapshots of read replicas
  - Multi-AZ read replicas
  - Creating read replicas of read replicas
  - Synchronization of user logins to read replicas
- Amazon RDS for SQL Server doesn't intervene to mitigate high replica lag between a source DB instance and its read replicas. Make sure that the source DB instance and its read replicas are sized properly, in terms of computing power and storage, to suit their operational load.
- A SQL Server read replica belongs to the same option group as the source DB instance. Modifications to the source option group or source option group membership propagate to read replicas. These changes are applied to the read replicas immediately after they are applied to the source DB instance, regardless of the read replica's maintenance window.

  For more information about option groups, see Working with Option Groups (p. 186).

Troubleshooting a SQL Server Read Replica Problem

You can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric. For information about replication lag time, see Monitoring Read Replication (p. 263).

If replication lag is too long, you can use the following query to get information about the lag.

```
SELECT AR.replica_server_name
     , DB_NAME (ARS.database_id) 'database_name'
     , AR.availability_mode_desc
     , ARS.synchronization_health_desc
     , ARS.last_hardened_lsn
     , ARS.last_redone_lsn
     , ARS.secondary_lag_seconds
FROM sys.dm_hadr_database_replica_states ARS
INNER JOIN sys.availability_replicas AR ON ARS.replica_id = AR.replica_id
--WHERE DB_NAME(ARS.database_id) = 'database_name'
ORDER BY AR.replica_server_name;
```

Multi-AZ Deployments for Microsoft SQL Server

Multi-AZ deployments provide increased availability, data durability, and fault tolerance for DB instances. In the event of planned database maintenance or unplanned service disruption, Amazon RDS automatically fails over to the up-to-date secondary DB instance. This functionality lets database operations resume quickly without manual intervention. The primary and standby instances use the same endpoint, whose physical network address transitions to the secondary replica as part of the failover process. You don't have to reconfigure your application when a failover occurs.

Amazon RDS supports Multi-AZ deployments for Microsoft SQL Server by using either SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs). Amazon RDS monitors and maintains the health of your Multi-AZ deployment. If problems occur, RDS automatically repairs unhealthy DB instances, reestablishes synchronization, and initiates failovers. Failover only occurs if the standby and primary are fully in sync. You don't have to manage anything.

When you set up SQL Server Multi-AZ, RDS automatically configures all databases on the instance to use DBM or AGs. Amazon RDS handles the primary, the witness, and the secondary DB instance for you. Because configuration is automatic, RDS selects DBM or Always On AGs based on the version of SQL Server that you deploy.

Amazon RDS supports Multi-AZ with Always On AGs for the following SQL Server versions and editions:

- SQL Server 2017: Enterprise Edition 14.00.3049.1 or later
- SQL Server 2016: Enterprise Edition 13.00.5216.0 or later

Amazon RDS supports Multi-AZ with DBM for the following SQL Server versions and editions, except for the versions of Enterprise Edition noted previously:

- SQL Server 2017: Standard and Enterprise Editions
- SQL Server 2016: Standard and Enterprise Editions
- SQL Server 2014: Standard and Enterprise Editions
- SQL Server 2012: Standard and Enterprise Editions

Amazon RDS supports Multi-AZ for SQL Server in all AWS Regions, with the following exceptions:

- US West (N. California): Neither DBM nor Always On AGs are supported here
- Asia Pacific (Osaka-Local): Neither DBM nor Always On AGs are supported here
- Asia Pacific (Sydney): Supported for DB instances in VPCs
- Asia Pacific (Tokyo): Supported for DB instances in VPCs
- South America (São Paulo): Supported on all DB instance classes except m1 and m2

Adding Multi-AZ to a Microsoft SQL Server DB Instance

When you create a new SQL Server DB instance using the AWS Management Console, you can add Multi-AZ with Database Mirroring (DBM) or Always On AGs. You do so by choosing **Yes (Mirroring / Always On)** from **Multi-AZ deployment**. For more information, see Creating an Amazon RDS DB Instance (p. 136).

When you modify an existing SQL Server DB instance using the AWS Management Console, you can add Multi-AZ with DBM or AGs by choosing **Yes (Mirroring / Always On)** from the **Multi-AZ**

Deployment list on the **Modify DB Instance** page. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

> **Note**
> If your DB instance is running Database Mirroring (DBM)—not Always On Availability Groups (AGs)—you might need to disable in-memory optimization before you add Multi-AZ. Disable in-memory optimization with DBM before you add Multi-AZ if your DB instance runs SQL Server 2014, 2016, or 2017 Enterprise Edition and has in-memory optimization enabled.
> If your DB instance is running AGs, it doesn't require this step.

Microsoft SQL Server Multi-AZ Deployment Notes and Recommendations

The following are some restrictions when working with Multi-AZ deployments for Microsoft SQL Server DB instances:

- Cross-Region Multi-AZ isn't supported.
- You can't configure the secondary DB instance to accept database read activity.
- Multi-AZ with Always On Availability Groups (AGs) supports in-memory optimization.
- Multi-AZ with Always On Availability Groups (AGs) doesn't support Kerberos authentication for the availability group listener. This is because the listener has no Service Principal Name (SPN).
- You can't rename a database on a SQL Server DB instance that is in a SQL Server Multi-AZ deployment. If you need to rename a database on such an instance, first turn off Multi-AZ for the DB instance, then rename the database. Finally, turn Multi-AZ back on for the DB instance.
- You can only restore Multi-AZ DB instances that are backed up using the full recovery model.

The following are some notes about working with Multi-AZ deployments for Microsoft SQL Server DB instances:

- Amazon RDS exposes the Always On AGs availability group listener endpoint. The endpoint is visible in the console, and is returned by the `DescribeDBInstances` API as an entry in the endpoints field.
- Amazon RDS supports availability group multisubnet failovers.
- To use SQL Server Multi-AZ with a SQL Server DB instance in a VPC, first create a DB subnet group that has subnets in at least two distinct Availability Zones. Then assign the DB subnet group to the primary replica of the SQL Server DB instance.
- When a DB instance is modified to be a Multi-AZ deployment, during the modification it has a status of **modifying**. Amazon RDS creates the standby, and makes a backup of the primary DB instance. After the process is complete, the status of the primary DB instance becomes **available**.
- Multi-AZ deployments maintain all databases on the same node. If a database on the primary host fails over, all your SQL Server databases fail over as one atomic unit to your standby host. Amazon RDS provisions a new healthy host, and replaces the unhealthy host.
- Multi-AZ with DBM or AGs supports a single standby replica.
- Users, logins, and permissions are automatically replicated for you on the secondary. You don’t need to recreate them. User-defined server roles (a SQL Server 2012 feature) are only replicated in Multi-AZ instances for AGs instances.
- If you have SQL Server Agent jobs, recreate them on the secondary. You do so because these jobs are stored in the msdb database, and you can't replicate this database by using Database Mirroring (DBM) or Always On Availability Groups (AGs). Create the jobs first in the original primary, then fail over, and create the same jobs in the new primary.
- You might observe elevated latencies compared to a standard DB instance deployment (in a single Availability Zone) because of the synchronous data replication.

- Failover times are affected by the time it takes to complete the recovery process. Large transactions increase the failover time.

The following are some recommendations for working with Multi-AZ deployments for Microsoft SQL Server DB instances:

- For databases used in production or preproduction, we recommend the following options:
  - Multi-AZ deployments for high availability
  - "Provisioned IOPS" for fast, consistent performance
  - “Memory optimized” rather than "General purpose"
- You can't select the Availability Zone (AZ) for the secondary instance, so when you deploy application hosts, take this into account. Your database might fail over to another AZ, and the application hosts might not be in the same AZ as the database. For this reason, we recommend that you balance your application hosts across all AZs in the given AWS Region.
- For best performance, don't enable Database Mirroring or Always On AGs during a large data load operation. If you want your data load to be as fast as possible, finish loading data before you convert your DB instance to a Multi-AZ deployment.
- Applications that access the SQL Server databases should have exception handling that catches connection errors. The following code sample shows a try/catch block that catches a communication error.

```
for (int iRetryCount = 0; (iRetryCount < RetryMaxAttempts && keepInserting); iRetryCount+
+)
{
   using (SqlConnection connection = new SqlConnection(DatabaseConnString))
   {
      using (SqlCommand command = connection.CreateCommand())
      {
         command.CommandText = "INSERT INTO SOME_TABLE VALUES ('SomeValue');";

         try
         {
            connection.Open();

            while (keepInserting)
            {
               command.ExecuteNonQuery();
               intervalCount++;
            }
                  connection.Close();
         }

         catch (Exception ex)
         {
                  Logger(ex.Message);
         }
      }
   }

   if (iRetryCount < RetryMaxAttempts && keepInserting)
   {
            Thread.Sleep(RetryIntervalPeriodInSeconds * 1000);
   }
}
```

- Don't use the `Set Partner Off` command when working with Multi-AZ instances. For example, don't do the following.

```
--Don't do this
```

```
ALTER DATABASE db1 SET PARTNER off
```

- Don't set the recovery mode to `simple`. For example, don't do the following.

```
--Don't do this
ALTER DATABASE db1 SET RECOVERY simple
```

- Don't use the `DEFAULT_DATABASE` parameter when creating new logins on Multi-AZ DB instances, because these settings can't be applied to the standby mirror. For example, don't do the following.

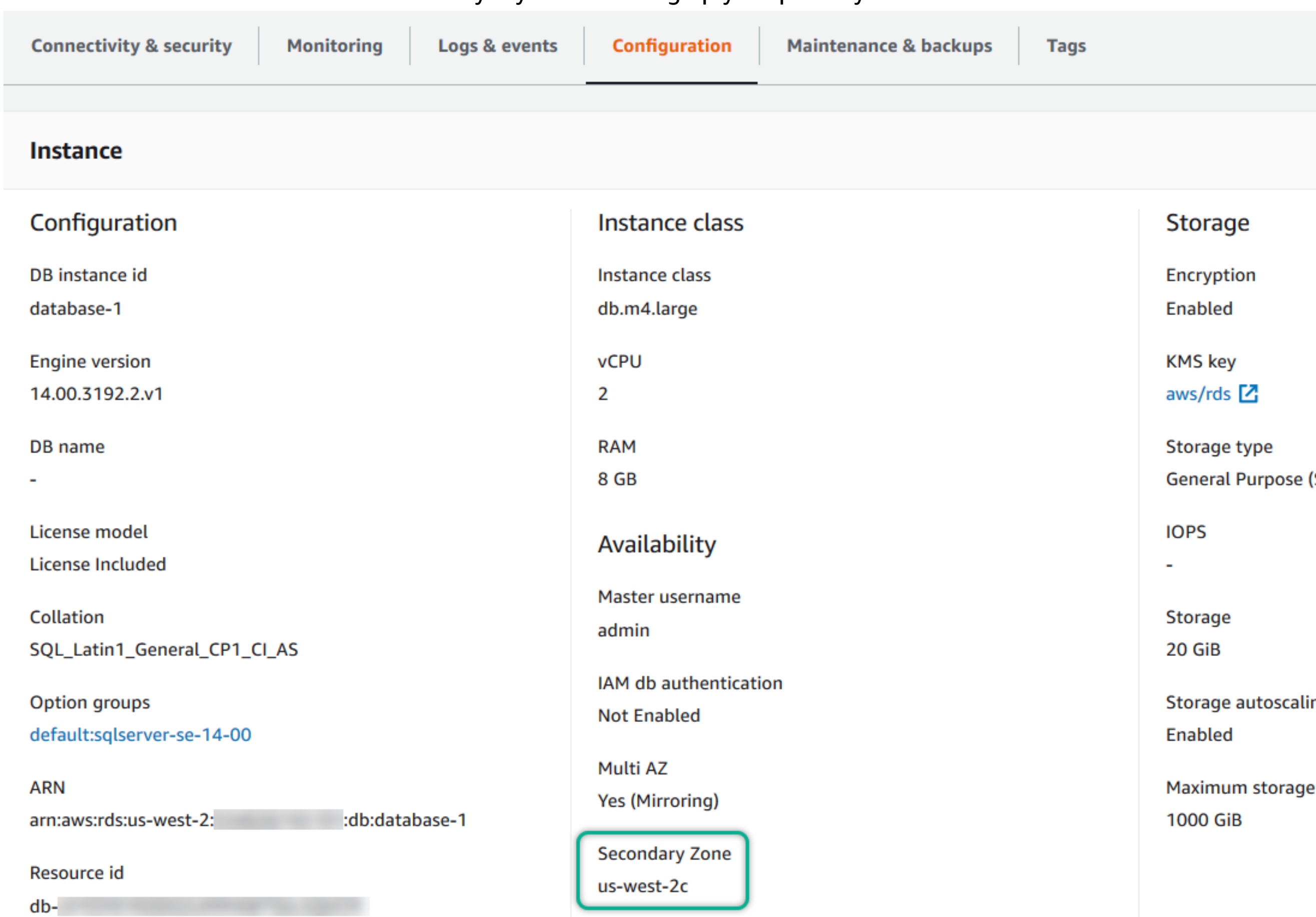
```
--Don't do this
CREATE LOGIN [test_dba] WITH PASSWORD=foo, DEFAULT_DATABASE=[db2]
```

  Also, don't do the following.

```
--Don't do this
ALTER LOGIN [test_dba] SET DEFAULT_DATABASE=[db3]
```

Determining the Location of the Secondary

You can determine the location of the secondary replica by using the AWS Management Console. You need to know the location of the secondary if you are setting up your primary DB instance in a VPC.



You can also view the Availability Zone of the secondary using the AWS CLI command `describe-db-instances` or RDS API operation `DescribeDBInstances`. The output shows the secondary AZ where the standby mirror is located.

Migrating from Database Mirroring to Always On Availability Groups

In version 14.00.3049.1 of Microsoft SQL Server Enterprise edition, Always On Availability Groups (AGs) is enabled by default.

To migrate from Database Mirroring (DBM) to AGs, first check your version. If you are using a DB instance with a version prior to Enterprise Edition 13.00.5216.0, modify the instance to patch it to 13.00.5216.0 or later. If you are using a DB instance with a version prior to Enterprise Edition 14.00.3049.1, modify the instance to patch it to 14.00.3049.1 or later.

If you want to upgrade a mirrored DB instance to use AGs, run the upgrade first, modify the instance to remove Multi-AZ, and then modify it again to add Multi-AZ. This converts your instance to use Always On AGs.

Additional Features for Microsoft SQL Server on Amazon RDS

In the following sections, you can find information about augmenting Amazon RDS instances running the Microsoft SQL Server DB engine by adding SSL, Windows Authentication, and S3 integration.

Topics

Using SSL with a Microsoft SQL Server DB Instance

You can use Secure Sockets Layer (SSL) to encrypt connections between your client applications and your Amazon RDS DB instances running Microsoft SQL Server. SSL support is available in all AWS regions for all supported SQL Server editions.

When you create a SQL Server DB instance, Amazon RDS creates an SSL certificate for it. The SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks.

There are 2 ways to use SSL to connect to your SQL Server DB instance:

- Force SSL for all connections — this happens transparently to the client, and the client doesn't have to do any work to use SSL.
- Encrypt specific connections — this sets up an SSL connection from a specific client computer, and you must do work on the client to encrypt connections.

For information about Transport Layer Security (TLS) support for SQL Server, see TLS 1.2 support for Microsoft SQL Server.

Forcing Connections to Your DB Instance to Use SSL

You can force all connections to your DB instance to use SSL. If you force connections to use SSL, it happens transparently to the client, and the client doesn't have to do any work to use SSL.

If you want to force SSL, use the `rds.force_ssl` parameter. By default, the `rds.force_ssl` parameter is set to `0 (off)`. Set the `rds.force_ssl` parameter to `1 (on)` to force connections to use SSL. The `rds.force_ssl` parameter is static, so after you change the value, you must reboot your DB instance for the change to take effect.

To force all connections to your DB instance to use SSL

1. Determine the parameter group that is attached to your DB instance:
   a. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
   b. In the top right corner of the Amazon RDS console, choose the AWS Region of your DB instance.
   c. In the navigation pane, choose **Databases**, and then choose the name of your DB instance to show its details.
   d. Choose the **Configuration** tab. Find the **Parameter group** in the section.
2. If necessary, create a new parameter group. If your DB instance uses the default parameter group, you must create a new parameter group. If your DB instance uses a nondefault parameter group, you can choose to edit the existing parameter group or to create a new parameter group. If you edit an existing parameter group, the change affects all DB instances that use that parameter group.

   To create a new parameter group, follow the instructions in Creating a DB Parameter Group (p. 203).
3. Edit your new or existing parameter group to set the `rds.force_ssl` parameter to `true`. To edit the parameter group, follow the instructions in Modifying Parameters in a DB Parameter Group (p. 204).
4. If you created a new parameter group, modify your DB instance to attach the new parameter group. Modify the **DB Parameter Group** setting of the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
5. Reboot your DB instance. For more information, see Rebooting a DB Instance (p. 247).

Encrypting Specific Connections

You can force all connections to your DB instance to use SSL, or you can encrypting connections from specific client computers only. To use SSL from a specific client, you must obtain certificates for the client computer, import certificates on the client computer, and then encrypt the connections from the client computer.

> **Note**
> All SQL Server instances created after August 5, 2014, use the DB instance endpoint in the Common Name (CN) field of the SSL certificate. Prior to August 5, 2014, SSL certificate verification was not available for VPC-based SQL Server instances. If you have a VPC-based SQL Server DB instance that was created before August 5, 2014, and you want to use SSL certificate verification and ensure that the instance endpoint is included as the CN for the SSL certificate for that DB instance, then rename the instance. When you rename a DB instance, a new certificate is deployed and the instance is rebooted to enable the new certificate.

Obtaining Certificates for Client Computers

To encrypt connections from a client computer to an Amazon RDS DB instance running Microsoft SQL Server, you need a certificate on your client computer.

To obtain that certificate, download the certificate to your client computer. You can download a root certificate that works for all regions. You can also download a certificate bundle that contains both the old and new root certificate. In addition, you can download region-specific intermediate certificates. For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

After you have downloaded the appropriate certificate, import the certificate into your Microsoft Windows operating system by following the procedure in the section following.

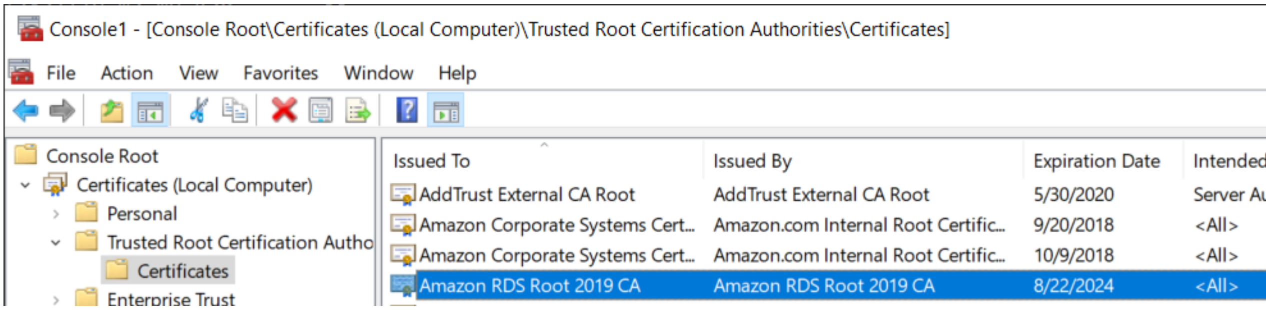
Importing Certificates on Client Computers

You can use the following procedure to import your certificate into the Microsoft Windows operating system on your client computer.

To import the certificate into your Windows operating system:

1. On the **Start** menu, type `Run` in the search box and press **Enter**.
2. In the **Open** box, type `MMC` and then choose **OK**.
3. In the MMC console, on the **File** menu, choose **Add/Remove Snap-in**.
4. In the **Add or Remove Snap-ins** dialog box, for **Available snap-ins**, select `Certificates`, and then choose **Add**.
5. In the **Certificates snap-in** dialog box, choose **Computer account**, and then choose **Next**.
6. In the **Select computer** dialog box, choose **Finish**.
7. In the **Add or Remove Snap-ins** dialog box, choose **OK**.
8. In the MMC console, expand **Certificates**, open the context (right-click) menu for **Trusted Root Certification Authorities**, choose **All Tasks**, and then choose **Import**.
9. On the first page of the Certificate Import Wizard, choose **Next**.
10. On the second page of the Certificate Import Wizard, choose **Browse**. In the browse window, change the file type to **All files (*.*)** because .pem is not a standard certificate extension. Locate the .pem file that you downloaded previously.
11. Choose **Open** to select the certificate file, and then choose **Next**.
12. On the third page of the Certificate Import Wizard, choose **Next**.
13. On the fourth page of the Certificate Import Wizard, choose **Finish**. A dialog box appears indicating that the import was successful.

14. In the MMC console, expand **Certificates**, expand **Trusted Root Certification Authorities**, and then choose **Certificates**. Locate the certificate to confirm it exists, as shown here.



15. Restart your computer.

Encrypting Connections to an Amazon RDS DB Instance Running Microsoft SQL Server

After you have imported a certificate into your client computer, you can encrypt connections from the client computer to an Amazon RDS DB instance running Microsoft SQL Server.

For SQL Server Management Studio, use the following procedure. For more information about SQL Server Management Studio, see Use SQL Server Management Studio.

To encrypt connections from SQL Server Management Studio

1. Launch SQL Server Management Studio.
2. For **Connect to server**, type the server information, login user name, and password.
3. Choose **Options**.
4. Select **Encrypt connection**.
5. Choose **Connect**.
6. Confirm that your connection is encrypted by running the following query. Verify that the query returns `true` for `encrypt_option`.

```
select ENCRYPT_OPTION from SYS.DM_EXEC_CONNECTIONS where SESSION_ID = @@SPID
```

For any other SQL client, use the following procedure.

To encrypt connections from other SQL clients

1. Append `encrypt=true` to your connection string. This string might be available as an option, or as a property on the connection page in GUI tools.

   Note
   To enable SSL encryption for clients that connect using JDBC, you might need to add the Amazon RDS SQL certificate to the Java CA certificate (cacerts) store. You can do this by using the keytool utility.

2. Confirm that your connection is encrypted by running the following query. Verify that the query returns `true` for `encrypt_option`.

```
select ENCRYPT_OPTION from SYS.DM_EXEC_CONNECTIONS where SESSION_ID = @@SPID
```

Using Windows Authentication with an Amazon RDS for SQL Server DB Instance

You can use Microsoft Windows Authentication to authenticate users when they connect to your Amazon RDS for Microsoft SQL Server DB instance. The DB instance works with AWS Directory Service for Microsoft Active Directory, also called AWS Managed Microsoft AD, to enable Windows Authentication. When users authenticate with a SQL Server DB instance joined to the trusting domain, authentication requests are forwarded to the domain directory that you create with AWS Directory Service.

Amazon RDS supports Windows Authentication for SQL Server in all AWS Regions except the following:

- Middle East (Bahrain)
- AWS GovCloud (US-East)
- AWS GovCloud (US-West)

Amazon RDS uses mixed mode for Windows Authentication. This approach means that the *master user* (the name and password used to create your SQL Server DB instance) uses SQL Authentication. Because the master user account is a privileged credential, you should restrict access to this account.

To get Windows Authentication using an on-premises or self-hosted Microsoft Active Directory, create a forest trust. The trust can be one-way or two-way. For more information on setting up forest trusts using AWS Directory Service, see When to Create a Trust Relationship in the *AWS Directory Service Administration Guide*.

To set up Windows authentication for a SQL Server DB instance, do the following steps, explained in greater detail in Setting Up Windows Authentication for SQL Server DB Instances (p. 613):

1. Use AWS Managed Microsoft AD, either from the AWS Management Console or AWS Directory Service API, to create an AWS Managed Microsoft AD directory.
2. If you use the AWS CLI or Amazon RDS API to create your SQL Server DB instance, create an AWS Identity and Access Management (IAM) role. This role uses the managed IAM policy `AmazonRDSDirectoryServiceAccess` and allows Amazon RDS to make calls to your directory. If you use the console to create your SQL Server DB instance, AWS creates the IAM role for you.

   For the role to allow access, the AWS Security Token Service (AWS STS) endpoint must be activated in the AWS Region for your AWS account. AWS STS endpoints are active by default in all AWS Regions, and you can use them without any further actions. For more information, see Managing AWS STS in an AWS Region in the *IAM User Guide*.
3. Create and configure users and groups in the AWS Managed Microsoft AD directory using the Microsoft Active Directory tools. For more information about creating users and groups in your Active Directory, see Manage Users and Groups in AWS Managed Microsoft AD in the *AWS Directory Service Administration Guide*.
4. If you plan to locate the directory and the DB instance in different VPCs, enable cross-VPC traffic.
5. Use Amazon RDS to create a new SQL Server DB instance either from the console, AWS CLI, or Amazon RDS API. In the create request, you provide the domain identifier ("`d-*`" identifier) that was generated when you created your directory and the name of the role you created. You can also modify an existing SQL Server DB instance to use Windows Authentication by setting the domain and IAM role parameters for the DB instance.
6. Use the Amazon RDS master user credentials to connect to the SQL Server DB instance as you do any other DB instance. Because the DB instance is joined to the AWS Managed Microsoft AD domain, you can provision SQL Server logins and users from the Active Directory users and groups in their domain. (These are known as SQL Server "Windows" logins.) Database permissions are managed through standard SQL Server permissions granted and revoked to these Windows logins.

Creating the Endpoint for Kerberos Authentication

Kerberos-based authentication requires that the endpoint be the customer-specified host name, a period, and then the fully qualified domain name (FQDN). For example, the following is an example of an endpoint you might use with Kerberos-based authentication. In this example, the SQL Server DB instance host name is `ad-test` and the domain name is `corp-ad.company.com`.

```
ad-test.corp-ad.company.com
```

If you want to make sure your connection is using Kerberos, run the following query:

```
SELECT net_transport, auth_scheme
  FROM sys.dm_exec_connections
 WHERE session_id = @@SPID;
```

Setting Up Windows Authentication for SQL Server DB Instances

You use AWS Directory Service for Microsoft Active Directory, also called AWS Managed Microsoft AD, to set up Windows Authentication for a SQL Server DB instance. To set up Windows Authentication, take the following steps.

Step 1: Create a Directory Using the AWS Directory Service for Microsoft Active Directory

AWS Directory Service creates a fully managed, Microsoft Active Directory in the AWS Cloud. When you create an AWS Managed Microsoft AD directory, AWS Directory Service creates two domain controllers and Domain Name Service (DNS) servers on your behalf. The directory servers are created in two subnets in two different Availability Zones within a VPC. This redundancy helps ensure that your directory remains accessible even if a failure occurs.

When you create an AWS Managed Microsoft AD directory, AWS Directory Service performs the following tasks on your behalf:

- Sets up a Microsoft Active Directory within the VPC.
- Creates a directory administrator account with the user name Admin and the specified password. You use this account to manage your directory.

  Note
  Be sure to save this password. AWS Directory Service doesn't store this password, and you can't retrieve or reset it.
- Creates a security group for the directory controllers.

When you launch an AWS Directory Service for Microsoft Active Directory, AWS creates an Organizational Unit (OU) that contains all your directory's objects. This OU, which has the NetBIOS name that you typed when you created your directory, is located in the domain root. The domain root is owned and managed by AWS.

The *admin* account that was created with your AWS Managed Microsoft AD directory has permissions for the most common administrative activities for your OU:

- Create, update, or delete users, groups, and computers.
- Add resources to your domain such as file or print servers, and then assign permissions for those resources to users and groups in your OU.
- Create additional OUs and containers.
- Delegate authority.

- Create and link group policies.
- Restore deleted objects from the Active Directory Recycle Bin.
- Run AD and DNS Windows PowerShell modules on the Active Directory Web Service.

The admin account also has rights to perform the following domain-wide activities:

- Manage DNS configurations (add, remove, or update records, zones, and forwarders).
- View DNS event logs.
- View security event logs.

To create a directory with AWS Managed Microsoft AD

1. In the AWS Directory Service console navigation pane, choose **Directories** and choose **Set up directory**.
2. Choose **AWS Managed Microsoft AD**. This is the only option currently supported for use with Amazon RDS.
3. Choose **Next**.
4. On the **Enter directory information** page, provide the following information:

   Edition

      Choose the edition that meets your requirements.

   Directory DNS name

      The fully qualified name for the directory, such as `corp.example.com`. Names longer than 47 characters aren't supported by SQL Server.

   Directory NetBIOS name

      An optional short name for the directory, such as `CORP`.

   Directory description

      An optional description for the directory.

   Admin password

      The password for the directory administrator. The directory creation process creates an administrator account with the user name Admin and this password.

      The directory administrator password can't include the word `admin`. The password is case-sensitive and must be 8–64 characters in length. It must also contain at least one character from three of the following four categories:

      - Lowercase letters (a-z)
      - Uppercase letters (A-Z)
      - Numbers (0-9)
      - Non-alphanumeric characters (~!@#$%^&*_-+=`|\(){}[]:;"'<>,.?/)

   Confirm password

      Retype the administrator password.
5. Choose **Next**.
6. On the **Choose VPC and subnets** page, provide the following information:

   VPC

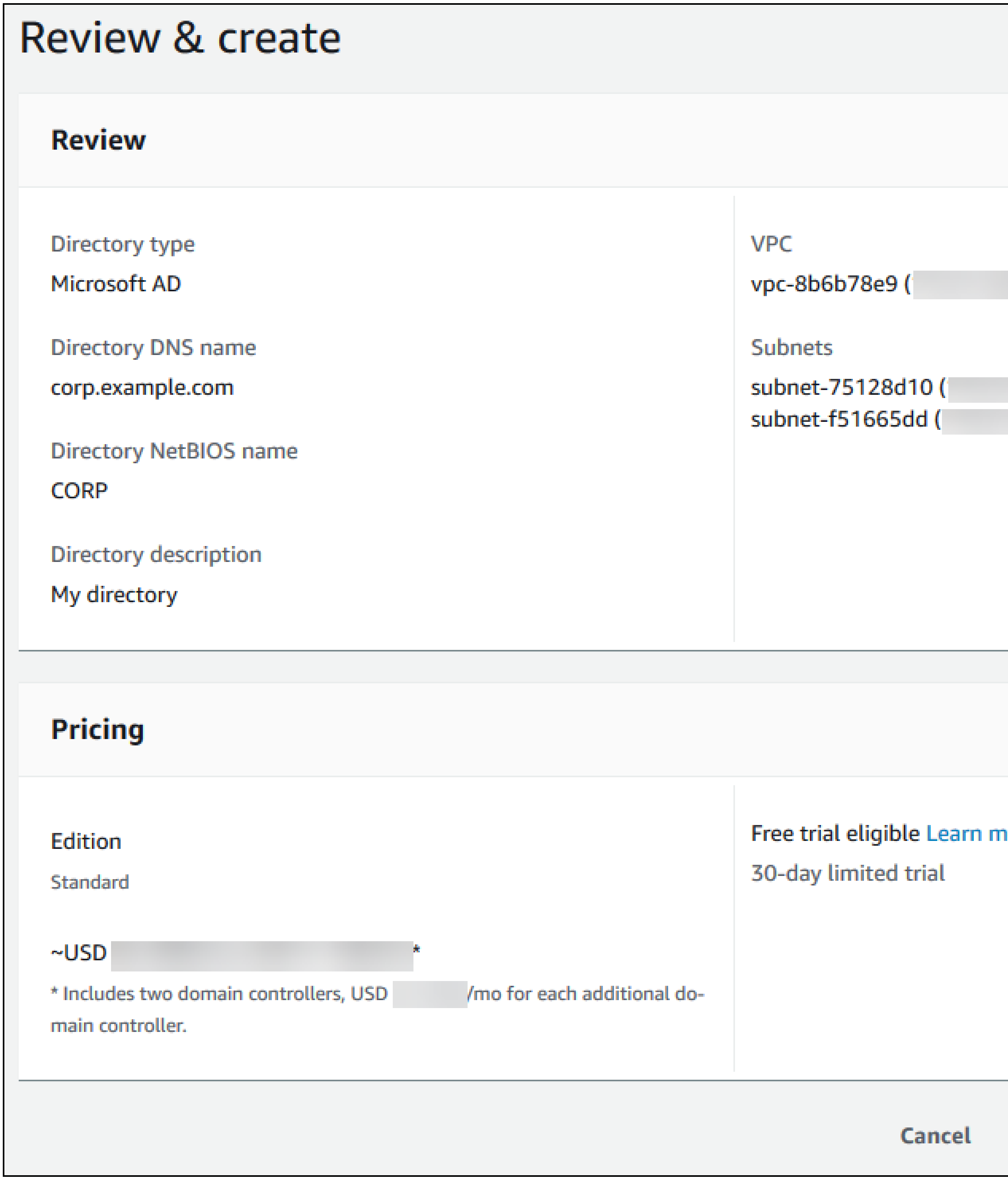
      Choose the VPC for the directory.

Note
You can locate the directory and the DB instance in different VPCs, but if you do so, make sure to enable cross-VPC traffic. For more information, see Step 4: Enable Cross-VPC Traffic Between the Directory and the DB Instance (p. 618).

Subnets

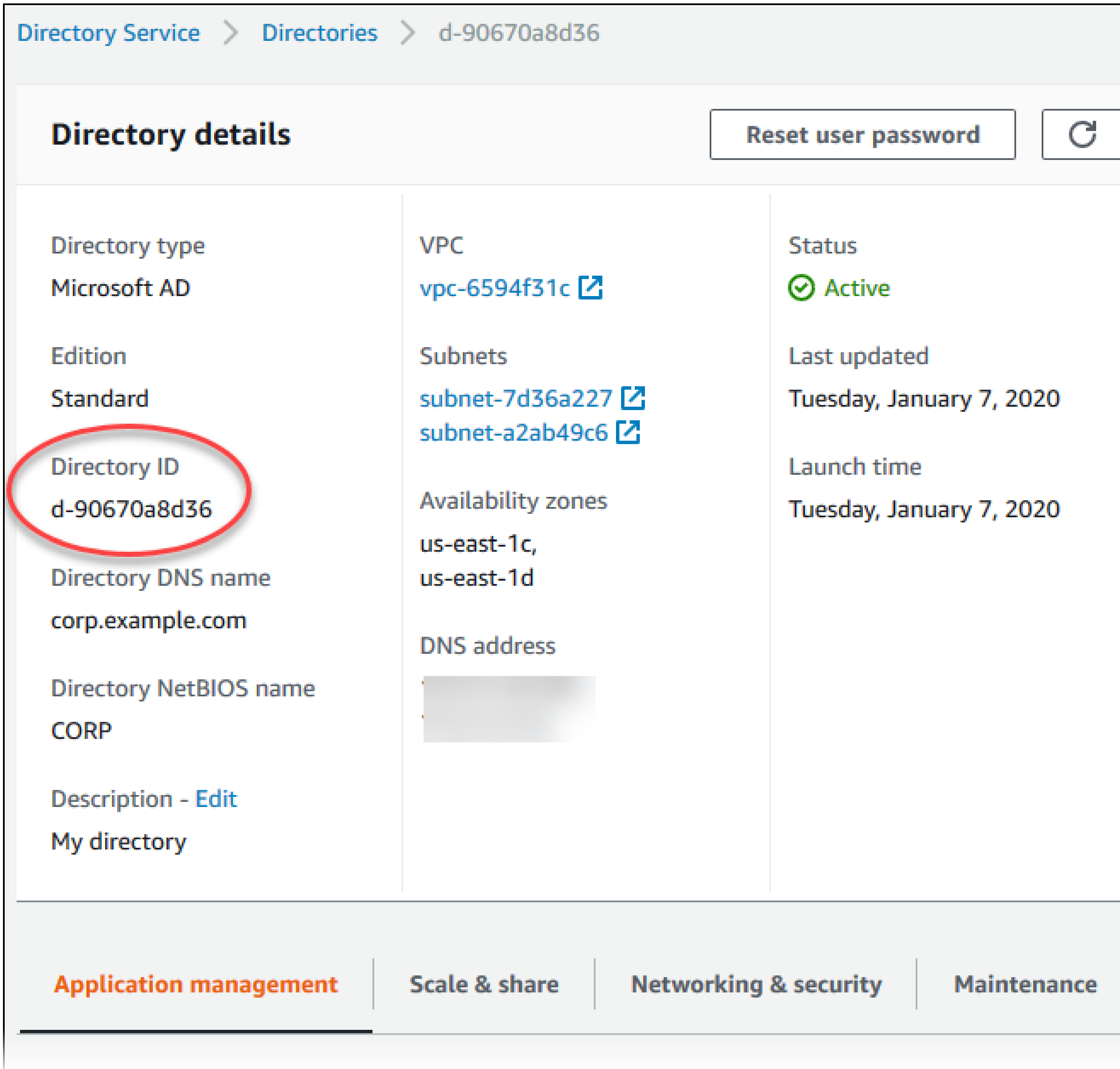
Choose the subnets for the directory servers. The two subnets must be in different Availability Zones.

7. Choose **Next**.
8. Review the directory information. If changes are needed, choose **Previous**. When the information is correct, choose **Create directory**.



It takes several minutes for the directory to be created. When it has been successfully created, the **Status** value changes to **Active**.

To see information about your directory, choose the directory ID in the directory listing. Make a note of the **Directory ID**. You need this value when you create or modify your SQL Server DB instance.



Step 2: Create the IAM Role for Use by Amazon RDS

If you use the console to create your SQL Server DB instance, you can skip this step. If you use the CLI or RDS API to create your SQL Server DB instance, you must create an IAM role that uses the `AmazonRDSDirectoryServiceAccess` managed IAM policy. This role allows Amazon RDS to make calls to the AWS Directory Service for you.

If you are using a custom policy for joining a domain, rather than using the AWS-managed `AmazonRDSDirectoryServiceAccess` policy, make sure that you allow the `ds:GetAuthorizedApplicationDetails` action. This requirement is effective starting July 2019, due to a change in the AWS Directory Service API.

The following IAM policy, `AmazonRDSDirectoryServiceAccess`, provides access to AWS Directory Service.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
            "ds:DescribeDirectories",
            "ds:AuthorizeApplication",
            "ds:UnauthorizeApplication",
            "ds:GetAuthorizedApplicationDetails"
        ],
      "Effect": "Allow",
      "Resource": "*"
    }
  ]
}
```

Create an IAM role using this policy. For more information about creating IAM roles, see Creating Customer Managed Policies in the *IAM User Guide*.

Step 3: Create and Configure Users and Groups

You can create users and groups with the Active Directory Users and Computers tool. This tool is one of the Active Directory Domain Services and Active Directory Lightweight Directory Services tools. Users represent individual people or entities that have access to your directory. Groups are very useful for giving or denying privileges to groups of users, rather than having to apply those privileges to each individual user.

To create users and groups in an AWS Directory Service directory, you must be connected to a Windows EC2 instance that is a member of the AWS Directory Service directory. You must also be logged in as a user that has privileges to create users and groups. For more information, see Add Users and Groups (Simple AD and AWS Managed Microsoft AD) in the *AWS Directory Service Administration Guide*.

Step 4: Enable Cross-VPC Traffic Between the Directory and the DB Instance

If you plan to locate the directory and the DB instance in the same VPC, skip this step and move on to Step 5: Create or Modify a SQL Server DB Instance (p. 619).

If you plan to locate the directory and the DB instance in different VPCs, configure cross-VPC traffic using VPC peering or AWS Transit Gateway.

The following procedure enables traffic between VPCs using VPC peering. Follow the instructions in What is VPC Peering? in the *Amazon Virtual Private Cloud Peering Guide*.

To enable cross-VPC traffic using VPC peering

1. Set up appropriate VPC routing rules to ensure that network traffic can flow both ways.
2. Ensure that the DB instance's security group can receive inbound traffic from the directory's security group.
3. Ensure that there is no network access control list (ACL) rule to block traffic.

If a different AWS account owns the directory, you must share the directory.

To share the directory between AWS accounts

1. Start sharing the directory with the AWS account that the DB instance will be created in by following the instructions in Tutorial: Sharing Your AWS Managed Microsoft AD Directory for Seamless EC2 Domain-Join in the *AWS Directory Service Administration Guide*.

2. Sign in to the AWS Directory Service console using the account for the DB instance, and ensure that the domain has the `SHARED` status before proceeding.
3. While signed into the AWS Directory Service console using the account for the DB instance, note the **Directory ID** value. You use this directory ID to join the DB instance to the domain.

Step 5: Create or Modify a SQL Server DB Instance

Create or modify a SQL Server DB instance for use with your directory. You can use the console, CLI, or RDS API to associate a DB instance with a directory. You can do this in one of the following ways:

- Create a new SQL Server DB instance using the console, the create-db-instance CLI command, or the CreateDBInstance RDS API operation.

  For instructions, see Creating an Amazon RDS DB Instance (p. 136).
- Modify an existing SQL Server DB instance using the console, the modify-db-instance CLI command, or the ModifyDBInstance RDS API operation.

  For instructions, see Modifying an Amazon RDS DB Instance (p. 220).
- Restore a SQL Server DB instance from a DB snapshot using the console, the restore-db-instance-from-db-snapshot CLI command, or the RestoreDBInstanceFromDBSnapshot RDS API operation.

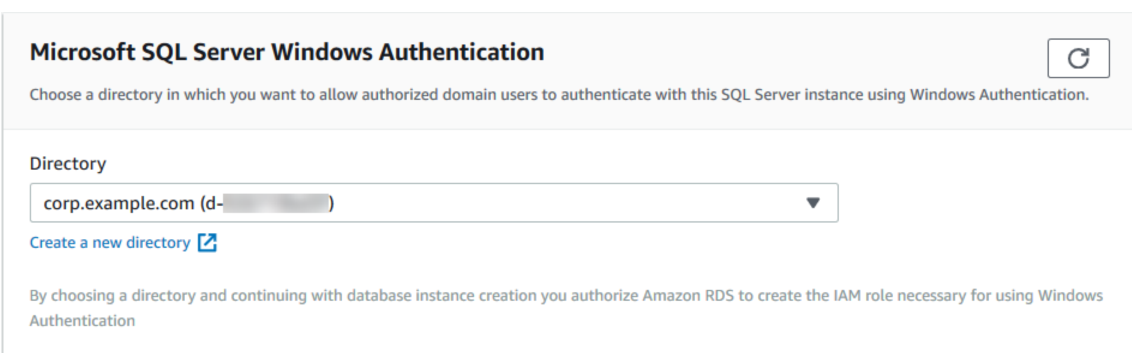
  For instructions, see Restoring from a DB Snapshot (p. 303).
- Restore a SQL Server DB instance to a point-in-time using the console, the restore-db-instance-to-point-in-time CLI command, or the RestoreDBInstanceToPointInTime RDS API operation.

  For instructions, see Restoring a DB Instance to a Specified Time (p. 336).

Windows Authentication is only supported for SQL Server DB instances in a VPC.

For the DB instance to be able to use the domain directory that you created, the following is required:

- For **Directory**, you must choose the domain identifier (`d-ID`) generated when you created the directory.
- Make sure that the VPC security group has an outbound rule that lets the DB instance communicate with the directory.



When you use the AWS CLI, the following parameters are required for the DB instance to be able to use the directory that you created:

- For the `--domain` parameter, use the domain identifier (`d-ID`) generated when you created the directory.

- For the `--domain-iam-role-name` parameter, use the role that you created that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`.

For example, the following CLI command modifies a DB instance to use a directory.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --domain d-ID \
    --domain-iam-role-name role-name
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --domain d-ID ^
    --domain-iam-role-name role-name
```

Important
If you modify a DB instance to enable Kerberos authentication, reboot the DB instance after making the change.

Step 6: Create Windows Authentication SQL Server Logins

Use the Amazon RDS master user credentials to connect to the SQL Server DB instance as you do any other DB instance. Because the DB instance is joined to the AWS Managed Microsoft AD domain, you can provision SQL Server logins and users. You do this from the Active Directory users and groups in your domain. Database permissions are managed through standard SQL Server permissions granted and revoked to these Windows logins.

For an Active Directory user to authenticate with SQL Server, a SQL Server Windows login must exist for the user or a group that the user is a member of. Fine-grained access control is handled through granting and revoking permissions on these SQL Server logins. A user that doesn't have a SQL Server login or belong to a group with such a login can't access the SQL Server DB instance.

The ALTER ANY LOGIN permission is required to create an Active Directory SQL Server login. If you haven't created any logins with this permission, connect as the DB instance's master user using SQL Server Authentication. Run the following data definition language (DDL) command to create a SQL Server login for an Active Directory user or group.

```
CREATE LOGIN [<user or group>] FROM WINDOWS WITH DEFAULT_DATABASE = [master],
   DEFAULT_LANGUAGE = [us_english];
```

Specify users or groups using the pre–Windows 2000 login name in the format *`domainName`*`\`*`login_name`*. You can't use a User Principal Name (UPN) in the format *`login_name`*`@`*`DomainName`*. For more information about CREATE LOGIN, see https://msdn.microsoft.com/en-us/library/ms189751.aspx in the Microsoft Developer Network documentation.

Users (both humans and applications) from your domain can now connect to the RDS SQL Server instance from a domain-joined client machine using Windows authentication.

Managing a DB Instance in a Domain

You can use the console, AWS CLI, or the Amazon RDS API to manage your DB instance and its relationship with your domain. For example, you can move the DB instance into, out of, or between domains.

For example, using the Amazon RDS API, you can do the following:

- To reattempt a domain join for a failed membership, use the ModifyDBInstance API operation and specify the current membership's directory ID.
- To update the IAM role name for membership, use the `ModifyDBInstance` API operation and specify the current membership's directory ID and the new IAM role.
- To remove a DB instance from a domain, use the `ModifyDBInstance` API operation and specify `none` as the domain parameter.
- To move a DB instance from one domain to another, use the `ModifyDBInstance` API operation and specify the domain identifier of the new domain as the domain parameter.
- To list membership for each DB instance, use the DescribeDBInstances API operation.

Understanding Domain Membership

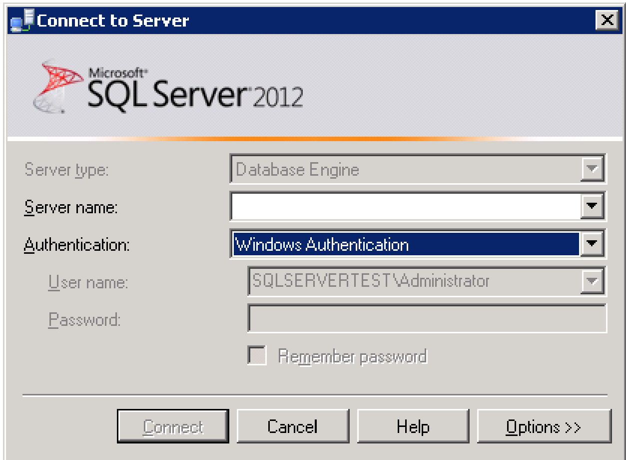
After you create or modify your DB instance, the instance becomes a member of the domain. The AWS console indicates the status of the domain membership for the DB instance. The status of the DB instance can be one of the following:

- **joined** – The instance is a member of the domain.
- **joining** – The instance is in the process of becoming a member of the domain.
- **pending-join** – The instance membership is pending.
- **pending-maintenance-join** – AWS will attempt to make the instance a member of the domain during the next scheduled maintenance window.
- **pending-removal** – The removal of the instance from the domain is pending.
- **pending-maintenance-removal** – AWS will attempt to remove the instance from the domain during the next scheduled maintenance window.
- **failed** – A configuration problem has prevented the instance from joining the domain. Check and fix your configuration before reissuing the instance modify command.
- **removing** – The instance is being removed from the domain.

A request to become a member of a domain can fail because of a network connectivity issue or an incorrect IAM role. For example, you might create a DB instance or modify an existing instance and have the attempt fail for the DB instance to become a member of a domain. In this case, either reissue the command to create or modify the DB instance or modify the newly created instance to join the domain.

Connecting to SQL Server with Windows Authentication

To connect to SQL Server with Windows Authentication, you must be logged into a domain-joined computer as a domain user. After launching SQL Server Management Studio, choose **Windows Authentication** as the authentication type, as shown following.



Restoring a SQL Server DB Instance and then Adding It to a Domain

You can restore a DB snapshot or do a point-in-time restore (PITR) for a SQL Server DB instance and then add it to a domain. Once the DB instance is restored, modify the instance using the process explained in Step 5: Create or Modify a SQL Server DB Instance (p. 619) to add the DB instance to a domain.

Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3

You can transfer files between a DB instance running Amazon RDS for SQL Server and an Amazon S3 bucket. By doing this, you can use Amazon S3 with SQL Server features such as BULK INSERT. For example, you can download .csv, .xml, .txt, and other files from Amazon S3 to the DB instance host and import the data from `D:\S3\` into the database. All files are stored in `D:\S3\` on the DB instance.

The following limitations apply:

- Files in the `D:\S3` folder are deleted on the standby replica after a failover on Multi-AZ instances. For more information, see Multi-AZ Limitations for S3 Integration (p. 633).
- The DB instance and the S3 bucket must be in the same AWS Region.
- S3 integration tasks are run sequentially and share the same queue as native backup and restore tasks. At maximum, you can have only two tasks in progress at any time in this queue.
- You must re-enable the S3 integration feature on restored instances. It isn't propagated from the source instance to the restored instance. Files in D:\S3 will be cleaned up on a restored instance.
- Downloading to the DB instance is limited to 100 files. In other words, there can't be more than 100 files in `D:\S3\`.
- Only files without file extensions or with the following file extensions are supported for download: .xml, .txt, .fmt, .lst, .dat, .csv, .info, .bcp, and .tbl.
- The S3 bucket must have the same owner as the related AWS Identity and Access Management (IAM) role. Also, the bucket can't be open to the public.
- File size for uploads is limited to 50 GB per file.

Topics

For more information on working with files in Amazon S3, see Getting Started with Amazon Simple Storage Service.

Prerequisites for Integrating RDS SQL Server with S3

Before you begin, find or create the S3 bucket that you want to use. Also, add permissions so that the RDS DB instance can access the S3 bucket. To configure this access, you create both an IAM policy and an IAM role.

Console

To create an IAM policy for access to Amazon S3

1. In the IAM Management Console, choose **Policies** in the navigation pane.
2. Create a new policy, and use the **Visual editor** tab for the following steps.
3. For **Service**, enter **`S3`** and then choose the **S3** service.
4. For **Actions**, choose the following to grant the access that your DB instance requires:

    - `ListAllMyBuckets` – required

- `ListBucket` – required
- `GetBucketACL` – required
- `GetBucketLocation` – required
- `GetObject` – required for downloading files from S3 to `D:\S3\`
- `PutObject` – required for uploading files from `D:\S3\` to S3
- `ListMultipartUploadParts` – required for uploading files from `D:\S3\` to S3
- `AbortMultipartUpload` – required for uploading files from `D:\S3\` to S3

5. For **Resources**, the options that display depend on which actions you choose in the previous step. You might see options for **bucket**, **object**, or both. For each of these, add the appropriate Amazon Resource Name (ARN).

   For **bucket**, add the ARN for the bucket that you want to use. For example, if your bucket is named `example-bucket`, set the ARN to `arn:aws:s3:::example-bucket`.

   For **object**, enter the ARN for the bucket and then choose one of the following:

   - To grant access to all files in the specified bucket, choose **Any** for both **Bucket name** and **Object name**.
   - To grant access to specific files or folders in the bucket, provide ARNs for the specific buckets and objects that you want SQL Server to access.
6. Follow the instructions in the console until you finish creating the policy.

   The preceding is an abbreviated guide to setting up a policy. For more detailed instructions on creating IAM policies, see Creating IAM Policies in the *IAM User Guide.*

To create an IAM role that uses the IAM policy from the previous procedure

1. In the IAM Management Console, choose **Roles** in the navigation pane.
2. Create a new IAM role, and choose the following options as they appear in the console:

   - **AWS service**
   - **RDS**
   - **RDS – Add Role to Database**

   Then choose **Next:Permissions** at the bottom.
3. For **Attach permissions policies**, enter the name of the IAM policy that you previously created. Then choose the policy from the list.
4. Follow the instructions in the console until you finish creating the role.

   The preceding is an abbreviated guide to setting up a role. If you want more detailed instructions on creating roles, see IAM Roles in the *IAM User Guide.*

AWS CLI

To grant Amazon RDS access to an Amazon S3 bucket

1. Create an IAM policy that grants Amazon RDS access to an S3 bucket.

   Include the appropriate actions to grant the access your DB instance requires:

   - `ListAllMyBuckets` – required
   - `ListBucket` – required

- `GetBucketACL` – required
- `GetBucketLocation` – required
- `GetObject` – required for downloading files from S3 to `D:\S3\`
- `PutObject` – required for uploading files from `D:\S3\` to S3
- `ListMultipartUploadParts` – required for uploading files from `D:\S3\` to S3
- `AbortMultipartUpload` – required for uploading files from `D:\S3\` to S3

The following AWS CLI command creates an IAM policy named *`rds-s3-integration-policy`* with these options. It grants access to a bucket named *`your-s3-bucket-arn`*.

Example

For Linux, macOS, or Unix:

```
aws iam create-policy \
  --policy-name rds-s3-integration-policy \
  --policy-document '{
         "Version": "2012-10-17",
         "Statement": [
             {
                 "Effect": "Allow",
                 "Action": "s3:ListAllMyBuckets",
                 "Resource": "*"
             },
             {
                 "Effect": "Allow",
                 "Action": [
                     "s3:ListBucket",
                     "s3:GetBucketACL",
                     "s3:GetBucketLocation"
                 ],
                 "Resource": "arn:aws:s3:::bucket_name"
             },
             {
                 "Effect": "Allow",
                 "Action": [
                     "s3:GetObject",
                     "s3:PutObject",
                     "s3:ListMultipartUploadParts",
                     "s3:AbortMultipartUpload"
                 ],
                 "Resource": "arn:aws:s3:::bucket_name/key_prefix/*"
             }
         ]
     }'
```

For Windows:

Make sure to change the line endings to the ones supported by your interface (^ instead of \). Also, in Windows, you must escape all double quotes with a \. To avoid the need to escape the quotes in the JSON, you can save it to a file instead and pass that in as a parameter.

First, create the `policy.json` file with the following permission policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
```

```
            "Action": "s3:ListAllMyBuckets",
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "s3:ListBucket",
                "s3:GetBucketACL",
                "s3:GetBucketLocation"
            ],
            "Resource": "arn:aws:s3:::bucket_name"
        },
        {
            "Effect": "Allow",
            "Action": [
                "s3:GetObject",
                "s3:PutObject",
                "s3:ListMultipartUploadParts",
                "s3:AbortMultipartUpload"
            ],
            "Resource": "arn:aws:s3:::bucket_name/key_prefix/*"
        }
    ]
}
```

Then use the following command to create the policy:

```
aws iam create-policy ^
     --policy-name rds-s3-integration-policy ^
     --policy-document file://policy_file_path
```

2. After the policy is created, note the Amazon Resource Name (ARN) of the policy. You need the ARN for a later step.
3. Create an IAM role that Amazon RDS can assume on your behalf to access your S3 buckets.

   The following AWS CLI command creates the *rds-s3-integration-role* for this purpose.

   Example

   For Linux, macOS, or Unix:

```
aws iam create-role \
    --role-name rds-s3-integration-role \
    --assume-role-policy-document '{
      "Version": "2012-10-17",
      "Statement": [
        {
          "Effect": "Allow",
          "Principal": {
             "Service": "rds.amazonaws.com"
           },
          "Action": "sts:AssumeRole"
        }
      ]
    }'
```

   For Windows:

   Make sure to change the line endings to the ones supported by your interface (^ instead of \). Also, in Windows, you must escape all double quotes with a \. To avoid the need to escape the quotes in the JSON, you can save it to a file instead and pass that in as a parameter.

First, create the `assume_role_policy.json` file with the following policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": [
                    "rds.amazonaws.com"
                ]
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

Then use the following command to create the IAM role:

```
aws iam create-role ^
     --role-name rds-s3-integration-role ^
     --assume-role-policy-document file://assume_role_policy_file_path
```

For more information, see Creating a Role to Delegate Permissions to an IAM User in the *IAM User Guide*.

4. After the IAM role is created, note the ARN of the role. You need the ARN for a later step.
5. Attach the IAM policy that you created to the IAM role that you created.

   The following AWS CLI command attaches the policy to the role named *`rds-s3-integration-role`*.

   Example

   For Linux, macOS, or Unix:

```
aws iam attach-role-policy \
    --policy-arn your-policy-arn \
    --role-name rds-s3-integration-role
```

   For Windows:

```
aws iam attach-role-policy ^
    --policy-arn your-policy-arn ^
    --role-name rds-s3-integration-role
```

   Replace *`your-policy-arn`* with the policy ARN that you noted in a previous step.

Enabling RDS SQL Server Integration with S3

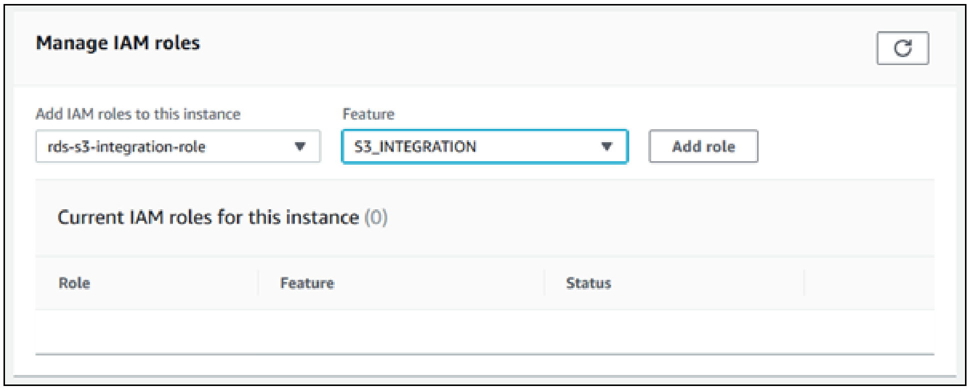
In the following section, you can find how to enable Amazon S3 integration with Amazon RDS for SQL Server. To work with S3 integration, your DB instance must be associated with the IAM role that you previously created before you use the `S3_INTEGRATION` feature-name parameter.

> **Note**
> To add an IAM role to a DB instance, the status of the DB instance must be **available**.

Console

To associate your IAM role with your DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose the RDS SQL Server DB instance name to display its details.
3. On the **Connectivity & security** tab, in the **Manage IAM roles** section, choose the IAM role to add for **Add IAM roles to this instance**.
4. For **Feature**, choose **S3_INTEGRATION**.



5. Choose **Add role**.

AWS CLI

To add the IAM role to the RDS SQL Server DB instance

- The following AWS CLI command adds your IAM role to an RDS SQL Server DB instance named *mydbinstance*.

  Example

  For Linux, macOS, or Unix:

```
aws rds add-role-to-db-instance \
    --db-instance-identifier mydbinstance \
    --feature-name S3_INTEGRATION \
    --role-arn your-role-arn
```

  For Windows:

```
aws rds add-role-to-db-instance ^
    --db-instance-identifier mydbinstance ^
    --feature-name S3_INTEGRATION ^
    --role-arn your-role-arn
```

  Replace *your-role-arn* with the role ARN that you noted in a previous step. `S3_INTEGRATION` must be specified for the `--feature-name` option.

Transferring Files Between RDS SQL Server and an S3 Bucket

You can use Amazon RDS stored procedures to download and upload files between S3 and your RDS DB instance. You can also use Amazon RDS stored procedures to list and delete files on the RDS instance.

The files that you download from and upload to Amazon S3 are stored in the `D:\S3` folder. This is the only folder that you can use to access your files. You can organize your files into subfolders, which are created for you when you include the destination folder during download.

Some of the stored procedures require that you provide an Amazon Resource Name (ARN) to your Amazon S3 bucket and file. The format for your ARN is `arn:aws:s3:::bucket_name/file_name`. Amazon S3 doesn't require an account number or AWS Region in ARNs.

S3 integration tasks run sequentially and share the same queue as native backup and restore tasks. At maximum, you can have only two tasks in progress at any time in this queue. It can take up to five minutes for the task to begin processing.

Downloading Files from an Amazon S3 Bucket to an SQL Server DB Instance

To download files from an S3 bucket to an RDS SQL Server DB instance, use the Amazon RDS stored procedure `msdb.dbo.rds_download_from_s3` with the following parameters.

Parameter Name	Data Type	Default	Required	Description
`@s3_arn_of_file`	NVARCHAR	–	Required	The S3 ARN of the file to download, for example: `arn:aws:s3:::bucket_name/mydata.csv`
`@rds_file_path`	NVARCHAR	–	Optional	The file path for the RDS instance. If not specified, the file path is `D:\S3\<filename in s3>`. RDS supports absolute paths and relative paths. If you want to create a subfolder, include it in the file path.
`@overwrite_file`	INT	0	Optional	Overwrite the existing file: 0 = Don't overwrite 1 = Overwrite

You can download files without a file extension and files with the following file extensions: xml, .txt, .fmt, .lst, .dat, .csv, .info, .bcp, and .tbl.

The following example shows the stored procedure to download files from S3.

```
exec msdb.dbo.rds_download_from_s3
     @s3_arn_of_file='arn:aws:s3:::bucket_name/bulk_data.csv',
     @rds_file_path='D:\S3\seed_data\data.csv',
     @overwrite_file=1;
```

The example `rds_download_from_s3` operation creates a folder named `seed_data` in `D:\S3\`, if the folder doesn't exist yet. Then the example downloads the source file `bulk_data.csv` from S3 to a new file named `data.csv` on the DB instance. If the file previously existed, it's overwritten because the `@overwrite_file` parameter is set to `1`.

Uploading Files from an SQL Server DB Instance to an Amazon S3 Bucket

To upload files from an RDS SQL Server DB instance to an S3 bucket, use the Amazon RDS stored procedure `msdb.dbo.rds_upload_to_s3` with the following parameters.

Parameter Name	Data Type	Default	Required	Description
`@s3_arn_of_file`	NVARCHAR	–	Required	The S3 ARN of the file to be created in S3, for example: `arn:aws:s3:::bucket_name/mydata.csv`
`@rds_file_path`	NVARCHAR	–	Required	The file path of the file to upload to S3. Absolute and relative paths are supported.
`@overwrite_file`	INT	–	Optional	Overwrite the existing file: 0 = Don't overwrite 1 = Overwrite

The following example uploads the file named `data.csv` from the specified location in `D:\S3\seed_data\` to a file `new_data.csv` in the S3 bucket specified by the ARN.

```
exec msdb.dbo.rds_upload_to_s3
  @rds_file_path='D:\S3\seed_data\data.csv',
  @s3_arn_of_file='arn:aws:s3:::bucket_name/new_data.csv',
  @overwrite_file=1;
```

If the file previously existed in S3, it's overwritten because the @overwrite_file parameter is set to `1`.

Listing Files on the RDS DB Instance

To list the files available on the DB instance, use both a stored procedure and a function. First, run the following stored procedure to gather file details from the files in `D:\S3\`.

```
exec msdb.dbo.rds_gather_file_details;
```

The stored procedure returns the ID of the task. Like other tasks, this stored procedure runs asynchronously. As soon as the status of the task is `SUCCESS`, you can use the task ID in the `rds_fn_list_file_details` function to list the existing files and directories in D:\S3\, as shown following.

```
SELECT * FROM msdb.dbo.rds_fn_list_file_details(TASK_ID);
```

The `rds_fn_list_file_details` function returns a table with the following columns.

Output Parameter	Description
`filepath`	Absolute path of the file (for example, `D:\S3\mydata.csv`)

Output Parameter	Description
size_in_bytes	File size (in bytes)
last_modified_utc	Last modification date and time in UTC format
is_directory	Option that indicates whether the item is a directory (true/false)

Deleting Files on the RDS Instance

To delete the files available on the DB instance, use the Amazon RDS stored procedure msdb.dbo.rds_delete_from_filesystem with the following parameters.

Parameter Name	Data Type	Default	Required	Description
@rds_file_path	NVARCHAR	–	Required	The file path of the file to delete. Absolute and relative paths are supported.
@force_delete	INT	0	Optional	To delete a directory, this flag must be included and set to 1. 1 = delete a directory This parameter is ignored if you are deleting a file.

To delete a directory, the @rds_file_path must end with a backslash (\) and @force_delete must be set to 1.

The following example deletes the file D:\S3\delete_me.txt.

```
exec msdb.dbo.rds_delete_from_filesystem
    @rds_file_path='D:\S3\delete_me.txt';
```

The following example deletes the directory D:\S3\example_folder\.

```
exec msdb.dbo.rds_delete_from_filesystem
    @rds_file_path='D:\S3\example_folder\',
    @force_delete=1;
```

Monitoring the Status of a File Transfer Task

To track the status of your S3 integration task, call the rds_fn_task_status function. It takes two parameters. The first parameter should always be NULL because it doesn't apply to S3 integration. The second parameter accepts a task ID. Set the second parameter to 0 to get results for all tasks.

To see a list of all tasks, set the first parameter to NULL and the second parameter to 0, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,0);
```

To get a specific task, set the first parameter to NULL and the second parameter to the task ID, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,42);
```

The rds_fn_task_status function returns the following information.

Output Parameter	Description
task_id	The ID of the task.
task_type	For S3 integration, tasks can have the following task types: • DOWNLOAD_FROM_S3 • UPLOAD_TO_S3 • LIST_FILES_ON_DISK • DELETE_FILES_ON_DISK
database_name	Not applicable to S3 integration tasks.
% complete	The progress of the task as a percentage.
duration(mins)	The amount of time spent on the task, in minutes.
lifecycle	The status of the task. Possible statuses are the following: • CREATED – After you call one of the S3 integration stored procedures, a task is created and the status is set to CREATED. • IN_PROGRESS – After a task starts, the status is set to IN_PROGRESS. It can take up to five minutes for the status to change from CREATED to IN_PROGRESS. • SUCCESS – After a task completes, the status is set to SUCCESS. • ERROR – If a task fails, the status is set to ERROR. For more information about the error, see the task_info column. • CANCEL_REQUESTED – After you call rds_cancel_task, the status of the task is set to CANCEL_REQUESTED. • CANCELLED – After a task is successfully canceled, the status of the task is set to CANCELLED.
task_info	Additional information about the task. If an error occurs during processing, this column contains information about the error.
last_updated	The date and time that the task status was last updated.
created_at	The date and time that the task was created.

Output Parameter	Description
`S3_object_arn`	The ARN of the S3 object downloaded from or uploaded to.
`overwrite_S3_backup_file`	Not applicable to S3 integration tasks.
`KMS_master_key_arn`	Not applicable to S3 integration tasks.
`filepath`	The file path on the RDS DB instance.
`overwrite_file`	An option that indicates if an existing file is overwritten.
`task_metadata`	Not applicable to S3 integration tasks.

Canceling a Task

To cancel S3 integration tasks, use the `msdb.dbo.rds_cancel_task` stored procedure with the `task_id` parameter. Delete and list tasks that are in progress can't be cancelled. The following example shows a request to cancel a task.

```
exec msdb.dbo.rds_cancel_task @task_id = 1234;
```

To get an overview of all tasks and their task IDs, use the `rds_fn_task_status` function as described in Monitoring the Status of a File Transfer Task (p. 631).

Multi-AZ Limitations for S3 Integration

On Multi-AZ instances, files in the `D:\S3` folder are deleted on the standby replica after a failover. A failover can be planned, for example, during DB instance modifications such as changing the instance class or upgrading the engine version. Or a failover can be unplanned, during an outage of the primary.

> **Note**
> We don't recommend using the `D:\S3` folder for file storage. The best practice is to upload created files to Amazon S3 to make them durable, and download files when you need to import data.

To determine the last failover time, you can use the `msdb.dbo.rds_failover_time` stored procedure. For more information, see Determining the Last Failover Time (p. 701).

Example of No Recent Failover

This example shows the output when there is no recent failover in the error logs. No failover has happened since 2020-04-29 23:59:00.01.

Therefore, all files downloaded after that time that haven't been deleted using the `rds_delete_from_filesystem` stored procedure are still accessible on the current host. Files downloaded before that time might also be available.

errorlog_available_from	recent_failover_time
2020-04-29 23:59:00.0100000	null

Example of Recent Failover

This example shows the output when there is a failover in the error logs. The most recent failover was at 2020-05-05 18:57:51.89.

All files downloaded after that time that haven't been deleted using the `rds_delete_from_filesystem` stored procedure are still accessible on the current host.

errorlog_available_from	recent_failover_time
2020-04-29 23:59:00.0100000	2020-05-05 18:57:51.8900000

Disabling RDS SQL Server Integration with S3

Following, you can find how to disable Amazon S3 integration with Amazon RDS for SQL Server. Files in `D:\S3\` aren't deleted when disabling S3 integration.

> **Note**
> To remove an IAM role from a DB instance, the status of the DB instance must be `available`.

Console

To disassociate your IAM role from your DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose the RDS SQL Server DB instance name to display its details.
3. On the **Connectivity & security** tab, in the **Manage IAM roles** section, choose the IAM role to remove.
4. Choose **Delete**.

AWS CLI

To remove the IAM role from the RDS SQL Server DB instance

- The following AWS CLI command removes the IAM role from a RDS SQL Server DB instance named *mydbinstance*.

  Example

  For Linux, macOS, or Unix:

```
aws rds remove-role-from-db-instance \
    --db-instance-identifier mydbinstance \
    --feature-name S3_INTEGRATION \
    --role-arn your-role-arn
```

  For Windows:

```
aws rds remove-role-from-db-instance ^
    --db-instance-identifier mydbinstance ^
    --feature-name S3_INTEGRATION ^
    --role-arn your-role-arn
```

  Replace *your-role-arn* with the appropriate IAM role ARN for the `--feature-name` option.

Options for the Microsoft SQL Server Database Engine

In this section, you can find descriptions for options that are available for Amazon RDS instances running the Microsoft SQL Server DB engine. To enable these options, you add them to an option group, and then associate the option group with your DB instance. For more information, see Working with Option Groups (p. 186).

If you're looking for optional features that aren't added through RDS option groups (such as SSL, Microsoft Windows Authentication, and Amazon S3 integration), see Additional Features for Microsoft SQL Server on Amazon RDS (p. 608).

Amazon RDS supports the following options for Microsoft SQL Server DB instances.

Option	Option ID	Engine Editions
Native Backup and Restore (p. 637)	`SQLSERVER_BACKUP_RESTORE`	SQL Server Enterprise Edition SQL Server Standard Edition SQL Server Web Edition SQL Server Express Edition
Transparent Data Encryption (p. 640)	`TRANSPARENT_DATA_ENCRYPTION`	SQL Server Enterprise Edition
SQL Server Audit (p. 642)	`SQLSERVER_AUDIT`	In RDS, starting with SQL Server 2012, all editions of SQL Server support server level audits, and Enterprise edition also supports database level audits. Starting with SQL Server SQL Server 2016 (13.x) SP1, all editions support both server and database level audits. For more information, see SQL Server Audit (Database Engine) in the SQL Server documentation.
SQL Server Analysis Services (p. 647)	`SSAS`	SQL Server Enterprise Edition SQL Server Standard Edition

Option	Option ID	Engine Editions
SQL Server Integration Services (p. 658)	SSIS	SQL Server Enterprise Edition SQL Server Standard Edition
SQL Server Reporting Services (p. 672)	SSRS	SQL Server Enterprise Edition SQL Server Standard Edition
Microsoft Distributed Transaction Coordinator (p. 681)	MSDTC	In RDS, starting with SQL Server 2012, all editions of SQL Server support distributed transactions.

Support for Native Backup and Restore in SQL Server

By using native backup and restore for SQL Server databases, you can create a differential or full backup of your on-premises database and store the backup files on Amazon S3. You can then restore to an existing Amazon RDS DB instance running SQL Server. You can also back up an RDS SQL Server database, store it on Amazon S3, and restore it in other locations. In addition, you can restore the backup to an on-premises server, or a different Amazon RDS DB instance running SQL Server. For more information, see Importing and Exporting SQL Server Databases (p. 576).

Amazon RDS supports native backup and restore for Microsoft SQL Server databases by using differential and full backup files (.bak files).

Adding the Native Backup and Restore Option

The general process for adding the native backup and restore option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the `SQLSERVER_BACKUP_RESTORE` option to the option group.
3. Associate an AWS Identity and Access Management (IAM) role with the option. The IAM role must have access to an S3 bucket to store the database backups.

   That is, it must have as its option setting a valid Amazon Resource Name (ARN) in the format `arn:aws:iam::`*`account-id`*`:role/`*`role-name`*. For more information, see Amazon Resource Names (ARNs) in the *AWS General Reference.*
4. Associate the option group with the DB instance.

After you add the native backup and restore option, you don't need to restart your DB instance. As soon as the option group is active, you can begin backing up and restoring immediately.

Console

To add the native backup and restore option

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Option groups**.
3. Create a new option group or use an existing option group. For information on how to create a custom DB option group, see Creating an Option Group (p. 187).

   To use an existing option group, skip to the next step.
4. Add the **SQLSERVER_BACKUP_RESTORE** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
5. Do one of the following:

   - To use an existing IAM role and Amazon S3 settings, choose an existing IAM role for **IAM Role**. If you use an existing IAM role, RDS uses the Amazon S3 settings configured for this role.
   - To create a new role and configure new Amazon S3 settings, do the following:
     1. For **IAM Role**, choose **Create a New Role**.
     2. For **Select S3 Bucket**, either create an S3 bucket or use an existing one. To create a new bucket, choose **Create a New S3 Bucket**. To use an existing bucket, choose it from the list.
     3. For **S3 folder path prefix (optional)**, specify a prefix to use for the files stored in your Amazon S3 bucket.

        This prefix can include a file path but doesn't have to. If you provide a prefix, RDS attaches that prefix to all backup files. RDS then uses the prefix during a restore to identify related files and ignore irrelevant files. For example, you might use the S3 bucket for purposes besides holding backup files. In this case, you can use the prefix to have RDS perform native backup and restore only on a particular folder and its subfolders.

        If you leave the prefix blank, then RDS doesn't use a prefix to identify backup files or files to restore. As a result, during a multiple-file restore, RDS attempts to restore every file in every folder of the S3 bucket.
     4. For **Enable Encryption**, choose **Yes** to encrypt the backup file. Choose **No** to leave the backup file unencrypted.

        If you choose **Yes**, choose an encryption key for **Master Key**. For more information about encryption keys, see Getting Started in the *AWS Key Management Service Developer Guide.*
6. Choose **Add option**.
7. Apply the option group to a new or existing DB instance:

   - For a new DB instance, apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

CLI

This procedure makes the following assumptions:

- You're adding the SQLSERVER_BACKUP_RESTORE option to an option group that already exists. For more information about adding options, see Adding an Option to an Option Group (p. 190).
- You're associating the option with an IAM role that already exists and has access to an S3 bucket to store the backups.
- You're applying the option group to a DB instance that already exists. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

To add the native backup and restore option

1. Add the `SQLSERVER_BACKUP_RESTORE` option to the option group.

Example

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
 --apply-immediately \
 --option-group-name mybackupgroup \
 --options "OptionName=SQLSERVER_BACKUP_RESTORE, \
   OptionSettings=[{Name=IAM_ROLE_ARN,Value=arn:aws:iam::account-id:role/role-name}]"
```

For Windows:

```
aws rds add-option-to-option-group ^
 --option-group-name mybackupgroup ^
 --options "[{\"OptionName\": \"SQLSERVER_BACKUP_RESTORE\", ^
 \"OptionSettings\": [{\"Name\": \"IAM_ROLE_ARN\", ^
 \"Value\": \"arn:aws:iam::account-id:role/role-name"}]}]" ^
 --apply-immediately
```

> **Note**
> When using the Windows command prompt, you must escape double quotes (") in JSON code by prefixing them with a backslash (\).

2. Apply the option group to the DB instance.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
 --db-instance-identifier mydbinstance \
 --option-group-name mybackupgroup \
 --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
 --db-instance-identifier mydbinstance ^
 --option-group-name mybackupgroup ^
 --apply-immediately
```

Modifying Native Backup and Restore Option Settings

After you enable the native backup and restore option, you can modify the settings for the option. For more information about how to modify option settings, see Modifying an Option Setting (p. 195).

Removing the Native Backup and Restore Option

You can turn off native backup and restore by removing the option from your DB instance. After you remove the native backup and restore option, you don't need to restart your DB instance.

To remove the native backup and restore option from a DB instance, do one of the following:

- Remove the option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).

- Modify the DB instance and specify a different option group that doesn't include the native backup and restore option. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Support for Transparent Data Encryption in SQL Server

Amazon RDS supports using Transparent Data Encryption (TDE) to encrypt stored data on your DB instances running Microsoft SQL Server. TDE automatically encrypts data before it is written to storage, and automatically decrypts data when the data is read from storage.

Amazon RDS supports TDE for the following SQL Server versions and editions:

- SQL Server 2017 Enterprise Edition
- SQL Server 2016 Enterprise Edition
- SQL Server 2014 Enterprise Edition
- SQL Server 2012 Enterprise Edition

To enable transparent data encryption for an RDS SQL Server DB instance, specify the TDE option in an RDS option group that is associated with that DB instance.

Transparent data encryption for SQL Server provides encryption key management by using a two-tier key architecture. A certificate, which is generated from the database master key, is used to protect the data encryption keys. The database encryption key performs the actual encryption and decryption of data on the user database. Amazon RDS backs up and manages the database master key and the TDE certificate. To comply with several security standards, Amazon RDS is working to implement automatic periodic master key rotation.

Transparent data encryption is used in scenarios where you need to encrypt sensitive data. For example, you might want to provide data files and backups to a third party, or address security-related regulatory compliance issues. You can't encrypt the system databases for SQL Server, such as the Model or Master databases.

A detailed discussion of transparent data encryption is beyond the scope of this guide, but you should understand the security strengths and weaknesses of each encryption algorithm and key. For information about transparent data encryption for SQL Server, see Transparent Data Encryption (TDE) on the Microsoft website.

Determine if your DB instance is already associated with an option group that has the TDE option. To view the option group that a DB instance is associated with, you can use the RDS console, the describe-db-instance AWS CLI command, or the API operation DescribeDBInstances.

The process for enabling transparent data encryption on a SQL Server DB instance is as follows:

1. If the DB instance isn't associated with an option group that has TDE enabled, you have two choices. You can create an option group and add the TDE option, or you can modify the associated option group to add it. For information about creating or modifying an option group, see Working with Option Groups (p. 186). For information about adding an option to an option group, see Adding an Option to an Option Group (p. 190).
2. Associate the DB instance with the option group with the TDE option. For information about associating a DB instance with an option group, see Modifying an Amazon RDS DB Instance (p. 220).

When the TDE option is added to an option group, Amazon RDS generates a certificate that is used in the encryption process. You can then use the certificate to run SQL statements that encrypt data in a database on the DB instance. The following example uses the RDS-created certificate called `RDSTDECertificateName` to encrypt a database called `customerDatabase`.

```
---------- Enabling TDE -------------

-- Find a RDSTDECertificate to use
USE [master]
GO
SELECT name FROM sys.certificates WHERE name LIKE 'RDSTDECertificate%'
GO

USE [customerDatabase]
GO
-- Create DEK using one of the certificates from the previous step
CREATE DATABASE ENCRYPTION KEY
WITH ALGORITHM = AES_128
ENCRYPTION BY SERVER CERTIFICATE [RDSTDECertificateName]
GO

-- Enable encryption on the database
ALTER DATABASE [customerDatabase]
SET ENCRYPTION ON
GO

-- Verify that the database is encrypted
USE [master]
GO
SELECT name FROM sys.databases WHERE is_encrypted = 1
GO
SELECT db_name(database_id) as DatabaseName, * FROM sys.dm_database_encryption_keys
GO
```

The time that it takes to encrypt a SQL Server database using TDE depends on several factors. These include the size of the DB instance, whether PIOPS is enabled for the instance, the amount of data, and other factors.

The TDE option is a persistent option that you can't remove from an option group unless all DB instances and backups are disassociated from the option group. After you add the TDE option to an option group, the option group can only be associated with DB instances that use TDE. For more information about persistent options in an option group, see Option Groups Overview (p. 186).

Because the TDE option is a persistent option, you can have a conflict between the option group and an associated DB instance. You can have a conflict between the option group and an associated DB instance in the following situations:

- The current option group has the TDE option, and you replace it with an option group that does not have the TDE option.
- You restore from a DB snapshot to a new DB instance that does not have an option group that contains the TDE option. For more information about this scenario, see Option Group Considerations (p. 307).

To disable TDE for a DB instance, first make sure that there are no encrypted objects left on the DB instance by either decrypting the objects or by dropping them. If any encrypted objects exist on the DB instance, you can't disable TDE for the DB instance. When you use the console to remove the TDE option from an option group, the console indicates that it is processing. In addition, an error event is created if the option group is associated with an encrypted DB instance or DB snapshot.

The following example removes the TDE encryption from a database called `customerDatabase`.

```
------------- Removing TDE ----------------

USE [customerDatabase]
```

```
GO

-- Disable encryption on the database
ALTER DATABASE [customerDatabase]
SET ENCRYPTION OFF
GO

-- Wait until the encryption state of the database becomes 1. The state is 5 (Decryption in
 progress) for a while
SELECT db_name(database_id) as DatabaseName, * FROM sys.dm_database_encryption_keys
GO

-- Drop the DEK used for encryption
DROP DATABASE ENCRYPTION KEY
GO

-- Alter to SIMPLE Recovery mode so that your encrypted log gets truncated
USE [master]
GO
ALTER DATABASE [customerDatabase] SET RECOVERY SIMPLE
GO
```

When all objects are decrypted, you can have two options. You can modify the DB instance to be associated with an option group without the TDE option. Or you can remove the TDE option from the option group.

SQL Server Performance Considerations

The performance of a SQL Server DB instance can be impacted by using transparent data encryption.

Performance for unencrypted databases can also be degraded if the databases are on a DB instance that has at least one encrypted database. As a result, we recommend that you keep encrypted and unencrypted databases on separate DB instances.

Because of the nature of encryption, the database size and the size of the transaction log is larger than for an unencrypted database. You could run over your allocation of free backup space. The nature of TDE causes an unavoidable performance hit. If you need high performance and TDE, measure the impact and make sure that it meets your needs. There is less of an impact on performance if you use Provisioned IOPS and at least an M3.Large DB instance class.

SQL Server Audit

In Amazon RDS, you can audit Microsoft SQL Server databases by using the built-in SQL Server auditing mechanism. You can create audits and audit specifications in the same way that you create them for on-premises database servers.

RDS uploads the completed audit logs to your S3 bucket, using the IAM role that you provide. If you enable retention, RDS keeps your audit logs on your DB instance for the configured period of time.

For more information, see SQL Server Audit (Database Engine) in the Microsoft SQL Server documentation.

Topics

- Manually Creating an IAM Role for SQL Server Audit (p. 646)

Support for SQL Server Audit

In Amazon RDS, starting with SQL Server 2012, all editions of SQL Server support server-level audits, and the Enterprise edition also supports database-level audits. Starting with SQL Server 2016 (13.x) SP1, all editions support both server-level and database-level audits. For more information, see SQL Server Audit (Database Engine) in the SQL Server documentation.

RDS supports configuring the following option settings for SQL Server Audit.

Option Setting	Valid Values	Description
`IAM_ROLE_ARN`	A valid Amazon Resource Name (ARN) in the format `arn:aws:iam::`*`account-id`*`:role/`*`role-name`*.	The ARN of the IAM role that grants access to the S3 bucket where you want to store your audit logs. For more information, see Amazon Resource Names (ARNs) in the *AWS General Reference.*
`S3_BUCKET_ARN`	A valid ARN in the format `arn:aws:s3:::bucket-name` or `arn:aws:s3:::bucket-name/key-prefix`	The ARN for the S3 bucket where you want to store your audit logs.
`ENABLE_COMPRESSION`	`true` or `false`	Controls audit log compression. By default, compression is enabled (set to `true`).
`RETENTION_TIME`	`0` to `840`	The retention time (in hours) that SQL Server audit records are kept on your RDS instance. By default, retention is disabled.

Adding SQL Server Audit to the DB Instance Options

Enabling SQL Server Audit requires two steps: enabling the option on the DB instance, and enabling the feature inside SQL Server. The process for adding the SQL Server Audit option to a DB instance is as follows:

1. Create a new option group, or copy or modify an existing option group.
2. Add and configure all required options.
3. Associate the option group with the DB instance.

After you add the SQL Server Audit option, you don't need to restart your DB instance. As soon as the option group is active, you can create audits and store audit logs in your S3 bucket.

To add and configure SQL Server Audit on a DB instance's option group

1. Choose one of the following:
   - Use an existing option group.
   - Create a custom DB option group and use that option group. For more information, see Creating an Option Group (p. 187).

2. Add the **SQLSERVER_AUDIT** option to the option group, and configure the option settings. For more information about adding options, see Adding an Option to an Option Group (p. 190).

   - For **IAM role**, if you already have an IAM role with the required policies, you can choose that role. To create a new IAM role, choose **Create a New Role**. For information about the required policies, see Manually Creating an IAM Role for SQL Server Audit (p. 646).
   - For **Select S3 destination**, if you already have an S3 bucket that you want to use, choose it. To create an S3 bucket, choose **Create a New S3 Bucket**.
   - For **Enable Compression**, leave this option checked to compress audit files. Compression is enabled by default. To disable compression, clear **Enable Compression**.
   - For **Audit log retention**, to keep audit records on the DB instance, choose this option. Specify a retention time in hours. The maximum retention time is 35 days.
3. Apply the option group to a new or existing DB instance. Choose one of the following:

   - If you are creating a new DB instance, apply the option group when you launch the instance.
   - On an existing DB instance, apply the option group by modifying the instance and then attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Modifying the SQL Server Audit Option

After you enable the SQL Server Audit option, you can modify the settings. For information about how to modify option settings, see Modifying an Option Setting (p. 195).

Removing SQL Server Audit from the DB Instance Options

You can turn off the SQL Server Audit feature by disabling audits and then deleting the option.

To remove auditing

1. Disable all of the audit settings inside SQL Server. To learn where audits are running, query the SQL Server security catalog views. For more information, see Security Catalog Views in the Microsoft SQL Server documentation.
2. Delete the SQL Server Audit option from the DB instance. Choose one of the following:

   - Delete the SQL Server Audit option from the option group that the DB instance uses. This change affects all DB instances that use the same option group. For more information, see Removing an Option from an Option Group (p. 198).
   - Modify the DB instance, and then choose an option group without the SQL Server Audit option. This change affects only the DB instance that you modify. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
3. After you delete the SQL Server Audit option from the DB instance, you don't need to restart the instance. Remove unneeded audit files from your S3 bucket.

Using SQL Server Audit

You can control server audits, server audit specifications, and database audit specifications the same way that you control them for on-premises database servers.

Creating Audits

You create server audits in the same way that you create them for on-premises database servers. For information about how to create server audits, see CREATE SERVER AUDIT in the Microsoft SQL Server documentation.

To avoid errors, adhere to the following limitations:

- Don't exceed the maximum number of supported server audits per instance of 50.
- Instruct SQL Server to write data to a binary file.
- Don't use `RDS_` as a prefix in the server audit name.
- For `FILEPATH`, specify `D:\rdsdbdata\SQLAudit`.
- For `MAXSIZE`, specify a size between 2 MB and 50 MB.
- Don't configure `MAX_ROLLOVER_FILES` or `MAX_FILES`.
- Don't configure SQL Server to shut down the DB instance if it fails to write the audit record.

Creating Audit Specifications

You create server audit specifications and database audit specifications the same way that you create them for on-premises database servers. For information about creating audit specifications, see CREATE SERVER AUDIT SPECIFICATION and CREATE DATABASE AUDIT SPECIFICATION in the Microsoft SQL Server documentation.

To avoid errors, don't use `RDS_` as a prefix in the name of the database audit specification or server audit specification.

Viewing Audit Logs

Your audit logs are stored in `D:\rdsdbdata\SQLAudit`.

After SQL Server finishes writing to an audit log file—when the file reaches its size limit—Amazon RDS uploads the file to your S3 bucket. If retention is enabled, Amazon RDS moves the file into the retention folder: `D:\rdsdbdata\SQLAudit\transmitted`.

For information about configuring retention, see Adding SQL Server Audit to the DB Instance Options (p. 643).

Audit records are kept on the DB instance until the audit log file is uploaded. You can view the audit records by running the following command.

```
SELECT   *
 FROM     msdb.dbo.rds_fn_get_audit_file
              ('D:\rdsdbdata\SQLAudit\*.sqlaudit'
              , default
              , default )
```

You can use the same command to view audit records in your retention folder by changing the filter to `D:\rdsdbdata\SQLAudit\transmitted\*.sqlaudit`.

```
SELECT   *
 FROM     msdb.dbo.rds_fn_get_audit_file
              ('D:\rdsdbdata\SQLAudit\transmitted\*.sqlaudit'
              , default
              , default )
```

Using SQL Server Audit with Multi-AZ Instances

For Multi-AZ instances, the process for sending audit log files to Amazon S3 is similar to the process for Single-AZ instances. However, there are some important differences:

- Database audit specification objects are replicated to all nodes.

- Server audits and server audit specifications aren't replicated to secondary nodes. Instead, you have to create or modify them manually.

To capture server audits or a server audit specification from both nodes:

1. Create a server audit or a server audit specification on the primary node.
2. Fail over to the secondary node and create a server audit or a server audit specification with the same name and GUID on the secondary node. Use the `AUDIT_GUID` parameter to specify the GUID.

Configuring an S3 Bucket

The audit log files are automatically uploaded from the DB instance to your S3 bucket. The following restrictions apply to the S3 bucket that you use as a target for audit files:

- It must be in the same AWS Region as the DB instance.
- It must not be open to the public.
- The bucket owner must also be the IAM role owner.

The target key that is used to store the data follows this naming schema: `bucket-name/key-prefix/instance-name/audit-name/node_file-name.ext`

> **Note**
> You set both the bucket name and the key prefix values with the (`S3_BUCKET_ARN` option setting.

The schema is composed of the following elements:

- **`bucket-name`** – The name of your S3 bucket.
- **`key-prefix`** – The custom key prefix you want to use for audit logs.
- **`instance-name`** – The name of your Amazon RDS instance.
- **`audit-name`** – The name of the audit.
- **`node`** – The identifier of the node that is the source of the audit logs (`node1` or `node2`). There is one node for a Single-AZ instance and two replication nodes for a Multi-AZ instance. These are not primary and secondary nodes, because the roles of primary and secondary change over time. Instead, the node identifier is a simple label.
  - **`node1`** – The first replication node (Single-AZ has one node only).
  - **`node2`** – The second replication node (Multi-AZ has two nodes).
- **`file-name`** – The target file name. The file name is taken as-is from SQL Server.
- **`ext`** – The extension of the file (`zip` or `sqlaudit`):
  - **`zip`** – If compression is enabled (default).
  - **`sqlaudit`** – If compression is disabled.

Manually Creating an IAM Role for SQL Server Audit

Typically, when you create a new option, the AWS Management Console creates the IAM role and the IAM trust policy for you. However, you can manually create a new IAM role to use with SQL Server Audits, so that you can customize it with any additional requirements you might have. To do this, you create an IAM role and delegate permissions so that the Amazon RDS service can use your Amazon S3 bucket. When you create this IAM role, you attach trust and permissions policies. The trust policy allows Amazon RDS to assume this role. The permission policy defines the actions that this role can do. For more information, see Creating a Role to Delegate Permissions to an AWS Service in the *AWS Identity and Access Management User Guide*.

You can use the examples in this section to create the trust and permissions policies you need.

The following example shows a trust policy for SQL Server Audit. The policy uses the *service principal* `rds.amazonaws.com` to allow RDS to write to the S3 bucket. A *service principal* is an identifier that is used to grant permissions to a service. Anytime you allow access to `rds.amazonaws.com` in this way, you are allowing RDS to perform an action on your behalf. For more information about service principals, see AWS JSON Policy Elements: Principal.

```
{
     "Version": "2012-10-17",
     "Statement": [
         {
             "Effect": "Allow",
             "Principal": {
                 "Service": "rds.amazonaws.com"
             },
             "Action": "sts:AssumeRole"
         }
     ]
 }
```

In the following example of a permissions policy for SQL Server Audit, we specify an Amazon Resource Name (ARN) for the Amazon S3 bucket. You can use ARNs to identify a specific account, user, or role that you want grant access to. For more information about using ARNs, see Amazon Resource Names (ARNs).

```
{
     "Version": "2012-10-17",
     "Statement": [
         {
             "Effect": "Allow",
             "Action": "s3:ListAllMyBuckets",
             "Resource": "*"
         },
         {
             "Effect": "Allow",
             "Action": [
                 "s3:ListBucket",
                 "s3:GetBucketACL",
                 "s3:GetBucketLocation"
             ],
             "Resource": "arn:aws:s3:::bucket_name"
         },
         {
             "Effect": "Allow",
             "Action": [
                 "s3:PutObject",
                 "s3:ListMultipartUploadParts",
                 "s3:AbortMultipartUpload"
             ],
             "Resource": "arn:aws:s3:::bucket_name/key_prefix/*"
         }
     ]
 }
```

Support for SQL Server Analysis Services in SQL Server

Microsoft SQL Server Analysis Services (SSAS) is part of the Microsoft Business Intelligence (MSBI) suite. SSAS is an online analytical processing (OLAP) and data mining tool that is installed within SQL Server. You use SSAS to analyze data to help make business decisions. SSAS differs from the

SQL Server relational database because SSAS is optimized for queries and calculations common in a business intelligence environment. For more information on SSAS, see the Microsoft Analysis Services documentation.

Amazon RDS for SQL Server supports running SQL Server Analysis Services (SSAS) in Tabular mode. You can enable SSAS on existing or new DB instances. It's installed on the same DB instance as your database engine. RDS supports the following SQL Server editions and versions:

- SQL Server 2017: Standard and Enterprise editions, version 14.00.3223.3.v1 and later
- SQL Server 2016: Standard and Enterprise editions, version 13.00.5426.0.v1 and later

Limitations

The following limitations apply to running SSAS on RDS for SQL Server:

- Tabular is the only supported mode for SSAS.
- Multi-AZ instances aren't supported.
- Instances must use AWS Directory Service for Microsoft Active Directory for SSAS authentication.
- Users aren't given SSAS server administrator access, but they can be granted database-level administrator access.
- The only supported port for accessing SSAS is 2383.
- You can't deploy projects directly. We provide an RDS stored procedure to do this. For more information, see Deploying SSAS Projects on Amazon RDS (p. 652).
- Processing during deployment isn't supported.
- Using .xmla files for deployment isn't supported.
- SSAS project input files and database backup output files can only be in the `D:\S3` folder on the DB instance.

Enabling SSAS

Use the following process to enable SSAS for your DB instance:

1. Create a new option group, or choose an existing option group.
2. Add the `SSAS` option to the option group.
3. Associate the option group with the DB instance.
4. Allow inbound access to the VPC security group for the SSAS listener port.
5. Enable Amazon S3 integration.

Creating the Option Group for SSAS

Use the AWS Management Console or the AWS CLI to create an option group that corresponds to the SQL Server engine and version of the DB instance that you plan to use.

> **Note**
> You can also use an existing option group if it's for the correct SQL Server engine and version.

Console

The following console procedure creates an option group for SQL Server Standard Edition 2017.

To create the option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Option groups**.
3. Choose **Create group**.
4. In the **Create option group** pane, do the following:

   a. For **Name**, enter a name for the option group that is unique within your AWS account, such as **ssas-se-2017**. The name can contain only letters, digits, and hyphens.
   b. For **Description**, enter a brief description of the option group, such as **SSAS option group for SQL Server SE 2017**. The description is used for display purposes.
   c. For **Engine**, choose **sqlserver-se**.
   d. For **Major engine version**, choose **14.00**.
5. Choose **Create**.

CLI

The following CLI example creates an option group for SQL Server Standard Edition 2017.

To create the option group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-option-group \
    --option-group-name ssas-se-2017 \
    --engine-name sqlserver-se \
    --major-engine-version 14.00 \
    --option-group-description "SSAS option group for SQL Server SE 2017"
```

  For Windows:

```
aws rds create-option-group ^
    --option-group-name ssas-se-2017 ^
    --engine-name sqlserver-se ^
    --major-engine-version 14.00 ^
    --option-group-description "SSAS option group for SQL Server SE 2017"
```

Adding the SSAS Option to the Option Group

Next, use the AWS Management Console or the AWS CLI to add the `SSAS` option to the option group.

Console

To add the SSAS option

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group that you just created.
4. Choose **Add option**.
5. Under **Option details**, choose **SSAS** for **Option name**.
6. Under **Option settings**, enter a value from 10–80 for **Max memory**.

Max memory specifies the upper threshold above which SSAS begins releasing memory more aggressively to make room for requests that are running, and also new high-priority requests. The number is a percentage of the total memory of the DB instance. The allowed values are 10–80, and the default is 45.

> **Note**
> The port for accessing SSAS, 2383, is prepopulated.

7. For **Security groups**, choose the VPC security group to associate with the option.
8. Under **Scheduling**, choose whether to add the option immediately or at the next maintenance window.
9. Choose **Add option**.

CLI

To add the SSAS option

1. Create a JSON file, for example `ssas-option.json`, with the following parameters:

   - `OptionGroupName` – The name of option group that you created or chose previously (`ssas-se-2017` in the following example).
   - `Port` – The port that you use to access SSAS. The only supported port is 2383.
   - `VpcSecurityGroupMemberships` – VPC security group memberships for your RDS DB instance.
   - `MAX_MEMORY` – The upper threshold above which SSAS should begin releasing memory more aggressively to make room for requests that are running, and also new high-priority requests. The number is a percentage of the total memory of the DB instance. The allowed values are 10–80, and the default is 45.

```
{
"OptionGroupName": "ssas-se-2017",
"OptionsToInclude": [
 {
 "OptionName": "SSAS",
 "Port": 2383,
 "VpcSecurityGroupMemberships" : ["sg-0abcdef123"],
 "OptionSettings": [{"Name" : "MAX_MEMORY","Value" : "60"}]
 }],
"ApplyImmediately": true
}
```

2. Add the `SSAS` option to the option group.

   #### Example

   For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --cli-input-json file://ssas-option.json \
    --apply-immediately
```

   For Windows:

```
aws rds add-option-to-option-group ^
    --cli-input-json file://ssas-option.json ^
    --apply-immediately
```

Associating the Option Group with Your DB Instance

You can use the AWS Management Console or the AWS CLI to associate the option group with your DB instance.

Console

Associate your option group with a new or existing DB instance:

- For a new DB instance, associate the option group with the DB instance when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
- For an existing DB instance, modify the instance and associate the new option group with it. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

  Note
  If you use an existing instance, it must already have an Active Directory domain and IAM role associated with it. If you create a new instance, specify an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

CLI

You can associate your option group with a new or existing DB instance.

Note
If you use an existing instance, it must already have an Active Directory domain and IAM role associated with it. If you create a new instance, specify an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

To create a DB instance that uses the option group

- Specify the same DB engine type and major version that you used when creating the option group.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier myssasinstance \
    --db-instance-class db.m5.2xlarge \
    --engine sqlserver-se \
    --engine-version 14.00.3223.3.v1 \
    --allocated-storage 100 \
    --master-user-password secret123 \
    --master-username master \
    --storage-type gp2 \
    --license-model li \
    --domain-iam-role-name my-directory-iam-role \
    --domain my-domain-id \
    --option-group-name ssas-se-2017
```

  For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier myssasinstance ^
    --db-instance-class db.m5.2xlarge ^
    --engine sqlserver-se ^
    --engine-version 14.00.3223.3.v1 ^
```

```
    --allocated-storage 100 ^
    --master-user-password secret123 ^
    --master-username master ^
    --storage-type gp2 ^
    --license-model li ^
    --domain-iam-role-name my-directory-iam-role ^
    --domain my-domain-id ^
    --option-group-name ssas-se-2017
```

To modify a DB instance to associate the option group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier myssasinstance \
    --option-group-name ssas-se-2017 \
    --apply-immediately
```

  For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier myssasinstance ^
    --option-group-name ssas-se-2017 ^
    --apply-immediately
```

Allowing Inbound Access to Your VPC Security Group

Create an inbound rule for the specified SSAS listener port in the VPC security group associated with your DB instance. For more information about setting up security groups, see Provide Access to Your DB Instance in Your VPC by Creating a Security Group (p. 61).

Enabling S3 Integration

To download model configuration files to your host for deployment, use S3 integration. For more information, see Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3 (p. 623).

Deploying SSAS Projects on Amazon RDS

On RDS, you can't deploy SSAS projects directly by using SQL Server Management Studio (SSMS). To deploy projects, use an RDS stored procedure.

> **Note**
> Using .xmla files for deployment isn't supported.

Before you deploy projects, make sure of the following:

- S3 integration is enabled. For more information, see Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3 (p. 623).
- The `Processing Option` configuration setting is set to `Do Not Process`. This setting means that no processing happens after deployment.
- You have both the `myssasproject.asdatabase` and `myssasproject.deploymentoptions` files. They're automatically generated when you build the SSAS project.

To deploy an SSAS project on RDS

1. Download the `.asdatabase` (SSAS model) file from your S3 bucket to your DB instance, as shown in the following example. For more information on the download parameters, see Downloading Files from an Amazon S3 Bucket to an SQL Server DB Instance (p. 629).

```
exec msdb.dbo.rds_download_from_s3
@s3_arn_of_file='arn:aws:s3:::bucket_name/myssasproject.asdatabase',
[@rds_file_path='D:\S3\myssasproject.asdatabase'],
[@overwrite_file=1];
```

2. Download the `.deploymentoptions` file from your S3 bucket to your DB instance.

```
exec msdb.dbo.rds_download_from_s3
@s3_arn_of_file='arn:aws:s3:::bucket_name/myssasproject.deploymentoptions',
[@rds_file_path='D:\S3\myssasproject.deploymentoptions'],
[@overwrite_file=1];
```

3. Deploy the project.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSAS_DEPLOY_PROJECT',
@file_path='D:\S3\myssasproject.asdatabase';
```

Monitoring the Status of a Deployment Task

To track the status of your deployment (or download) task, call the `rds_fn_task_status` function. It takes two parameters. The first parameter should always be `NULL` because it doesn't apply to SSAS. The second parameter accepts a task ID.

To see a list of all tasks, set the first parameter to `NULL` and the second parameter to `0`, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,0);
```

To get a specific task, set the first parameter to `NULL` and the second parameter to the task ID, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,42);
```

The `rds_fn_task_status` function returns the following information.

Output Parameter	Description
`task_id`	The ID of the task.
`task_type`	For SSAS, tasks can have the following task types: • `SSAS_DEPLOY_PROJECT` • `SSAS_ADD_DB_ADMIN_MEMBER` • `SSAS_BACKUP_DB` • `SSAS_RESTORE_DB`
`database_name`	Not applicable to SSAS tasks.

Output Parameter	Description
`% complete`	The progress of the task as a percentage.
`duration (mins)`	The amount of time spent on the task, in minutes.
`lifecycle`	The status of the task. Possible statuses are the following: • `CREATED` – After you call one of the SSAS stored procedures, a task is created and the status is set to `CREATED`. • `IN_PROGRESS` – After a task starts, the status is set to `IN_PROGRESS`. It can take up to five minutes for the status to change from `CREATED` to `IN_PROGRESS`. • `SUCCESS` – After a task completes, the status is set to `SUCCESS`. • `ERROR` – If a task fails, the status is set to `ERROR`. For more information about the error, see the `task_info` column. • `CANCEL_REQUESTED` – After you call `rds_cancel_task`, the status of the task is set to `CANCEL_REQUESTED`. • `CANCELLED` – After a task is successfully canceled, the status of the task is set to `CANCELLED`.
`task_info`	Additional information about the task. If an error occurs during processing, this column contains information about the error.
`last_updated`	The date and time that the task status was last updated.
`created_at`	The date and time that the task was created.
`S3_object_arn`	Not applicable to SSAS tasks.
`overwrite_S3_backup_file`	Not applicable to SSAS tasks.
`KMS_master_key_arn`	Not applicable to SSAS tasks.
`filepath`	Not applicable to SSAS tasks.
`overwrite_file`	Not applicable to SSAS tasks.
`task_metadata`	Metadata associated with the SSAS task.

Using SSAS on Amazon RDS

After deploying the SSAS project, you can directly process the OLAP database on SSMS.

To use SSAS on RDS

1. In SSMS, connect to SSAS using the user name and password for the Active Directory domain.
2. Expand **Databases**. The newly deployed SSAS database appears.

3. Expand **Connections**, open the context (right-click) menu for the connection object, and then choose **Properties**.
4. In the connection string, update the user name and password to those for the source SQL database. Doing this is required for processing tables.
5. Open the context (right-click) menu for the SSAS database that you created and choose **Process Database**.

   Depending on the size of the input data, the processing operation might take several minutes to complete.

Adding a Domain User as a Database Administrator

You can add a domain user as an SSAS database administrator in the following ways:

- A database administrator can use SSMS to create a role with `admin` privileges, then add users to that role.
- You can use the following stored procedure.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSAS_ADD_DB_ADMIN_MEMBER',
@database_name='myssasdb',
@ssas_role_name='exampleRole',
@ssas_role_member='domain_name\domain_user_name';
```

  The following parameters are required:
  - `@task_type` – The type of the MSBI task, in this case `SSAS_ADD_DB_ADMIN_MEMBER`.
  - `@database_name` – The name of the SSAS database to which you're granting administrator privileges.
  - `@ssas_role_name` – The SSAS database administrator role name. If the role doesn't already exist, it's created.
  - `@ssas_role_member` – The SSAS database user that you're adding to the administrator role.

Backing Up an SSAS Database

You can create SSAS database backup files only in the `D:\S3` folder on the DB instance. To move the backup files to your S3 bucket, use Amazon S3.

You can back up an SSAS database as follows:

- A domain user with the `admin` role for a particular database can use SSMS to back up the database to the `D:\S3` folder.

  For more information, see Adding a Domain User as a Database Administrator (p. 655).
- You can use the following stored procedure.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSAS_BACKUP_DB',
@database_name='myssasdb',
@file_path='D:\S3\ssas_db_backup.abf',
[@ssas_apply_compression=1],
[@ssas_overwrite_file=1];
```

  The following parameters are required:
  - `@task_type` – The type of the MSBI task, in this case `SSAS_BACKUP_DB`.

- `@database_name` – The name of the SSAS database that you're backing up.
- `@file_path` – The path for the SSAS backup file. The `.abf` extension is required.

The following parameters are optional:

- `@ssas_apply_compression` – Whether to apply SSAS backup compression. Valid values are 1 (Yes) and 0 (No).
- `@ssas_overwrite_file` – Whether to overwrite the SSAS backup file. Valid values are 1 (Yes) and 0 (No).

Note
The stored procedure for backup doesn't support encryption.

Restoring an SSAS Database

Use the following stored procedure to restore an SSAS database from a backup.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSAS_RESTORE_DB',
@database_name='mynewssasdb',
@file_path='D:\S3\ssas_db_backup.abf';
```

The following parameters are required:

- `@task_type` – The type of the MSBI task, in this case `SSAS_RESTORE_DB`.
- `@database_name` – The name of the new SSAS database that you're restoring to.
- `@file_path` – The path to the SSAS backup file.

Note
You can't restore a database if there is an existing SSAS database with the same name. The stored procedure for restoring doesn't support encrypted backup files.

Restoring a DB Instance to a Specified Time

Point-in-time recovery (PITR) doesn't apply to SSAS databases. If you do PITR, only the SSAS data in the last snapshot before the requested time is available on the restored instance.

To have up-to-date SSAS databases on a restored DB instance

1. Back up your SSAS databases to the `D:\S3` folder on the source instance.
2. Transfer the backup files to the S3 bucket.
3. Transfer the backup files from the S3 bucket to the `D:\S3` folder on the restored instance.
4. Run the stored procedure to restore the SSAS databases onto the restored instance.

Note
You can also reprocess the SSAS project to restore the databases.

Disabling SSAS

To disable SSAS, remove the `SSAS` option from its option group. Before you remove the `SSAS` option, delete your SSAS databases.

Important
We highly recommend that you back up your SSAS databases before deleting them and removing the `SSAS` option.

Console

To remove the SSAS option from its option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group with the `SSAS` option (`ssas-se-2017` in the previous examples).
4. Choose **Delete option**.
5. Under **Deletion options**, choose **SSAS** for **Options to delete**.
6. Under **Apply immediately**, choose **Yes** to delete the option immediately, or **No** to delete it at the next maintenance window.
7. Choose **Delete**.

CLI

To remove the SSAS option from its option group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds remove-option-from-option-group \
    --option-group-name ssas-se-2017 \
    --options SSAS \
    --apply-immediately
```

  For Windows:

```
aws rds remove-option-from-option-group ^
    --option-group-name ssas-se-2017 ^
    --options SSAS ^
    --apply-immediately
```

Support for SQL Server Integration Services in SQL Server

Microsoft SQL Server Integration Services (SSIS) is a component that you can use to perform a broad range of data migration tasks. SSIS is a platform for data integration and workflow applications. It features a data warehousing tool used for data extraction, transformation, and loading (ETL). You can also use this tool to automate maintenance of SQL Server databases and updates to multidimensional cube data.

SSIS projects are organized into packages saved as XML-based .dtsx files. Packages can contain control flows and data flows. You use data flows to represent ETL operations. After deployment, packages are stored in SQL Server in the SSISDB database. SSISDB is an online transaction processing (OLTP) database in the full recovery mode.

Amazon RDS for SQL Server supports running SSIS directly on an RDS DB instance. You can enable SSIS on an existing or new DB instance. SSIS is installed on the same DB instance as your database engine. RDS supports the following SQL Server editions and versions for SSIS:

- SQL Server 2017: Standard and Enterprise editions, version 14.00.3223.3.v1 and later
- SQL Server 2016: Standard and Enterprise editions, version 13.00.5426.0.v1 and later

Limitations and Recommendations

The following limitations and recommendations apply to running SSIS on RDS for SQL Server:

- The DB instance must use AWS Managed Microsoft AD for SSIS authentication.
- The DB instance must have an associated parameter group with the `clr enabled` parameter set to 1. For more information, see Modifying the Parameter for SSIS (p. 662).

  Note
  If you enable the `clr enabled` parameter on SQL Server 2017, you can't use the common language runtime (CLR) on your DB instance.
- The following control flow tasks are supported:
  - Analysis Services Execute DDL Task
  - Analysis Services Processing Task
  - Bulk Insert Task
  - Check Database Integrity Task
  - Data Flow Task
  - Data Mining Query Task
  - Data Profiling Task
  - Execute Package Task
  - Execute SQL Server Agent Job Task
  - Execute SQL Task
  - Execute T-SQL Statement Task
  - Notify Operator Task
  - Rebuild Index Task
  - Reorganize Index Task
  - Shrink Database Task
  - Transfer Database Task
  - Transfer Jobs Task

- Transfer Logins Task
- Transfer SQL Server Objects Task
- Update Statistics Task
- Only project deployment is supported.
- Running SSIS packages by using SQL Server Agent is supported.
- Only SQL Server–based logging is supported.
- Use only the `D:\S3` folder for working with files. Files placed in any other directory are deleted. Be aware of a few other file location details:
  - Place SSIS project input and output files in the `D:\S3` folder.
  - For the Data Flow Task, change the location for `BLOBTempStoragePath` and `BufferTempStoragePath` to a file inside the `D:\S3` folder.
  - Ensure that all parameters, variables, and expressions used for file connections point to the `D:\S3` folder.
  - On Multi-AZ instances, files created by SSIS in the `D:\S3` folder are deleted after a failover. For more information, see Multi-AZ Limitations for S3 Integration (p. 633).
  - Upload the files created by SSIS in the `D:\S3` folder to your Amazon S3 bucket to make them durable.
- Import Column and Export Column transformations and the Script component on the Data Flow Task aren't supported.
- You can't enable dump on SSIS package execution, and you can't add data taps on SSIS packages.
- The SSIS Scale Out feature isn't supported.
- You can’t deploy projects directly. We provide RDS stored procedures to do this. For more information, see Deploying an SSIS Project (p. 666).
- Build SSIS project (.ispac) files with the `DoNotSavePasswords` protection mode for deploying on RDS.
- SSIS isn't supported on Always On instances with read replicas.
- You can't back up the SSISDB database that is associated with the `SSIS` option.
- Importing and restoring the SSISDB database from other instances of SSIS isn't supported.

Enabling SSIS

You enable SSIS by adding the SSIS option to your DB instance. Use the following process:

1. Create a new option group, or choose an existing option group.
2. Add the `SSIS` option to the option group.
3. Create a new parameter group, or choose an existing parameter group.
4. Modify the parameter group to set the `clr enabled` parameter to 1.
5. Associate the option group and parameter group with the DB instance.
6. Enable Amazon S3 integration.

> **Note**
> If a database with the name SSISDB or a reserved SSIS login already exists on the DB instance, you can't enable SSIS on the instance.

Creating the Option Group for SSIS

To work with SSIS, create an option group or modify an option group that corresponds to the SQL Server edition and version of the DB instance that you plan to use. To do this, use the AWS Management Console or the AWS CLI.

Console

The following procedure creates an option group for SQL Server Standard Edition 2016.

To create the option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose **Create group**.
4. In the **Create option group** window, do the following:

   a. For **Name**, enter a name for the option group that is unique within your AWS account, such as **`ssis-se-2016`**. The name can contain only letters, digits, and hyphens.

   b. For **Description**, enter a brief description of the option group, such as **`SSIS option group for SQL Server SE 2016`**. The description is used for display purposes.

   c. For **Engine**, choose **sqlserver-se**.

   d. For **Major engine version**, choose **13.00**.
5. Choose **Create**.

CLI

The following procedure creates an option group for SQL Server Standard Edition 2016.

To create the option group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-option-group \
    --option-group-name ssis-se-2016 \
    --engine-name sqlserver-se \
    --major-engine-version 13.00 \
    --option-group-description "SSIS option group for SQL Server SE 2016"
```

  For Windows:

```
aws rds create-option-group ^
    --option-group-name ssis-se-2016 ^
    --engine-name sqlserver-se ^
    --major-engine-version 13.00 ^
    --option-group-description "SSIS option group for SQL Server SE 2016"
```

Adding the SSIS Option to the Option Group

Next, use the AWS Management Console or the AWS CLI to add the `SSIS` option to your option group.

Console

To add the SSIS option

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.

2. In the navigation pane, choose **Option groups**.
3. Choose the option group that you just created, **ssis-se-2016** in this example.
4. Choose **Add option**.
5. Under **Option details**, choose **SSIS** for **Option name**.
6. Under **Scheduling**, choose whether to add the option immediately or at the next maintenance window.
7. Choose **Add option**.

CLI

To add the SSIS option

- Add the `SSIS` option to the option group.

  Example

  For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --option-group-name ssis-se-2016 \
    --options OptionName=SSIS \
    --apply-immediately
```

  For Windows:

```
aws rds add-option-to-option-group ^
    --option-group-name ssis-se-2016 ^
    --options OptionName=SSIS ^
    --apply-immediately
```

Creating the Parameter Group for SSIS

Create or modify a parameter group for the `clr enabled` parameter that corresponds to the SQL Server edition and version of the DB instance that you plan to use for SSIS.

Console

The following procedure creates a parameter group for SQL Server Standard Edition 2016.

To create the parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose **Create parameter group**.
4. In the **Create parameter group** pane, do the following:
   a. For **Parameter group family**, choose **sqlserver-se-13.0**.
   b. For **Group name**, enter an identifier for the parameter group, such as **`ssis-sqlserver-se-13`**.
   c. For **Description**, enter **`clr enabled parameter group`**.
5. Choose **Create**.

CLI

The following procedure creates a parameter group for SQL Server Standard Edition 2016.

To create the parameter group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-db-parameter-group \
    --db-parameter-group-name ssis-sqlserver-se-13 \
    --db-parameter-group-family "sqlserver-se-13.0" \
    --description "clr enabled parameter group"
```

  For Windows:

```
aws rds create-db-parameter-group ^
    --db-parameter-group-name ssis-sqlserver-se-13 ^
    --db-parameter-group-family "sqlserver-se-13.0" ^
    --description "clr enabled parameter group"
```

Modifying the Parameter for SSIS

Modify the `clr enabled` parameter in the parameter group that corresponds to the SQL Server edition and version of your DB instance. For SSIS, set the `clr enabled` parameter to 1.

Console

The following procedure modifies the parameter group that you created for SQL Server Standard Edition 2016.

To modify the parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose the parameter group, such as **ssis-sqlserver-se-13**.
4. Under **Parameters**, filter the parameter list for **`clr`**.
5. Choose **clr enabled**.
6. Choose **Edit parameters**.
7. From **Values**, choose **1**.
8. Choose **Save changes**.

CLI

The following procedure modifies the parameter group that you created for SQL Server Standard Edition 2016.

To modify the parameter group

- Run one of the following commands.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-parameter-group \
    --db-parameter-group-name ssis-sqlserver-se-13 \
    --parameters "ParameterName='clr enabled',ParameterValue=1,ApplyMethod=immediate"
```

For Windows:

```
aws rds modify-db-parameter-group ^
    --db-parameter-group-name ssis-sqlserver-se-13 ^
    --parameters "ParameterName='clr enabled',ParameterValue=1,ApplyMethod=immediate"
```

Associating the Option Group and Parameter Group with Your DB Instance

To associate the SSIS option group and parameter group with your DB instance, use the AWS Management Console or the AWS CLI

> **Note**
> If you use an existing instance, it must already have an Active Directory domain and AWS Identity and Access Management (IAM) role associated with it. If you create a new instance, specify an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

Console

To finish enabling SSIS, associate your SSIS option group and parameter group with a new or existing DB instance:

- For a new DB instance, associate them when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
- For an existing DB instance, associate them by modifying the instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

CLI

You can associate the SSIS option group and parameter group with a new or existing DB instance.

To create an instance with the SSIS option group and parameter group

- Specify the same DB engine type and major version as you used when creating the option group.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier myssisinstance \
    --db-instance-class db.m5.2xlarge \
    --engine sqlserver-se \
    --engine-version 13.00.5426.0.v1 \
    --allocated-storage 100 \
    --master-user-password secret123 \
    --master-username master \
    --storage-type gp2 \
    --license-model li \
```

```
    --domain-iam-role-name my-directory-iam-role \
    --domain my-domain-id \
    --option-group-name ssis-se-2016 \
    --db-parameter-group-name ssis-sqlserver-se-13
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier myssisinstance ^
    --db-instance-class db.m5.2xlarge ^
    --engine sqlserver-se ^
    --engine-version 13.00.5426.0.v1 ^
    --allocated-storage 100 ^
    --master-user-password secret123 ^
    --master-username master ^
    --storage-type gp2 ^
    --license-model li ^
    --domain-iam-role-name my-directory-iam-role ^
    --domain my-domain-id ^
    --option-group-name ssis-se-2016 ^
    --db-parameter-group-name ssis-sqlserver-se-13
```

To modify an instance and associate the SSIS option group and parameter group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier myssisinstance \
    --option-group-name ssis-se-2016 \
    --db-parameter-group-name ssis-sqlserver-se-13 \
    --apply-immediately
```

  For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier myssisinstance ^
    --option-group-name ssis-se-2016 ^
    --db-parameter-group-name ssis-sqlserver-se-13 ^
    --apply-immediately
```

Enabling S3 Integration

To download SSIS project (.ispac) files to your host for deployment, use S3 file integration. For more information, see Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3 (p. 623).

Master User Permissions on SSISDB

When the instance is created or modified with the SSIS option, the result is an SSISDB database with the ssis_admin and ssis_logreader roles granted to the master user. The master user has the following privileges in SSISDB:

- alter on ssis_admin role

- alter on ssis_logreader role
- alter any user

Because the master user is a SQL-authenticated user, you can't use the master user for executing SSIS packages. The master user can use these privileges to create new SSISDB users and add them to the ssis_admin and ssis_logreader roles. Doing this is useful for giving access to your domain users for using SSIS.

Setting Up a Windows-Authenticated User for SSIS

The master user can use the following code example to set up a Windows-authenticated login in SSISDB and grant the required procedure permissions. Doing this grants permissions to the domain user to deploy and run SSIS packages, use S3 file transfer procedures, create credentials, and work with the SQL Server Agent proxy. For more information, see Credentials (Database Engine) and Create a SQL Server Agent Proxy in the Microsoft documentation.

> **Note**
> You can grant some or all of the following permissions as needed to Windows-authenticated users.

Example

```
USE [SSISDB]
GO
CREATE USER [mydomain\user_name] FOR LOGIN [mydomain\user_name]
ALTER ROLE [ssis_admin] ADD MEMBER [mydomain\user_name]
ALTER ROLE [ssis_logreader] ADD MEMBER [mydomain\user_name]
GO

USE [msdb]
GO
CREATE USER [mydomain\user_name] FOR LOGIN [mydomain\user_name]
GRANT EXEC ON msdb.dbo.rds_msbi_task TO [mydomain\user_name] with grant option
GRANT SELECT ON msdb.dbo.rds_fn_task_status TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_task_status TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_cancel_task TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_download_from_s3 TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_upload_to_s3 TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_delete_from_filesystem TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.rds_gather_file_details TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_add_proxy TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_update_proxy TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_grant_login_to_proxy TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_revoke_login_from_proxy TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_delete_proxy TO [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_enum_login_for_proxy to [mydomain\user_name] with grant option
GRANT EXEC ON msdb.dbo.sp_enum_proxy_for_subsystem TO [mydomain\user_name]  with grant
 option
GRANT EXEC ON msdb.dbo.rds_sqlagent_proxy TO [mydomain\user_name] WITH GRANT OPTION
ALTER ROLE [SQLAgentUserRole] ADD MEMBER [mydomain\user_name]
GO

USE [master]
GO
GRANT ALTER ANY CREDENTIAL TO [mydomain\user_name]
GO
```

Deploying an SSIS Project

On RDS, you can't deploy SSIS projects directly by using SQL Server Management Studio (SSMS) or SSIS procedures. To download project files from Amazon S3 and then deploy them, use RDS stored procedures.

To run the stored procedures, log in as the master user or any other user that you granted execution permissions for the stored procedures. For more information, see Setting Up a Windows-Authenticated User for SSIS (p. 665).

To deploy the SSIS project

1. Download the project (.ispac) file.

```
exec msdb.dbo.rds_download_from_s3
@s3_arn_of_file='arn:aws:s3:::bucket_name/ssisproject.ispac',
[@rds_file_path='D:\S3\ssisproject.ispac'],
[@overwrite_file=1];
```

2. Submit the deployment task, making sure of the following:

   - The folder is present in the SSIS catalog.
   - The project name matches the project name that you used while developing the SSIS project.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSIS_DEPLOY_PROJECT',
@folder_name='DEMO',
@project_name='ssisproject',
@file_path='D:\S3\ssisproject.ispac;
```

Monitoring the Status of a Deployment Task

To track the status of your deployment task, call the `rds_fn_task_status` function. It takes two parameters. The first parameter should always be `NULL` because it doesn't apply to SSIS. The second parameter accepts a task ID.

To see a list of all tasks, set the first parameter to `NULL` and the second parameter to `0`, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,0);
```

To get a specific task, set the first parameter to `NULL` and the second parameter to the task ID, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,42);
```

The `rds_fn_task_status` function returns the following information.

Output Parameter	Description
`task_id`	The ID of the task.
`task_type`	`SSIS_DEPLOY_PROJECT`

Output Parameter	Description
database_name	Not applicable to SSIS tasks.
% complete	The progress of the task as a percentage.
duration (mins)	The amount of time spent on the task, in minutes.
lifecycle	The status of the task. Possible statuses are the following: • CREATED – After you call the msdb.dbo.rds_msbi_task stored procedure, a task is created and the status is set to CREATED. • IN_PROGRESS – After a task starts, the status is set to IN_PROGRESS. It can take up to five minutes for the status to change from CREATED to IN_PROGRESS. • SUCCESS – After a task completes, the status is set to SUCCESS. • ERROR – If a task fails, the status is set to ERROR. For more information about the error, see the task_info column. • CANCEL_REQUESTED – After you call rds_cancel_task, the status of the task is set to CANCEL_REQUESTED. • CANCELLED – After a task is successfully canceled, the status of the task is set to CANCELLED.
task_info	Additional information about the task. If an error occurs during processing, this column contains information about the error.
last_updated	The date and time that the task status was last updated.
created_at	The date and time that the task was created.
S3_object_arn	Not applicable to SSIS tasks.
overwrite_S3_backup_file	Not applicable to SSIS tasks.
KMS_master_key_arn	Not applicable to SSIS tasks.
filepath	Not applicable to SSIS tasks.
overwrite_file	Not applicable to SSIS tasks.
task_metadata	Metadata associated with the SSIS task.

Using SSIS

After deploying the SSIS project into the SSIS catalog, you can run packages directly from SSMS or schedule them by using SQL Server Agent. You must use a Windows-authenticated login for executing SSIS packages. For more information, see Setting Up a Windows-Authenticated User for SSIS (p. 665).

Setting Database Connection Managers for SSIS Projects

When you use a connection manager, you can use these types of authentication:

- For local database connections, you can use SQL authentication or Windows authentication. For Windows authentication, use *DB_instance_name*.*fully_qualified_domain_name* as the server name of the connection string.

  An example is `myssisinstance.corp-ad.example.com`, where `myssisinstance` is the DB instance name and `corp-ad.example.com` is the fully qualified domain name.
- For remote connections, always use SQL authentication.

Creating an SSIS Proxy

To be able to schedule SSIS packages using SQL Server Agent, create an SSIS credential and an SSIS proxy. Run these procedures as a Windows-authenticated user.

To create the SSIS credential

- Create the credential for the proxy. To do this, you can use SSMS or the following SQL statement.

```
USE [master]
GO
CREATE CREDENTIAL [SSIS_Credential] WITH IDENTITY = N'mydomain\user_name', SECRET =
 N'mysecret'
GO
```

> **Note**
> `IDENTITY` must be a domain-authenticated login. Replace *mysecret* with the password for the domain-authenticated login.
> Whenever the SSISDB primary host is changed, alter the SSIS proxy credentials to allow the new host to access them.

To create the SSIS proxy

1. Use the following SQL statement to create the proxy.

```
USE [msdb]
GO
EXEC msdb.dbo.sp_add_proxy
 @proxy_name=N'SSIS_Proxy',@credential_name=N'SSIS_Credential',@description=N''
GO
```

2. Use the following SQL statement to grant access to the proxy to other users.

```
USE [msdb]
GO
EXEC msdb.dbo.sp_grant_login_to_proxy
 @proxy_name=N'SSIS_Proxy',@login_name=N'mydomain\user_name'
GO
```

3. Use the following SQL statement to give the SSIS subsystem access to the proxy.

```
USE [msdb]
GO
EXEC msdb.dbo.rds_sqlagent_proxy
 @task_type='GRANT_SUBSYSTEM_ACCESS',@proxy_name='SSIS_Proxy',@proxy_subsystem='SSIS'
```

```
GO
```

To view the proxy and grants on the proxy

1. Use the following SQL statement to view the grantees of the proxy.

```
USE [msdb]
GO
EXEC sp_help_proxy
GO
```

2. Use the following SQL statement to view the subsystem grants.

```
USE [msdb]
GO
EXEC msdb.dbo.sp_enum_proxy_for_subsystem
GO
```

Scheduling an SSIS Package Using SQL Server Agent

After you create the credential and proxy and grant SSIS access to the proxy, you can create a SQL Server Agent job to schedule the SSIS package.

To schedule the SSIS package

- You can use SSMS or T-SQL for creating the SQL Server Agent job. The following example uses T-SQL.

```
USE [msdb]
GO
DECLARE @jobId BINARY(16)
EXEC msdb.dbo.sp_add_job @job_name=N'MYSSISJob',
@enabled=1,
@notify_level_eventlog=0,
@notify_level_email=2,
@notify_level_page=2,
@delete_level=0,
@category_name=N'[Uncategorized (Local)]',
@job_id = @jobId OUTPUT
GO
EXEC msdb.dbo.sp_add_jobserver @job_name=N'MYSSISJob',@server_name=N'(local)'
GO
EXEC msdb.dbo.sp_add_jobstep @job_name=N'MYSSISJob',@step_name=N'ExecuteSSISPackage',
@step_id=1,
@cmdexec_success_code=0,
@on_success_action=1,
@on_fail_action=2,
@retry_attempts=0,
@retry_interval=0,
@os_run_priority=0,
@subsystem=N'SSIS',
@command=N'/ISSERVER "\"\SSISDB\MySSISFolder\MySSISProject\MySSISPackage.dtsx\"" /
SERVER "\"my-rds-ssis-instance.corp-ad.company.com/\""
/Par "\"$ServerOption::LOGGING_LEVEL(Int16)\"";1 /Par
 "\"$ServerOption::SYNCHRONIZED(Boolean)\"";True /CALLERINFO SQLAGENT /REPORTING E',
@database_name=N'master',
@flags=0,
@proxy_name=N'SSIS_Proxy'
GO
```

Revoking SSIS Access from the Proxy

You can revoke access to the SSIS subsystem and delete the SSIS proxy using the following stored procedures.

To revoke access and delete the proxy

1. Revoke subsystem access.

```
USE [msdb]
GO
EXEC msdb.dbo.rds_sqlagent_proxy
 @task_type='REVOKE_SUBSYSTEM_ACCESS',@proxy_name='SSIS_Proxy',@proxy_subsystem='SSIS'
GO
```

2. Revoke the grants on the proxy.

```

USE [msdb]
GO
EXEC msdb.dbo.sp_revoke_login_from_proxy
 @proxy_name=N'SSIS_Proxy',@name=N'mydomain\user_name'
GO
```

3. Delete the proxy.

```
USE [msdb]
GO
EXEC dbo.sp_delete_proxy @proxy_name = N'SSIS_Proxy'
GO
```

Disabling SSIS

To disable SSIS, remove the `SSIS` option from its option group.

> **Important**
> Removing the option doesn't delete the SSISDB database, so you can safely remove the option without losing the SSIS projects.
> You can re-enable the `SSIS` option after removal to reuse the SSIS projects that were previously deployed to the SSIS catalog.

Console

The following procedure removes the `SSIS` option.

To remove the SSIS option from its option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group with the `SSIS` option (`ssis-se-2016` in the previous examples).
4. Choose **Delete option**.
5. Under **Deletion options**, choose **SSIS** for **Options to delete**.
6. Under **Apply immediately**, choose **Yes** to delete the option immediately, or **No** to delete it at the next maintenance window.
7. Choose **Delete**.

CLI

The following procedure removes the `SSIS` option.

To remove the SSIS option from its option group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds remove-option-from-option-group \
    --option-group-name ssis-se-2016 \
    --options SSIS \
    --apply-immediately
```

  For Windows:

```
aws rds remove-option-from-option-group ^
    --option-group-name ssis-se-2016 ^
    --options SSIS ^
    --apply-immediately
```

Dropping the SSISDB Database

After removing the SSIS option, the SSISDB database isn't deleted. To drop the SSISDB database, use the `rds_drop_ssis_database` stored procedure after removing the SSIS option.

To drop the SSIS database

- Use the following stored procedure.

```
USE [msdb]
GO
EXEC dbo.rds_drop_ssis_database
GO
```

After dropping the SSISDB database, if you re-enable the SSIS option you get a fresh SSISDB catalog.

Support for SQL Server Reporting Services in SQL Server

Microsoft SQL Server Reporting Services (SSRS) is a server-based application used for report generation and distribution. It's part of a suite of SQL Server services that also includes SQL Server Analysis Services (SSAS) and SQL Server Integration Services (SSIS). SSRS is a service built on top of SQL Server. You can use it to collect data from various data sources and present it in a way that's easily understandable and ready for analysis.

Amazon RDS for SQL Server supports running SSRS directly on RDS DB instances. You can enable SSRS for existing or new DB instances.

Limitations and Recommendations

The following limitations and recommendations apply to running SSRS on RDS for SQL Server:

- SSRS is supported for SQL Server Standard and Enterprise Editions, version 14.00.3223.3.v1 and later.
- Instances must use AWS Managed Microsoft AD for SSRS web portal and web server authentication.
- Importing and restoring report server databases from other instances of SSRS isn't supported.

  Make sure to use the databases that are created when the `SSRS` option is added to the RDS DB instance. For more information, see Report Server Databases (p. 676).
- You can't configure SSRS to listen on the default SSL port (443). The allowed values are 1150–49511, except 1234, 1434, 3260, 3343, 3389, and 47001.
- Subscriptions through email or a Microsoft Windows file share aren't supported.
- Using Reporting Services Configuration Manager isn't supported.
- Creating and modifying roles isn't supported.
- Modifying report server properties isn't supported.
- System administrator and system user roles aren't granted.
- You can't edit system-level role assignments through the web portal.

Enabling SSRS

Use the following process to enable SSRS on your DB instance:

1. Create a new option group, or choose an existing option group.
2. Add the `SSRS` option to the option group.
3. Associate the option group with the DB instance.
4. Allow inbound access to the virtual private cloud (VPC) security group for the SSRS listener port.

Creating an Option Group for SSRS

To work with SSRS, create an option group that corresponds to the SQL Server engine and version of the DB instance that you plan to use. To do this, use the AWS Management Console or the AWS CLI.

> **Note**
> You can also use an existing option group if it's for the correct SQL Server engine and version.

Console

The following procedure creates an option group for SQL Server Standard Edition 2017.

To create the option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose **Create group**.
4. In the **Create option group** pane, do the following:

   a. For **Name**, enter a name for the option group that is unique within your AWS account, such as **`ssrs-se-2017`**. The name can contain only letters, digits, and hyphens.

   b. For **Description**, enter a brief description of the option group, such as **`SSRS option group for SQL Server SE 2017`**. The description is used for display purposes.

   c. For **Engine**, choose **sqlserver-se**.

   d. For **Major engine version**, choose **14.00**.
5. Choose **Create**.

CLI

The following procedure creates an option group for SQL Server Standard Edition 2017.

To create the option group

- Run one of the following commands.

Example

For Linux, macOS, or Unix:

```
aws rds create-option-group \
    --option-group-name ssrs-se-2017 \
    --engine-name sqlserver-se \
    --major-engine-version 14.00 \
    --option-group-description "SSRS option group for SQL Server SE 2017"
```

For Windows:

```
aws rds create-option-group ^
    --option-group-name ssrs-se-2017 ^
    --engine-name sqlserver-se ^
    --major-engine-version 14.00 ^
    --option-group-description "SSRS option group for SQL Server SE 2017"
```

Adding the SSRS Option to Your Option Group

Next, use the AWS Management Console or the AWS CLI to add the `SSRS` option to your option group.

Console

To add the SSRS option

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group that you just created.

4. Choose **Add option**.
5. Under **Option details**, choose **SSRS** for **Option name**.
6. Under **Option settings**, do the following:

   a. Enter the port for the SSRS service to listen on. The default is 8443. For a list of allowed values, see Limitations and Recommendations (p. 672).
   b. Enter a value for **Max memory**.

      Max memory specifies the upper threshold above which no new memory allocation requests are granted to report server applications. The number is a percentage of the total memory of the DB instance. The allowed values are 10–80.
7. For **Security groups**, choose the VPC security group to associate with the option. Use the same security group that is associated with your DB instance.
8. Under **Scheduling**, choose whether to add the option immediately or at the next maintenance window.
9. Choose **Add option**.

CLI

To add the SSRS option

1. Create a JSON file, for example `ssrs-option.json`, with the following parameters:

   - `OptionGroupName` – The name of option group that you created or chose previously (`ssrs-se-2017` in the following example).
   - `Port` – The port for the SSRS service to listen on. The default is 8443. For a list of allowed values, see Limitations and Recommendations (p. 672).
   - `VpcSecurityGroupMemberships` – VPC security group memberships for your RDS DB instance.
   - `MAX_MEMORY` – The upper threshold above which no new memory allocation requests are granted to report server applications. The number is a percentage of the total memory of the DB instance. The allowed values are 10–80.

```
{
"OptionGroupName": "ssrs-se-2017",
"OptionsToInclude": [
 {
 "OptionName": "SSRS",
 "Port": 8443,
 "VpcSecurityGroupMemberships": ["sg-0abcdef123"],
 "OptionSettings": [{"Name": "MAX_MEMORY","Value": "60"}]
 }],
"ApplyImmediately": true
}
```

2. Add the `SSRS` option to the option group.

   Example

   For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --cli-input-json file://ssrs-option.json \
    --apply-immediately
```

   For Windows:

```
aws rds add-option-to-option-group ^
    --cli-input-json file://ssrs-option.json ^
    --apply-immediately
```

Associating Your Option Group with Your DB Instance

Use the AWS Management Console or the AWS CLI to associate your option group with your DB instance.

If you use an existing DB instance, it must already have an Active Directory domain and AWS Identity and Access Management (IAM) role associated with it. If you create a new instance, specify an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

Console

You can associate your option group with a new or existing DB instance:

- For a new DB instance, associate the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
- For an existing DB instance, modify the instance and associate the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

CLI

You can associate your option group with a new or existing DB instance.

To create a DB instance that uses your option group

- Specify the same DB engine type and major version as you used when creating the option group.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier myssrsinstance \
    --db-instance-class db.m5.2xlarge \
    --engine sqlserver-se \
    --engine-version 14.00.3223.3.v1 \
    --allocated-storage 100 \
    --master-user-password secret123 \
    --master-username master \
    --storage-type gp2 \
    --license-model li \
    --domain-iam-role-name my-directory-iam-role \
    --domain my-domain-id \
    --option-group-name ssrs-se-2017
```

  For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier myssrsinstance ^
    --db-instance-class db.m5.2xlarge ^
    --engine sqlserver-se ^
    --engine-version 14.00.3223.3.v1 ^
    --allocated-storage 100 ^
```

```
    --master-user-password secret123 ^
    --master-username master ^
    --storage-type gp2 ^
    --license-model li ^
    --domain-iam-role-name my-directory-iam-role ^
    --domain my-domain-id ^
    --option-group-name ssrs-se-2017
```

To modify a DB instance to use your option group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier myssrsinstance \
    --option-group-name ssrs-se-2017 \
    --apply-immediately
```

  For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier myssrsinstance ^
    --option-group-name ssrs-se-2017 ^
    --apply-immediately
```

Allowing Inbound Access to Your VPC Security Group

To allow inbound access to the VPC security group associated with your DB instance, create an inbound rule for the specified SSRS listener port. For more information about setting up security groups, see Provide Access to Your DB Instance in Your VPC by Creating a Security Group (p. 61).

Report Server Databases

When your DB instance is associated with the SSRS option, two new databases are created on your DB instance: rdsadmin_ReportServer and rdsadmin_ReportServerTempDB. These databases act as the ReportServer and ReportServerTempDB databases. SSRS stores its data in the ReportServer database and caches its data in the ReportServerTempDB database. RDS owns and manages these databases, so database operations on them such as ALTER and DROP aren't permitted.

Accessing the SSRS Web Portal

Use the following process to access the SSRS web portal:

1. Enable Secure Sockets Layer (SSL).
2. Grant access to domain users.
3. Access the web portal using a browser and the domain user credentials.

Enabling SSL on RDS

SSRS uses the HTTPS SSL protocol for its connections. To work with this protocol, import an SSL certificate into the Microsoft Windows operating system on your client computer.

For more information on SSL certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For more information about using SSL with SQL Server, see Using SSL with a Microsoft SQL Server DB Instance (p. 609).

Granting Access to Domain Users

In a new SSRS activation, there are no role assignments in SSRS. To give a domain user or user group access to the web portal, RDS provides a stored procedure.

To grant access to a domain user on the web portal

- Use the following stored procedure.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSRS_GRANT_PORTAL_PERMISSION',
@ssrs_group_or_username=N'AD_domain\user';
```

The domain user or user group is granted the `RDS_SSRS_ROLE` system role. This role has the following system-level tasks granted to it:

- Execute report definitions
- Manage jobs
- Manage shared schedules
- View shared schedules

The item-level role of `Content Manager` on the root folder is also granted.

Accessing the Web Portal

After the `SSRS_GRANT_PORTAL_PERMISSION` task finishes successfully, you have access to the portal using a web browser. The web portal URL has the following format.

```
https://rds_endpoint:port/Reports
```

In this format, the following applies:

- *`rds_endpoint`* – The endpoint for the RDS DB instance that you're using with SSRS.

  You can find the endpoint on the **Connectivity & security** tab for your DB instance. For more information, see Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560).
- *`port`* – The listener port for SSRS that you set in the `SSRS` option.

To access the web portal

1. Enter the web portal URL in your browser.

```
https://myssrsinstance.cg034itsfake.us-east-1.rds.amazonaws.com:8443/Reports
```

2. Log in with the credentials for a domain user that you granted access with the `SSRS_GRANT_PORTAL_PERMISSION` task.

Revoking System-Level Permissions

The RDS_SSRS_ROLE system role doesn't have sufficient permissions to delete system-level role assignments. To remove a user or user group from RDS_SSRS_ROLE, use the same stored procedure that you used to grant the role but use the SSRS_REVOKE_PORTAL_PERMISSION task type.

To revoke access from a domain user for the web portal

- Use the following stored procedure.

```
exec msdb.dbo.rds_msbi_task
@task_type='SSRS_REVOKE_PORTAL_PERMISSION',
@ssrs_group_or_username=N'AD_domain\user';
```

Doing this deletes the user from the RDS_SSRS_ROLE system role. It also deletes the user from the Content Manager item-level role if the user has it.

Monitoring the Status of a Task

To track the status of your granting or revoking task, call the rds_fn_task_status function. It takes two parameters. The first parameter should always be NULL because it doesn't apply to SSRS. The second parameter accepts a task ID.

To see a list of all tasks, set the first parameter to NULL and the second parameter to 0, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,0);
```

To get a specific task, set the first parameter to NULL and the second parameter to the task ID, as shown in the following example.

```
SELECT * FROM msdb.dbo.rds_fn_task_status(NULL,42);
```

The rds_fn_task_status function returns the following information.

Output Parameter	Description
task_id	The ID of the task.
task_type	For SSRS, tasks can have the following task types: • SSRS_GRANT_PORTAL_PERMISSION • SSRS_REVOKE_PORTAL_PERMISSION
database_name	Not applicable to SSRS tasks.
% complete	The progress of the task as a percentage.
duration (mins)	The amount of time spent on the task, in minutes.
lifecycle	The status of the task. Possible statuses are the following: • CREATED – After you call one of the SSRS stored procedures, a task is created and the status is set to CREATED.

Output Parameter	Description
	• `IN_PROGRESS` – After a task starts, the status is set to `IN_PROGRESS`. It can take up to five minutes for the status to change from `CREATED` to `IN_PROGRESS`. • `SUCCESS` – After a task completes, the status is set to `SUCCESS`. • `ERROR` – If a task fails, the status is set to `ERROR`. For more information about the error, see the `task_info` column. • `CANCEL_REQUESTED` – After you call the `rds_cancel_task` stored procedure, the status of the task is set to `CANCEL_REQUESTED`. • `CANCELLED` – After a task is successfully canceled, the status of the task is set to `CANCELLED`.
`task_info`	Additional information about the task. If an error occurs during processing, this column contains information about the error.
`last_updated`	The date and time that the task status was last updated.
`created_at`	The date and time that the task was created.
`S3_object_arn`	Not applicable to SSRS tasks.
`overwrite_S3_backup_file`	Not applicable to SSRS tasks.
`KMS_master_key_arn`	Not applicable to SSRS tasks.
`filepath`	Not applicable to SSRS tasks.
`overwrite_file`	Not applicable to SSRS tasks.
`task_metadata`	Metadata associated with the SSRS task.

Disabling SSRS

To disable SSRS, remove the `SSRS` option from its option group. Removing the option doesn't delete the SSRS databases. For more information, see Deleting the SSRS Databases (p. 680).

You can re-enable SSRS by adding back the `SSRS` option. If you have also deleted the SSRS databases, re-enabling SSRS on the same DB instance creates new report server databases.

Console

To remove the SSRS option from its option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group with the `SSRS` option (`ssrs-se-2017` in the previous examples).
4. Choose **Delete option**.
5. Under **Deletion options**, choose **SSRS** for **Options to delete**.

6. Under **Apply immediately**, choose **Yes** to delete the option immediately, or **No** to delete it at the next maintenance window.
7. Choose **Delete**.

CLI

To remove the SSRS option from its option group

- Run one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds remove-option-from-option-group \
    --option-group-name ssrs-se-2017 \
    --options SSRS \
    --apply-immediately
```

  For Windows:

```
aws rds remove-option-from-option-group ^
    --option-group-name ssrs-se-2017 ^
    --options SSRS ^
    --apply-immediately
```

Deleting the SSRS Databases

Removing the `SSRS` option doesn't delete the report server databases. To delete them, use the following stored procedure.

To delete the report server databases, be sure to remove the `SSRS` option first.

To delete the SSRS databases

- Use the following stored procedure.

```
exec msdb.dbo.rds_drop_ssrs_databases
```

Support for Microsoft Distributed Transaction Coordinator in SQL Server

A *distributed transaction* is a database transaction in which two or more network hosts are involved. Amazon RDS for SQL Server supports distributed transactions among hosts, where a single host can be one of the following:

- RDS for SQL Server DB instance
- On-premises SQL Server host
- Amazon EC2 host with SQL Server installed
- Any other EC2 host or RDS DB instance with a database engine that supports distributed transactions

In RDS, starting with SQL Server 2012 (version 11.00.5058.0.v1 and later), all editions of SQL Server support distributed transactions. The support is provided using Microsoft Distributed Transaction Coordinator (MSDTC). For in-depth information about MSDTC, see Distributed Transaction Coordinator in the Microsoft documentation.

Limitations

The following limitations apply to using MSDTC on RDS for SQL Server:

- MSDTC isn't supported on instances using SQL Server Database Mirroring. For more information, see Transactions - availability groups and database mirroring.
- The `in-doubt xact resolution` parameter must be set to 1 or 2. For more information, see Modifying the Parameter for MSDTC (p. 685).
- MSDTC requires all host names participating in distributed transactions to be resolvable using their computer names. RDS automatically maintains this functionality for domain-joined instances. However, for standalone instances make sure to configure the DNS server manually.
- Distributed transactions that depend on client dynamic link libraries (DLLs) on RDS instances aren't supported.

Enabling MSDTC

Use the following process to enable MSDTC for your DB instance:

1. Create a new option group, or choose an existing option group.
2. Add the `MSDTC` option to the option group.
3. Create a new parameter group, or choose an existing parameter group.
4. Modify the parameter group to set the `in-doubt xact resolution` parameter to 1 or 2.
5. Associate the option group and parameter group with the DB instance.

Creating the Option Group for MSDTC

Use the AWS Management Console or the AWS CLI to create an option group that corresponds to the SQL Server engine and version of your DB instance.

> **Note**
> You can also use an existing option group if it's for the correct SQL Server engine and version.

Console

The following procedure creates an option group for SQL Server Standard Edition 2016.

To create the option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose **Create group**.
4. In the **Create option group** pane, do the following:

    a. For **Name**, enter a name for the option group that is unique within your AWS account, such as **`msdtc-se-2016`**. The name can contain only letters, digits, and hyphens.

    b. For **Description**, enter a brief description of the option group, such as **`MSDTC option group for SQL Server SE 2016`**. The description is used for display purposes.

    c. For **Engine**, choose **sqlserver-se**.

    d. For **Major engine version**, choose **13.00**.
5. Choose **Create**.

CLI

The following example creates an option group for SQL Server Standard Edition 2016.

To create the option group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-option-group \
    --option-group-name msdtc-se-2016 \
    --engine-name sqlserver-se \
    --major-engine-version 13.00 \
    --option-group-description "MSDTC option group for SQL Server SE 2016"
```

  For Windows:

```
aws rds create-option-group ^
    --option-group-name msdtc-se-2016 ^
    --engine-name sqlserver-se ^
    --major-engine-version 13.00 ^
    --option-group-description "MSDTC option group for SQL Server SE 2016"
```

Adding the MSDTC Option to the Option Group

Next, use the AWS Management Console or the AWS CLI to add the `MSDTC` option to the option group.

The following option settings are required:

- **Port** – The port that you use to access MSDTC. Allowed values are 1150–49151 except for 1234, 1434, 3260, 3343, 3389, and 47001. The default value is 5000.

  Make sure that the port you want to use is enabled in your firewall rules. Also, make sure as needed that this port is enabled in the inbound and outbound rules for the security group associated with your DB instance. For more information, see Can't Connect to Amazon RDS DB Instance (p. 1458).

- **Security groups** – The VPC or DB security group memberships for your RDS DB instance.
- **Authentication type** – The authentication mode between hosts. The following authentication types are supported:
  - Mutual – The RDS instances are mutually authenticated to each other using integrated authentication. If this option is selected, all instances associated with this option group must be domain-joined.
  - None – No authentication is performed between hosts. We don't recommend using this mode in production environments.
- **Transaction log size** – The size of the MSDTC transaction log. Allowed values are 4–1024 MB. The default size is 4 MB.

The following option settings are optional:

- **Enable inbound connections** – Whether to allow inbound MSDTC connections to instances associated with this option group.
- **Enable outbound connections** – Whether to allow outbound MSDTC connections from instances associated with this option group.
- **Enable XA** – Whether to allow XA transactions. For more information on the XA protocol, see XA Specification.

  Note
  Using custom XA dynamic link libraries isn't supported.
- **Enable SNA LU** – Whether to allow the SNA LU protocol to be used for distributed transactions. For more information on SNA LU protocol support, see Managing IBM CICS LU 6.2 Transactions in the Microsoft documentation.

Console

To add the MSDTC option

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group that you just created.
4. Choose **Add option**.
5. Under **Option details**, choose **MSDTC** for **Option name**.
6. Under **Option settings**:

   a. For **Port**, enter the port number for accessing MSDTC. The default is **5000**.
   b. For **Security groups**, choose the VPC or DB security group to associate with the option.
   c. For **Authentication type**, choose **Mutual** or **None**.
   d. For **Transaction log size**, enter a value from 4–1024. The default is **4**.
7. Under **Additional configuration**, do the following:

   a. For **Connections**, as needed choose **Enable inbound connections** and **Enable outbound connections**.
   b. For **Allowed protocols**, as needed choose **Enable XA** and **Enable SNA LU**.
8. Under **Scheduling**, choose whether to add the option immediately or at the next maintenance window.
9. Choose **Add option**.

   To add this option, no reboot is required.

CLI

To add the MSDTC option

1. Create a JSON file, for example `msdtc-option.json`, with the following required parameters.

```
{
"OptionGroupName":"msdtc-se-2016",
"OptionsToInclude": [
 {
 "OptionName":"MSDTC",
 "Port":5000,
 "VpcSecurityGroupMemberships":["sg-0abcdef123"],
 "OptionSettings":[{"Name":"AUTHENTICATION","Value":"MUTUAL"},
{"Name":"TRANSACTION_LOG_SIZE","Value":4}]
 }],
"ApplyImmediately": true
}
```

2. Add the `MSDTC` option to the option group.

   Example

   For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --cli-input-json file://msdtc-option.json \
    --apply-immediately
```

   For Windows:

```
aws rds add-option-to-option-group ^
    --cli-input-json file://msdtc-option.json ^
    --apply-immediately
```

   No reboot is required.

Creating the Parameter Group for MSDTC

Create or modify a parameter group for the `in-doubt xact resolution` parameter that corresponds to the SQL Server edition and version of your DB instance.

Console

The following example creates a parameter group for SQL Server Standard Edition 2016.

To create the parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose **Create parameter group**.
4. In the **Create parameter group** pane, do the following:

   a. For **Parameter group family**, choose **sqlserver-se-13.0**.
   b. For **Group name**, enter an identifier for the parameter group, such as **`msdtc-sqlserver-se-13`**.

   c. For **Description**, enter **`in-doubt xact resolution`**.
5. Choose **Create**.

CLI

The following example creates a parameter group for SQL Server Standard Edition 2016.

To create the parameter group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds create-db-parameter-group \
    --db-parameter-group-name msdtc-sqlserver-se-13 \
    --db-parameter-group-family "sqlserver-se-13.0" \
    --description "in-doubt xact resolution"
```

  For Windows:

```
aws rds create-db-parameter-group ^
    --db-parameter-group-name msdtc-sqlserver-se-13 ^
    --db-parameter-group-family "sqlserver-se-13.0" ^
    --description "in-doubt xact resolution"
```

Modifying the Parameter for MSDTC

Modify the `in-doubt xact resolution` parameter in the parameter group that corresponds to the SQL Server edition and version of your DB instance.

For MSDTC, set the `in-doubt xact resolution` parameter to one of the following:

- `1` – Presume commit. Any MSDTC in-doubt transactions are presumed to have committed.
- `2` – Presume abort. Any MSDTC in-doubt transactions are presumed to have aborted.

For more information, see in-doubt xact resolution Server Configuration Option in the Microsoft documentation.

Console

The following example modifies the parameter group that you created for SQL Server Standard Edition 2016.

To modify the parameter group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Parameter groups**.
3. Choose the parameter group, such as **msdtc-sqlserver-se-13**.
4. Under **Parameters**, filter the parameter list for **`xact`**.
5. Choose **in-doubt xact resolution**.
6. Choose **Edit parameters**.

7. Enter **1** or **2**.
8. Choose **Save changes**.

CLI

The following example modifies the parameter group that you created for SQL Server Standard Edition 2016.

To modify the parameter group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds modify-db-parameter-group \
    --db-parameter-group-name msdtc-sqlserver-se-13 \
    --parameters "ParameterName='in-doubt xact
 resolution',ParameterValue=1,ApplyMethod=immediate"
```

  For Windows:

```
aws rds modify-db-parameter-group ^
    --db-parameter-group-name msdtc-sqlserver-se-13 ^
    --parameters "ParameterName='in-doubt xact
 resolution',ParameterValue=1,ApplyMethod=immediate"
```

Associating the Option Group and Parameter Group with the DB Instance

You can use the AWS Management Console or the AWS CLI to associate the MSDTC option group and parameter group with the DB instance.

Console

You can associate the MSDTC option group and parameter group with a new or existing DB instance.

- For a new DB instance, associate them when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
- For an existing DB instance, associate them by modifying the instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

  Note
  If you use an domain-joined existing DB instance, it must already have an Active Directory domain and AWS Identity and Access Management (IAM) role associated with it. If you create a new domain-joined instance, specify an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

CLI

You can associate the MSDTC option group and parameter group with a new or existing DB instance.

Note
If you use an existing domain-joined DB instance, it must already have an Active Directory domain and IAM role associated with it. If you create a new domain-joined instance, specify

an existing Active Directory domain and IAM role. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).

To create a DB instance with the MSDTC option group and parameter group

- Specify the same DB engine type and major version as you used when creating the option group.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --db-instance-class db.m5.2xlarge \
    --engine sqlserver-se \
    --engine-version 13.00.5426.0.v1 \
    --allocated-storage 100 \
    --master-user-password secret123 \
    --master-username master \
    --storage-type gp2 \
    --license-model li \
    --domain-iam-role-name my-directory-iam-role \
    --domain my-domain-id \
    --option-group-name msdtc-se-2016 \
    --db-parameter-group-name msdtc-sqlserver-se-13
```

For Windows:

```
aws rds create-db-instance ^
    --db-instance-identifier mydbinstance ^
    --db-instance-class db.m5.2xlarge ^
    --engine sqlserver-se ^
    --engine-version 13.00.5426.0.v1 ^
    --allocated-storage 100 ^
    --master-user-password secret123 ^
    --master-username master ^
    --storage-type gp2 ^
    --license-model li ^
    --domain-iam-role-name my-directory-iam-role ^
    --domain my-domain-id ^
    --option-group-name msdtc-se-2016 ^
    --db-parameter-group-name msdtc-sqlserver-se-13
```

To modify a DB instance and associate the MSDTC option group and parameter group

- Use one of the following commands.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --option-group-name msdtc-se-2016 \
    --db-parameter-group-name msdtc-sqlserver-se-13 \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --option-group-name msdtc-se-2016 ^
    --db-parameter-group-name msdtc-sqlserver-se-13 ^
    --apply-immediately
```

Using Distributed Transactions

In Amazon RDS for SQL Server, you run distributed transactions in the same way as distributed transactions running on-premises:

- Using .NET framework `System.Transactions` promotable transactions, which optimizes distributed transactions by deferring their creation until they're needed.

  In this case, promotion is automatic and doesn't require you to make any intervention. If there's only one resource manager within the transaction, no promotion is performed. For more information about implicit transaction scopes, see Implementing an Implicit Transaction using Transaction Scope in the Microsoft documentation.

  Promotable transactions are supported with these .NET implementations:

  - Starting with ADO.NET 2.0, `System.Data.SqlClient` supports promotable transactions with SQL Server. For more information, see System.Transactions Integration with SQL Server in the Microsoft documentation.
  - ODP.NET supports `System.Transactions`. A local transaction is created for the first connection opened in the `TransactionsScope` scope to Oracle Database 11g release 1 (version 11.1) and later. When a second connection is opened, this transaction is automatically promoted to a distributed transaction. For more information about distributed transaction support in ODP.NET, see Microsoft Distributed Transaction Coordinator Integration in the Microsoft documentation.
- Using the `BEGIN DISTRIBUTED TRANSACTION` statement. For more information, see BEGIN DISTRIBUTED TRANSACTION (Transact-SQL) in the Microsoft documentation.

Using Transaction Tracing

RDS supports controlling MSDTC transaction traces and downloading them from the RDS DB instance for troubleshooting. You can control transaction tracing sessions by running the following RDS stored procedure.

```
exec msdb.dbo.rds_msdtc_transaction_tracing 'trace_action'
[@traceall='0|1'],
[@traceaborted='0|1'],
[@tracelong='0|1'];
```

The following parameter is required:

- `trace_action` – The tracing action. It can be `START`, `STOP`, or `STATUS`.

The following parameters are optional:

- `@traceall` – Set to 1 to trace all distributed transactions. The default is 0.
- `@traceaborted` – Set to 1 to trace canceled distributed transactions. The default is 0.
- `@tracelong` – Set to 1 to trace long-running distributed transactions. The default is 0.

Example of START Tracing Action

To start a new transaction tracing session, run the following example statement.

```
exec msdb.dbo.rds_msdtc_transaction_tracing 'START'
@traceall='0',
@traceaborted='1',
@tracelong='1';
```

> **Note**
> Only one transaction tracing session can be active at one time. If a new tracing session `START` command is issued while a tracing session is active, an error is returned and the active tracing session remains unchanged.

Example of STOP Tracing Action

To stop a transaction tracing session, run the following statement.

```
exec msdb.dbo.rds_msdtc_transaction_tracing 'STOP'
```

This statement stops the active transaction tracing session and saves the transaction trace data into the log directory on the RDS DB instance. The first row of the output contains the overall execution result, and the following lines indicate details of the operation.

The following is an example of a successful tracing session stop.

```
OK: Trace session has been successfully stopped.
Setting log file to: D:\rdsdbdata\MSDTC\Trace\dtctrace.log
Examining D:\rdsdbdata\MSDTC\Trace\msdtctr.mof for message formats,  8 found.
Searching for TMF files on path: (null)
Logfile D:\rdsdbdata\MSDTC\Trace\dtctrace.log:
 OS version    10.0.14393  (Currently running on 6.2.9200)
 Start Time    <timestamp>
 End Time      <timestamp>
 Timezone is   @tzres.dll,-932 (Bias is 0mins)
 BufferSize            16384 B
 Maximum File Size     10 MB
 Buffers  Written      Not set (Logger may not have been stopped).
 Logger Mode Settings (11000002) ( circular paged
 ProcessorCount         1
Processing completed   Buffers: 1, Events: 3, EventsLost: 0 :: Format Errors: 0, Unknowns:
 3
Event traces dumped to d:\rdsdbdata\Log\msdtc_<timestamp>.log
```

You can use the detailed information to query the name of the generated log file. For more information about downloading log files from the RDS DB instance, see Amazon RDS Database Log Files (p. 453).

The trace session logs remain on the instance for 35 days. Any older trace session logs are automatically deleted.

Example of STATUS Tracing Action

To trace the status of a transaction tracing session, run the following statement.

```
exec msdb.dbo.rds_msdtc_transaction_tracing 'STATUS'
```

This statement outputs the following as separate rows of the result set.

```
OK
```

```
SessionStatus: <Started|Stopped>
TraceAll: <True|False>
TraceAborted: <True|False>
TraceLongLived: <True|False>
```

The first line indicates the overall result of the operation: `OK` or `ERROR` with details, if applicable. The subsequent lines indicate details about the tracing session status:

- `SessionStatus` can be one of the following:
  - `Started` if a tracing session is running.
  - `Stopped` if no tracing session is running.
- The tracing session flags can be `True` or `False` depending on how they were set in the `START` command.

Modifying the MSDTC Option

After you enable the `MSDTC` option, you can modify its settings. For information about how to modify option settings, see Modifying an Option Setting (p. 195).

> **Note**
> Some changes to MSDTC option settings require the MSDTC service to be restarted. This requirement can affect running distributed transactions.

Disabling MSDTC

To disable MSDTC, remove the `MSDTC` option from its option group.

Console

To remove the MSDTC option from its option group

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Option groups**.
3. Choose the option group with the `MSDTC` option (`msdtc-se-2016` in the previous examples).
4. Choose **Delete option**.
5. Under **Deletion options**, choose **MSDTC** for **Options to delete**.
6. Under **Apply immediately**, choose **Yes** to delete the option immediately, or **No** to delete it at the next maintenance window.
7. Choose **Delete**.

CLI

To remove the MSDTC option from its option group

- Use one of the following commands.

  Example

  For Linux, macOS, or Unix:

```
aws rds remove-option-from-option-group \
    --option-group-name msdtc-se-2016 \
    --options MSDTC \
```

```
    --apply-immediately
```

For Windows:

```
aws rds remove-option-from-option-group ^
    --option-group-name msdtc-se-2016 ^
    --options MSDTC ^
    --apply-immediately
```

Troubleshooting MSDTC for RDS SQL Server

In some cases, you might have trouble establishing a connection between MSDTC running on a client computer and the MSDTC service running on an RDS SQL Server DB instance. If so, make sure of the following:

- The inbound rules for the security group associated with the DB instance are configured correctly. For more information, see Can't Connect to Amazon RDS DB Instance (p. 1458).
- Your client computer is configured correctly.
- The MSDTC firewall rules on your client compter are enabled.

To configure the client computer

1. Open **Component Services**.

   Or, in **Server Manager**, choose **Tools**, and then choose **Component Services**.
2. Expand **Component Services**, expand **Computers**, expand **My Computer**, and then expand **Distributed Transaction Coordinator**.
3. Open the context (right-click) menu for **Local DTC** and choose **Properties**.
4. Choose the **Security** tab.
5. Choose all of the following:
   - **Network DTC Access**
   - **Allow Inbound**
   - **Allow Outbound**
6. Make sure that the correct authentication mode is chosen:
   - **Mutual Authentication Required** – The client machine is joined to the same domain as other nodes participating in distributed transaction, or there is a trust relationship configured between domains.
   - **No Authentication Required** – All other cases.
7. Choose **OK** to save your changes.
8. If prompted to restart the service, choose **Yes**.

To enable MSDTC firewall rules

1. Open Windows Firewall, then choose **Advanced settings**.

   Or, in **Server Manager**, choose **Tools**, and then choose **Windows Firewall with Advanced Security**.

   Note
   Depending on your operating system, Windows Firewall might be called Windows Defender Firewall.

2. Choose **Inbound Rules** in the left pane.
3. Enable the following firewall rules, if they are not already enabled:
   - **Distributed Transaction Coordinator (RPC)**
   - **Distributed Transaction Coordinator (RPC)-EPMAP**
   - **Distributed Transaction Coordinator (TCP-In)**
4. Close Windows Firewall.

Common DBA Tasks for Microsoft SQL Server

This section describes the Amazon RDS-specific implementations of some common DBA tasks for DB instances that are running the Microsoft SQL Server database engine. In order to deliver a managed service experience, Amazon RDS does not provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges.

Note
When working with a SQL Server DB instance, you can run scripts to modify a newly created database, but you cannot modify the [model] database, the database used as the model for new databases.

Topics

Accessing the tempdb Database on Microsoft SQL Server DB Instances on Amazon RDS

You can access the tempdb database on your Microsoft SQL Server DB instances on Amazon RDS. You can run code on tempdb by using Transact-SQL through Microsoft SQL Server Management Studio (SSMS), or any other standard SQL client application. For more information about connecting to your DB instance, see Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560).

The master user for your DB instance is granted `CONTROL` access to tempdb so that this user can modify the tempdb database options. The master user isn't the database owner of the tempdb database. If necessary, the master user can grant `CONTROL` access to other users so that they can also modify the tempdb database options.

Note
You can't run Database Console Commands (DBCC) on the tempdb database.

Modifying tempdb Database Options

You can modify the database options on the tempdb database on your Amazon RDS DB instances. For more information about which options can be modified, see tempdb Database in the Microsoft documentation.

Database options such as the maximum file size options are persistent after you restart your DB instance. You can modify the database options to optimize performance when importing data, and to prevent running out of storage.

Optimizing Performance when Importing Data

To optimize performance when importing large amounts of data into your DB instance, set the `SIZE` and `FILEGROWTH` properties of the tempdb database to large numbers. For more information about how to optimize tempdb, see Optimizing tempdb Performance in the Microsoft documentation.

The following example demonstrates setting the size to 100 GB and file growth to 10 percent.

```
alter database[tempdb] modify file (NAME = N'templog', SIZE=100GB, FILEGROWTH = 10%)
```

Preventing Storage Problems

To prevent the tempdb database from using all available disk space, set the `MAXSIZE` property. The following example demonstrates setting the property to 2048 MB.

```
alter database [tempdb] modify file (NAME = N'templog', MAXSIZE = 2048MB)
```

Shrinking the tempdb Database

There are two ways to shrink the tempdb database on your Amazon RDS DB instance. You can use the `rds_shrink_tempdbfile` procedure, or you can set the `SIZE` property,

Using the rds_shrink_tempdbfile Procedure

You can use the Amazon RDS procedure `msdb.dbo.rds_shrink_tempdbfile` to shrink the tempdb database. You can only call `rds_shrink_tempdbfile` if you have `CONTROL` access to tempdb. When you call `rds_shrink_tempdbfile`, there is no downtime for your DB instance.

The `rds_shrink_tempdbfile` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`@temp_filename`	SYSNAME	—	required	The logical name of the file to shrink.
`@target_size`	int	null	optional	The new size for the file, in megabytes.

The following example gets the names of the files for the tempdb database.

```
use tempdb;
GO

select name, * from sys.sysfiles;
GO
```

The following example shrinks a tempdb database file named `test_file`, and requests a new size of `10` megabytes:

```
exec msdb.dbo.rds_shrink_tempdbfile @temp_filename = N'test_file', @target_size = 10;
```

Setting the SIZE Property

You can also shrink the tempdb database by setting the `SIZE` property and then restarting your DB instance. For more information about restarting your DB instance, see Rebooting a DB Instance (p. 247).

The following example demonstrates setting the `SIZE` property to 1024 MB.

```
alter database [tempdb] modify file (NAME = N'templog', SIZE = 1024MB)
```

Considerations for Multi-AZ Deployments

If your Amazon RDS DB instance is in a Multi-AZ Deployment for Microsoft SQL Server with Database Mirroring (DBM) or Always On Availability Groups (AGs), there are some things to consider.

The tempdb database can't be replicated. No data that you store on your primary instance is replicated to your secondary instance.

If you modify any database options on the tempdb database, you can capture those changes on the secondary by using one of the following methods:

- First modify your DB instance and turn Multi-AZ off, then modify tempdb, and finally turn Multi-AZ back on. This method doesn't involve any downtime.

  For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- First modify tempdb in the original primary instance, then fail over manually, and finally modify tempdb in the new primary instance. This method involves downtime.

  For more information, see Rebooting a DB Instance (p. 247).

Analyzing Your Database Workload on an Amazon RDS DB Instance with SQL Server Tuning Advisor

The Database Engine Tuning Advisor is a client application provided by Microsoft that analyzes database workload and recommends an optimal set of indexes for your Microsoft SQL Server databases based on the kinds of queries you run. Like SQL Server Management Studio, you run Tuning Advisor from a client computer that connects to your Amazon RDS DB instance that is running SQL Server. The client computer can be a local computer that you run on premises within your own network or it can be an Amazon EC2 Windows instance that is running in the same region as your Amazon RDS DB instance.

This section shows how to capture a workload for Tuning Advisor to analyze. This is the preferred process for capturing a workload because Amazon RDS restricts host access to the SQL Server instance. The full documentation on Tuning Advisor can be found on MSDN.

To use Tuning Advisor, you must provide what is called a workload to the advisor. A workload is a set of Transact-SQL statements that execute against a database or databases that you want to tune. Database Engine Tuning Advisor uses trace files, trace tables, Transact-SQL scripts, or XML files as workload input when tuning databases. When working with Amazon RDS, a workload can be a file on a client computer or a database table on an Amazon RDS SQL Server DB accessible to your client computer. The file or the table must contain queries against the databases you want to tune in a format suitable for replay.

For Tuning Advisor to be most effective, a workload should be as realistic as possible. You can generate a workload file or table by performing a trace against your DB instance. While a trace is running, you can either simulate a load on your DB instance or run your applications with a normal load.

There are two types of traces: client-side and server-side. A client-side trace is easier to set up and you can watch trace events being captured in real-time in SQL Server Profiler. A server-side trace is more complex to set up and requires some Transact-SQL scripting. In addition, because the trace is written to a file on the Amazon RDS DB instance, storage space is consumed by the trace. It is important to track of how much storage space a running server-side trace uses because the DB instance could enter a storage-full state and would no longer be available if it runs out of storage space.

For a client-side trace, when a sufficient amount of trace data has been captured in the SQL Server Profiler, you can then generate the workload file by saving the trace to either a file on your local computer or in a database table on a DB instance that is available to your client computer. The main disadvantage of using a client-side trace is that the trace may not capture all queries when under heavy loads. This could weaken the effectiveness of the analysis performed by the Database Engine Tuning Advisor. If you need to run a trace under heavy loads and you want to ensure that it captures every query during a trace session, you should use a server-side trace.

For a server-side trace, you must get the trace files on the DB instance into a suitable workload file or you can save the trace to a table on the DB instance after the trace completes. You can use the SQL Server Profiler to save the trace to a file on your local computer or have the Tuning Advisor read from the trace table on the DB instance.

Running a Client-Side Trace on a SQL Server DB Instance

To run a client-side trace on a SQL Server DB instance

1. Start SQL Server Profiler. It is installed in the Performance Tools folder of your SQL Server instance folder. You must load or define a trace definition template to start a client-side trace.
2. In the SQL Server Profiler File menu, choose **New Trace**. In the **Connect to Server** dialog box, enter the DB instance endpoint, port, master user name, and password of the database you would like to run a trace on.
3. In the **Trace Properties** dialog box, enter a trace name and choose a trace definition template. A default template, TSQL_Replay, ships with the application. You can edit this template to define your

trace. Edit events and event information under the **Events Selection** tab of the **Trace Properties** dialog box. For more information about trace definition templates and using the SQL Server Profiler to specify a client-side trace see the documentation in MSDN.

4. Start the client-side trace and watch SQL queries in real-time as they execute against your DB instance.
5. Select **Stop Trace** from the **File** menu when you have completed the trace. Save the results as a file or as a trace table on you DB instance.

Running a Server-Side Trace on a SQL Server DB Instance

Writing scripts to create a server-side trace can be complex and is beyond the scope of this document. This section contains sample scripts that you can use as examples. As with a client-side trace, the goal is to create a workload file or trace table that you can open using the Database Engine Tuning Advisor.

The following is an abridged example script that starts a server-side trace and captures details to a workload file. The trace initially saves to the file RDSTrace.trc in the D:\RDSDBDATA\Log directory and rolls-over every 100 MB so subsequent trace files are named RDSTrace_1.trc, RDSTrace_2.trc, etc.

```
DECLARE @file_name NVARCHAR(245) = 'D:\RDSDBDATA\Log\RDSTrace';
DECLARE @max_file_size BIGINT = 100;
DECLARE @on BIT = 1
DECLARE @rc INT
DECLARE @traceid INT

EXEC @rc = sp_trace_create @traceid OUTPUT, 2, @file_name, @max_file_size
IF (@rc = 0) BEGIN
   EXEC sp_trace_setevent @traceid, 10, 1, @on
   EXEC sp_trace_setevent @traceid, 10, 2, @on
   EXEC sp_trace_setevent @traceid, 10, 3, @on
 . . .
   EXEC sp_trace_setfilter @traceid, 10, 0, 7, N'SQL Profiler'
   EXEC sp_trace_setstatus @traceid, 1
   END
```

The following example is a script that stops a trace. Note that a trace created by the previous script continues to run until you explicitly stop the trace or the process runs out of disk space.

```
DECLARE @traceid INT
SELECT @traceid = traceid FROM ::fn_trace_getinfo(default)
WHERE property = 5 AND value = 1 AND traceid <> 1

IF @traceid IS NOT NULL BEGIN
   EXEC sp_trace_setstatus @traceid, 0
   EXEC sp_trace_setstatus @traceid, 2
END
```

You can save server-side trace results to a database table and use the database table as the workload for the Tuning Advisor by using the fn_trace_gettable function. The following commands load the results of all files named RDSTrace.trc in the D:\rdsdbdata\Log directory, including all rollover files like RDSTrace_1.trc, into a table named RDSTrace in the current database.

```
SELECT * INTO RDSTrace
FROM fn_trace_gettable('D:\rdsdbdata\Log\RDSTrace.trc', default);
```

To save a specific rollover file to a table, for example the RDSTrace_1.trc file, specify the name of the rollover file and substitute 1 instead of default as the last parameter to fn_trace_gettable.

```
SELECT * INTO RDSTrace_1
FROM fn_trace_gettable('D:\rdsdbdata\Log\RDSTrace_1.trc', 1);
```

Running Tuning Advisor with a Trace

Once you create a trace, either as a local file or as a database table, you can then run Tuning Advisor against your DB instance. Microsoft includes documentation on using the Database Engine Tuning Advisor in MSDN. Using Tuning Advisor with Amazon RDS is the same process as when working with a standalone, remote SQL Server instance. You can either use the Tuning Advisor UI on your client machine or use the dta.exe utility from the command line. In both cases, you must connect to the Amazon RDS DB instance using the endpoint for the DB instance and provide your master user name and master user password when using Tuning Advisor.

The following code example demonstrates using the dta.exe command line utility against an Amazon RDS DB instance with an endpoint of **dta.cnazcmklsdei.us-east-1.rds.amazonaws.com**. The example includes the master user name **admin** and the master user password **test**, the example database to tune is named **RDSDTA** and the input workload is a trace file on the local machine named **C:\RDSTrace.trc**. The example command line code also specifies a trace session named **RDSTrace1** and specifies output files to the local machine named **RDSTrace.sql** for the SQL output script, **RDSTrace.txt** for a result file, and **RDSTrace.xml** for an XML file of the analysis. There is also an error table specified on the RDSDTA database named **RDSTraceErrors**.

```
dta -S dta.cnazcmklsdei.us-east-1.rds.amazonaws.com -U admin -P test -D RDSDTA -if C:
\RDSTrace.trc -s RDSTrace1 -of C:\ RDSTrace.sql -or C:\ RDSTrace.txt -ox C:\ RDSTrace.xml -
e RDSDTA.dbo.RDSTraceErrors
```

Here is the same example command line code except the input workload is a table on the remote Amazon RDS instance named **RDSTrace** which is on the **RDSDTA** database.

```
dta -S dta.cnazcmklsdei.us-east-1.rds.amazonaws.com -U admin -P test -D RDSDTA -it
 RDSDTA.dbo.RDSTrace -s RDSTrace1 -of C:\ RDSTrace.sql -or C:\ RDSTrace.txt -ox C:\
 RDSTrace.xml -e RDSDTA.dbo.RDSTraceErrors
```

A full list of dta utility command-line parameters can be found in MSDN.

Collations and Character Sets for Microsoft SQL Server

SQL Server supports collations at multiple levels. You set the default server collation when you create the DB instance. You can override the collation in the database, table, or column level.

Topics

Server-Level Collation for Microsoft SQL Server

When you create a Microsoft SQL Server DB instance, you can set the server collation that you want to use. If you don't choose a different collation, the server-level collation defaults to SQL_Latin1_General_CP1_CI_AS. The server collation is applied by default to all databases and database objects.

Currently, Amazon RDS supports the following server collations:

Collation	Description
Chinese_PRC_CI_AS	Chinese-PRC, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Chinese_Taiwan_Stroke_CI_AS	Chinese-Taiwan-Stroke, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Finnish_Swedish_CI_AS	Finnish, Swedish, and Swedish (Finland), case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
French_CI_AS	French, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Hebrew_BIN	Hebrew, binary sort
Japanese_CI_AS	Japanese, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Korean_Wansung_CI_AS	Korean-Wansung, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Latin1_General_100_BIN	Latin1-General-100, binary sort
Latin1_General_100_BIN2	Latin1-General-100, binary code point comparison sort
Latin1_General_BIN	Latin1-General, binary sort
Latin1_General_CI_AI	Latin1-General, case-insensitive, accent-insensitive, kanatype-insensitive, width-insensitive
Latin1_General_CI_AS	Latin1-General, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Latin1_General_CS_AS	Latin1-General, case-sensitive, accent-sensitive, kanatype-insensitive, width-insensitive
Modern_Spanish_CI_AS	Modern-Spanish, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive
SQL_Latin1_General_CP1_CI_AI	Latin1-General, case-insensitive, accent-insensitive, kanatype-insensitive, width-insensitive for Unicode Data, SQL Server Sort Order 54 on Code Page 1252 for non-Unicode Data
SQL_Latin1_General_CP1_CI_AS (default)	Latin1-General, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive for Unicode Data, SQL Server Sort Order 52 on Code Page 1252 for non-Unicode Data
SQL_Latin1_General_CP1_CS_AS	Latin1-General, case-sensitive, accent-sensitive, kanatype-insensitive, width-insensitive for Unicode Data, SQL Server Sort Order 51 on Code Page 1252 for non-Unicode Data
SQL_Latin1_General_CP437_CI_AI	Latin1-General, case-insensitive, accent-insensitive, kanatype-insensitive, width-insensitive

Collation	Description
	for Unicode Data, SQL Server Sort Order 34 on Code Page 437 for non-Unicode Data
SQL_Latin1_General_CP850_BIN2	Latin1-General, binary code point comparison sort for Unicode Data, SQL Server Sort Order 40 on Code Page 850 for non-Unicode Data
SQL_Latin1_General_CP850_CI_AS	Latin1-General, case-insensitive, accent-sensitive, kanatype-insensitive, width-insensitive for Unicode Data, SQL Server Sort Order 42 on Code Page 850 for non-Unicode Data

To choose the collation:

- If you're using the Amazon RDS console, when creating a new DB instance choose **Additional configuration**, then choose the collation from the **Collation** menu under **Database options**. For more information, see Creating an Amazon RDS DB Instance (p. 136).
- If you're using the AWS CLI, use the `--character-set-name` option with the `create-db-instance` command. For more information, see create-db-instance.
- If you're using the Amazon RDS API, use the `CharacterSetName` parameter with the `CreateDBInstance` operation. For more information, see CreateDBInstance.

Database-Level Collation for Microsoft SQL Server

You can change the default collation at the database, table, or column level by overriding the collation when creating a new database or database object. For example, if your default server collation is SQL_Latin1_General_CP1_CI_AS, you can change it to Mohawk_100_CI_AS for Mohawk collation support. Even arguments in a query can be type-cast to use a different collation if necessary.

For example, the following query would change the default collation for the AccountName column to Mohawk_100_CI_AS

```
CREATE TABLE [dbo].[Account]
 (
     [AccountID] [nvarchar](10) NOT NULL,
     [AccountName] [nvarchar](100) COLLATE Mohawk_100_CI_AS NOT NULL
 ) ON [PRIMARY];
```

The Microsoft SQL Server DB engine supports Unicode by the built-in NCHAR, NVARCHAR, and NTEXT data types. For example, if you need CJK support, use these Unicode data types for character storage and override the default server collation when creating your databases and tables. Here are several links from Microsoft covering collation and Unicode support for SQL Server:

- Working with Collations
- Collation and International Terminology
- Using SQL Server Collations
- International Considerations for Databases and Database Engine Applications

Determining a Recovery Model for Your Microsoft SQL Server Database

In Amazon RDS, the recovery model, retention period, and database status are linked.

It's important to understand the consequences before making a change to one of these settings. Each setting can affect the others. For example:

- If you change a database's recovery model to SIMPLE or BULK_LOGGED while backup retention is enabled, Amazon RDS resets the recovery model to FULL within five minutes. This also results in RDS taking a snapshot of the DB instance.
- If you set backup retention to `0` days, RDS sets the recovery mode to SIMPLE.
- If you change a database's recovery model from SIMPLE to any other option while backup retention is set to `0` days, RDS resets the recovery model to SIMPLE.

Important
Never change the recovery model on Multi-AZ instances, even if it seems you can do so—for example, by using ALTER DATABASE. Backup retention, and therefore FULL recovery mode, is required for Multi-AZ. If you alter the recovery model, RDS immediately changes it back to FULL. This automatic reset forces RDS to completely rebuild the mirror. During this rebuild, the availability of the database is degraded for about 30–90 minutes until the mirror is ready for failover. The DB instance also experiences performance degradation in the same way it does during a conversion from Single-AZ to Multi-AZ. How long performance is degraded depends on the database storage size—the bigger the stored database, the longer the degradation.

For more information on SQL Server recovery models, see Recovery Models (SQL Server) in the Microsoft documentation.

Determining the Last Failover Time

To determine the last failover time, use the following stored procedure:

```
execute msdb.dbo.rds_failover_time;
```

This procedure returns the following information.

Output Parameter	Description
errorlog_available_from	Shows the time from when error logs are available in the log directory.
recent_failover_time	Shows the last failover time if it's available from the error logs. Otherwise it shows `null`.

Note
The stored procedure searches all of the available SQL Server error logs in the log directory to retrieve the most recent failover time. If the failover messages have been overwritten by SQL Server, then the procedure doesn't retrieve the failover time.

Example of No Recent Failover

This example shows the output when there is no recent failover in the error logs. No failover has happened since 2020-04-29 23:59:00.01.

errorlog_available_from	recent_failover_time
2020-04-29 23:59:00.0100000	null

Example of Recent Failover

This example shows the output when there is a failover in the error logs. The most recent failover was at 2020-05-05 18:57:51.89.

errorlog_available_from	recent_failover_time
2020-04-29 23:59:00.0100000	2020-05-05 18:57:51.8900000

Dropping a Microsoft SQL Server Database

You can drop a database on an Amazon RDS DB instance running Microsoft SQL Server in a Single-AZ or Multi-AZ deployment. To drop the database, use the following command:

```
--replace your-database-name with the name of the database you want to drop
EXECUTE msdb.dbo.rds_drop_database  N'your-database-name'
```

Note
Use straight single quotes in the command. Smart quotes will cause an error.

After you use this procedure to drop the database, Amazon RDS drops all existing connections to the database and removes the database's backup history.

Using Change Data Capture

Amazon RDS supports change data capture (CDC) for your DB instances running Microsoft SQL Server. CDC captures changes that are made to the data in your tables. It stores metadata about each change, which you can access later. For more information about how CDC works, see Change Data Capture in the Microsoft documentation.

Before you use CDC with your Amazon RDS DB instances, enable it in the database by running `msdb.dbo.rds_cdc_enable_db`. You must have master user privileges to enable CDC in the Amazon RDS DB instance. After CDC is enabled, any user who is `db_owner` of that database can enable or disable CDC on tables in that database.

Important
During restores, CDC will be disabled. All of the related metadata is automatically removed from the database. This applies to snapshot restores, point-in-time restores, and SQL Server Native restores from S3. After performing one of these types of restores, you can re-enable CDC and re-specify tables to track.

```
--Enable CDC for RDS DB Instance
exec msdb.dbo.rds_cdc_enable_db '<database name>'
```

To disable CDC, `msdb.dbo.rds_cdc_disable_db` run .

```
--Disable CDC for RDS DB Instance
```

```
exec msdb.dbo.rds_cdc_disable_db '<database name>'
```

Topics

Tracking Tables with Change Data Capture

After CDC is enabled on the database, you can start tracking specific tables. You can choose the tables to track by running sys.sp_cdc_enable_table.

```
--Begin tracking a table
exec sys.sp_cdc_enable_table
   @source_schema           = N'<source_schema>'
,  @source_name             = N'<source_name>'
,  @role_name               = N'<role name>'

--The following parameters are optional:

--, @capture_instance       = '<capture_instance>'
--, @supports_net_changes   = <supports_net_changes>
--, @index_name             = '<index_name>'
--, @captured_column_list   = '<captured_column_list>'
--, @filegroup_name         = '<filegroup_name>'
--, @allow_partition_switch = '<allow_partition_switch>'
;
```

To view the CDC configuration for your tables, run sys.sp_cdc_help_change_data_capture.

```
--View CDC configuration
exec sys.sp_cdc_help_change_data_capture

--The following parameters are optional and must be used together.
--  '<schema name>', '<table name>'
;
```

For more information on CDC tables, functions, and stored procedures in SQL Server documentation, see the following:

- Change Data Capture Stored Procedures (Transact-SQL)
- Change Data Capture Functions (Transact-SQL)
- Change Data Capture Tables (Transact-SQL)

Change Data Capture Jobs

When you enable CDC, SQL Server creates the CDC jobs. Database owners (`db_owner`) can view, create, modify, and delete the CDC jobs. However, the RDS system account owns them. Therefore, the jobs aren't visible from native views, procedures, or in SQL Server Management Studio.

To control behavior of CDC in a database, use native SQL Server procedures such as sp_cdc_enable_table and sp_cdc_start_job. To change CDC job parameters, like `maxtrans` and `maxscans`, you can use sp_cdc_change_job..

To get more information regarding the CDC jobs, you can query the following dynamic management views:

- sys.dm_cdc_errors
- sys.dm_cdc_log_scan_sessions
- sysjobs
- sysjobhistory

Change Data Capture for Multi-AZ Instances

If you use CDC on a Multi-AZ instance, make sure the mirror's CDC job configuration matches the one on the principal. CDC jobs are mapped to the `database_id`. If the database IDs on the secondary are different from the principal, then the jobs won't be associated with the correct database. To try to prevent errors after failover, RDS drops and recreates the jobs on the new principal. The recreated jobs use the parameters that the principal recorded before failover.

Although this process runs quickly, it's still possible that the CDC jobs might run before RDS can correct them. Here are three ways to force parameters to be consistent between primary and secondary replicas:

- Use the same job parameters for all the databases that have CDC enabled.
- Before you change the CDC job configuration, convert the Multi-AZ instance to Single-AZ.
- Manually transfer the parameters whenever you change them on the principal.

To view and define the CDC parameters that are used to recreate the CDC jobs after a failover, use `rds_show_configuration` and `rds_set_configuration`.

The following example returns the value set for cdc_capture_maxtrans. For any parameter that is set to RDS_DEFAULT, RDS automatically configures the value.

```
-- Show configuration for each parameter on either primary and secondary replicas.
exec rdsadmin.dbo.rds_show_configuration 'cdc_capture_maxtrans'
```

To set the configuration on the secondary, run `rdsadmin.dbo.rds_set_configuration`. This procedure sets the parameter values for all of the databases on the secondary server. These settings are used only after a failover. The following example sets the `maxtrans` for all CDC capture jobs to *`1000`*:

```
--To set values on secondary. These are used after failover.
exec rdsadmin..rds_set_configuration 'cdc_capture_maxtrans' , 1000
```

To set the CDC job parameters on the principal, use sys.sp_cdc_change_job instead.

Renaming a Microsoft SQL Server Database in a Multi-AZ Deployment

To rename a Microsoft SQL Server database instance that uses Multi-AZ, use the following procedure:

1. First, turn off Multi-AZ for the DB instance.
2. Rename the database by running `rdsadmin.dbo.rds_modify_db_name`.
3. Then, turn on Multi-AZ Mirroring or Always On Availability Groups for the DB instance, to return it to its original state.

For more information, see Adding Multi-AZ to a Microsoft SQL Server DB Instance (p. 603).

Note
If your instance doesn't use Multi-AZ, you don't need to change any settings before or after running `rdsadmin.dbo.rds_modify_db_name`.

Example: In the following example, the `rdsadmin.dbo.rds_modify_db_name` stored procedure renames a database from **MOO** to **ZAR**. This is similar to running the statement `DDL ALTER DATABASE [MOO] MODIFY NAME = [ZAR]`.

```
EXEC rdsadmin.dbo.rds_modify_db_name N'MOO', N'ZAR'
GO
```

Resetting the `db_owner` Role Password

If you lock yourself out of the `db_owner` role on your Microsoft SQL Server database, you can reset the `db_owner` role password by modifying the DB instance master password. By changing the DB instance master password, you can regain access to the DB instance, access databases using the modified password for the `db_owner`, and restore privileges for the `db_owner` role that may have been accidentally revoked. You can change the DB instance password by using the Amazon RDS console, the AWS CLI command modify-db-instance, or by using the ModifyDBInstance operation. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Restoring License-Terminated DB Instances

Microsoft has requested that some Amazon RDS customers who did not report their Microsoft License Mobility information terminate their DB instance. Amazon RDS takes snapshots of these DB instances, and you can restore from the snapshot to a new DB instance that has the License Included model.

You can restore from a snapshot of Standard Edition to either Standard Edition or Enterprise Edition.

You can restore from a snapshot of Enterprise Edition to either Standard Edition or Enterprise Edition.

To restore from a SQL Server snapshot after Amazon RDS has created a final snapshot of your instance:

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the snapshot of your SQL Server DB instance. Amazon RDS creates a final snapshot of your DB instance. The name of the terminated instance snapshot is in the format '<name of instance>-final-snapshot'. For example, if your DB instance name is **`mytest.cdxgahslksma.us-east-1.rds.com`**, the final snapshot is called **`mytest-final-snapshot`** and is located in the same AWS Region as the original DB instance.
4. For **Actions**, choose **Restore Snapshot**.

   The **Restore DB Instance** window appears.
5. For **License Model**, choose **license-included**.
6. Choose the SQL Server DB engine that you want to use.
7. For **DB Instance Identifier**, enter the name for the restored DB instance.
8. Choose **Restore DB Instance**.

For more information about restoring from a snapshot, see Restoring from a DB Snapshot (p. 303).

Transitioning a Microsoft SQL Server Database from OFFLINE to ONLINE

You can transition your Microsoft SQL Server database on an Amazon RDS DB instance from `OFFLINE` to `ONLINE`.

SQL Server method	Amazon RDS method
ALTER DATABASE *name* SET ONLINE;	EXEC rdsadmin.dbo.rds_set_database_online *name*

Using SQL Server Agent

With Amazon RDS, you can use SQL Server Agent on a DB instance running Microsoft SQL Server Standard, Web Edition, or Enterprise Edition. SQL Server Agent is a Microsoft Windows service that executes scheduled administrative tasks, which are called jobs. You can use SQL Server Agent to run T-SQL jobs to rebuild indexes, run corruption checks, and aggregate data in a SQL Server DB instance.

SQL Server Agent can run a job on a schedule, in response to a specific event, or on demand. For more information, see SQL Server Agent in the SQL Server documentation. You should avoid scheduling jobs to run during the maintenance and backup windows for your DB instance because these maintenance and backup processes that are launched by AWS could interrupt the job or cause it to be cancelled. Because Amazon RDS backs up your DB instance, you do not use SQL Server Agent to create backups.

To view the history of an individual SQL Server Agent job in the SQL Server Management Studio, you open Object Explorer, right-click the job, and then click **View History**.

Because SQL Server Agent is running on a managed host in a DB instance, there are some actions that are not supported. Running replication jobs and running command-line scripts by using ActiveX, Windows command shell, or Windows PowerShell are not supported. In addition, you cannot manually start, stop, or restart SQL Server Agent because its operation is managed by the host. Email notifications through SQL Server Agent are not available from a DB instance.

When you create a SQL Server DB instance, the master user name is enrolled in the SQLAgentUserRole role. To allow an additional login/user to use SQL Server Agent, you must log in as the master user and do the following.

1. Create another server-level login by using the `CREATE LOGIN` command.
2. Create a user in msdb using `CREATE USER` command, and then link this user to the login that you created in the previous step.
3. Add the user to the SQLAgentUserRole using the `sp_addrolemember` system stored procedure.

For example, suppose your master user name is **`myawsmaster`** and you want to give access to SQL Server Agent to a user named **`theirname`** with a password **`theirpassword`**. You would log in using the master user name and run the following commands.

```
--Initially set context to master database
USE [master];
GO
--Create a server-level login named theirname with password theirpassword
CREATE LOGIN [theirname] WITH PASSWORD = 'theirpassword';
GO
--Set context to msdb database
USE [msdb];
```

```
GO
--Create a database user named theirname and link it to server-level login theirname
CREATE USER [theirname] FOR LOGIN [theirname];
GO
--Added database user theirname in msdb to SQLAgentUserRole in msdb
EXEC sp_addrolemember [SQLAgentUserRole], [theirname];
```

To delete a SQL Server Agent job, run the following T-SQL statement.

```
EXEC msdb..sp_delete_job @job_name = '<job-name>';
```

> **Note**
> Don't use the UI in SQL Server Management Console (SSMS) to delete a SQL Server Agent job. If you do, you get an error message similar to the following:
>
> ```
> The EXECUTE permission was denied on the object 'xp_regread', database
>  'mssqlsystemresource', schema 'sys'.
> ```
>
> This error occurs because, as a managed service, RDS is restricted from running procedures that access the Windows registry. When you use SSMS to delete the job, it tries to run a process that RDS isn't authorized to do.

Working with Microsoft SQL Server Logs

You can use the Amazon RDS console to view, watch, and download SQL Server Agent logs and Microsoft SQL Server error logs.

Watching Log Files

If you view a log in the Amazon RDS console, you can see its contents as they exist at that moment. Watching a log in the console opens it in a dynamic state so that you can see updates to it in near real time.

Only the latest log is active for watching. For example, suppose you have the logs shown following:

Name	Last Written	Size			
log/ERROR	January 14, 2015 at 5:17:35 AM UTC-8	6.1 kB	view	watch	download
log/ERROR.1	January 13, 2015 at 3:59:00 PM UTC-8	53.3 kB	view	watch	download
log/ERROR.2	January 12, 2015 at 3:59:00 PM UTC-8	5.9 kB	view	watch	download
log/ERROR.3	January 11, 2015 at 3:59:00 PM UTC-8	5.9 kB	view	watch	download
log/ERROR.4	January 10, 2015 at 3:59:00 PM UTC-8	5.9 kB	view	watch	download

Only log/ERROR, as the most recent log, is being actively updated. You can choose to watch others, but they are static and will not update.

Archiving Log Files

The Amazon RDS console shows logs for the past week through the current day. You can download and archive logs to keep them for reference past that time. One way to archive logs is to load them into an Amazon S3 bucket. For instructions on how to set up an Amazon S3 bucket and upload a file, see Amazon S3 Basics in the *Amazon Simple Storage Service Getting Started Guide* and click **Get Started**.

Using the rds_read_error_log Procedure

To view Microsoft SQL server error and agent logs, use the Amazon RDS stored procedure `rds_read_error_log` with the following parameters:

- **@index** – the version of the log to retrieve. The default value is 0, which retrieves the current error log. Specify 1 to retrieve the previous log, specify 2 to retrieve the one before that, and so on.
- **@type** – the type of log to retrieve. Specify 1 to retrieve an error log. Specify 2 to retrieve an agent log.

Example

The following example requests the current error log.

```
EXEC rdsadmin.dbo.rds_read_error_log @index = 0, @type = 1;
```

Working with Trace and Dump Files

This section describes working with trace files and dump files for your Amazon RDS DB instances running Microsoft SQL Server.

Generating a Trace SQL Query

```
declare @rc int
declare @TraceID int
declare @maxfilesize bigint

set @maxfilesize = 5

exec @rc = sp_trace_create @TraceID output,  0, N'D:\rdsdbdata\log\rdstest', @maxfilesize,
 NULL
```

Viewing an Open Trace

```
select * from ::fn_trace_getinfo(default)
```

Viewing Trace Contents

```
select * from ::fn_trace_gettable('D:\rdsdbdata\log\rdstest.trc', default)
```

Setting the Retention Period for Trace and Dump Files

Trace and dump files can accumulate and consume disk space. By default, Amazon RDS purges trace and dump files that are older than seven days.

To view the current trace and dump file retention period, use the `rds_show_configuration` procedure, as shown in the following example.

```
exec rdsadmin..rds_show_configuration;
```

To modify the retention period for trace files, use the `rds_set_configuration` procedure and set the `tracefile retention` in minutes. The following example sets the trace file retention period to 24 hours.

```
exec rdsadmin..rds_set_configuration 'tracefile retention', 1440;
```

To modify the retention period for dump files, use the `rds_set_configuration` procedure and set the `dumpfile retention` in minutes. The following example sets the dump file retention period to 3 days.

```
exec rdsadmin..rds_set_configuration 'dumpfile retention', 4320;
```

For security reasons, you cannot delete a specific trace or dump file on a SQL Server DB instance. To delete all unused trace or dump files, set the retention period for the files to 0.

MySQL on Amazon RDS

Amazon RDS supports DB instances running several versions of MySQL. You can use the following major versions:

- MySQL 8.0
- MySQL 5.7
- MySQL 5.6
- MySQL 5.5

For more information about minor version support, see MySQL on Amazon RDS Versions (p. 713).

You first use the Amazon RDS management tools or interfaces to create an Amazon RDS MySQL DB instance. You can then resize the DB instance, authorize connections to the DB instance, create and restore from backups or snapshots, create Multi-AZ secondaries, create read replicas, and monitor the performance of the DB instance. You use standard MySQL utilities and applications to store and access the data in the DB instance.

Amazon RDS for MySQL is compliant with many industry standards. For example, you can use Amazon RDS for MySQL databases to build HIPAA-compliant applications and to store healthcare related information, including protected health information (PHI) under an executed Business Associate Agreement (BAA) with AWS. Amazon RDS for MySQL also meets Federal Risk and Authorization Management Program (FedRAMP) security requirements and has received a FedRAMP Joint Authorization Board (JAB) Provisional Authority to Operate (P-ATO) at the FedRAMP HIGH Baseline within the AWS GovCloud (US-West) Region. For more information on supported compliance standards, see AWS Cloud Compliance.

For information about the features in each version of MySQL, see The Main Features of MySQL in the MySQL documentation.

Common Management Tasks for MySQL on Amazon RDS

The following are the common management tasks you perform with an Amazon RDS MySQL DB instance, with links to relevant documentation for each task.

Task Area	Relevant Documentation
Understanding Amazon RDS Understand key Amazon RDS components, including DB instances, AWS Regions, Availability Zones, security groups, parameter groups, and option groups.	What Is Amazon Relational Database Service (Amazon RDS)? (p. 1)
Setting up Amazon RDS for first time use Set up Amazon RDS so that you can create MySQL DB instances in Amazon Web Services (AWS).	Setting Up for Amazon RDS (p. 58)

Task Area	Relevant Documentation
Understanding Amazon RDS DB instances Create virtual MySQL server instances that run in AWS. Because DB instances are the building blocks of Amazon RDS, we recommend that you understand their principles.	Amazon RDS DB Instances (p. 5)
Creating a DB instance for production Create a DB instance for production purposes. Creating an instance includes choosing a DB instance class with appropriate processing power and memory capacity and choosing a storage type that supports the way you expect to use your database.	DB Instance Classes (p. 7) Amazon RDS Storage Types (p. 29) Creating an Amazon RDS DB Instance (p. 136)
Managing security for your DB instance By default, DB instances are created with a firewall that prevents access to them. You must create a security group with the correct IP addresses and network configuration to access the DB instance. You can also use AWS Identity and Access Management (IAM) policies to assign permissions that determine who is allowed to manage RDS resources.	Security in Amazon RDS (p. 1356) Managing Access Using Policies (p. 1373) Controlling Access with Security Groups (p. 1414) Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434)
Connecting to your DB instance Connect to your DB instance using a standard SQL client application such as the MySQL command line utility or MySQL Workbench.	Connecting to a DB Instance Running the MySQL Database Engine (p. 722)
Configuring high availability for a production DB instance Provide high availability with synchronous standby replication in a different Availability Zone, automatic failover, fault tolerance for DB instances using Multi-AZ deployments, and read replicas.	High Availability (Multi-AZ) for Amazon RDS (p. 41)
Configuring a DB instance in an Amazon Virtual Private Cloud Configure a virtual private cloud (VPC) in the Amazon VPC service. An Amazon VPC is a virtual network logically isolated from other virtual networks in AWS.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Working with a DB Instance in a VPC (p. 1442)

Task Area	Relevant Documentation
Configuring specific MySQL database parameters and features Configure specific MySQL database parameters with a parameter group that can be associated with many DB instances. You can also configure specific MySQL database features with an option group that can be associated with many DB instances.	Working with DB Parameter Groups (p. 202) Working with Option Groups (p. 186) Options for MySQL DB Instances (p. 794)
Modifying a DB instance running the MySQL database engine Change the settings of a DB instance to accomplish tasks such as adding additional storage or changing the DB instance class.	Modifying an Amazon RDS DB Instance (p. 220)
Configuring database backup and restore Configure your DB instance to take automated backups. You can also back up and restore your databases manually by using full backup files.	Working With Backups (p. 291) Backing Up and Restoring an Amazon RDS DB Instance (p. 290)
Importing and exporting data Import data from other RDS MySQL DB instances, MySQL instances running external to Amazon RDS, and other types of data sources, and export data to MySQL instances running external to Amazon RDS.	Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747)
Monitoring a MySQL DB instance Monitor your RDS MySQL DB instance by using Amazon CloudWatch RDS metrics, events, and Enhanced Monitoring. View log files for your RDS MySQL DB instance.	Monitoring an Amazon RDS DB Instance (p. 345) Viewing DB Instance Metrics (p. 356) Viewing Amazon RDS Events (p. 448) Amazon RDS Database Log Files (p. 453) MySQL Database Log Files (p. 468)
Replicating your data Create a MySQL read replica, in the same AWS Region or a different one. You can use read replicas for load balancing, disaster recovery, and processing read-heavy database workloads, such as for analysis and reporting.	Working with Read Replicas (p. 250) Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783)

There are also several sections with useful information about working with Amazon RDS MySQL DB instances:

- Common DBA Tasks for MySQL DB Instances (p. 802)
- Options for MySQL DB Instances (p. 794)
- MySQL on Amazon RDS SQL Reference (p. 820)

MySQL on Amazon RDS Versions

For MySQL, version numbers are organized as version = X.Y.Z. In Amazon RDS terminology, X.Y denotes the major version, and Z is the minor version number. For Amazon RDS implementations, a version change is considered major if the major version number changes—for example, going from version 5.6 to 5.7. A version change is considered minor if only the minor version number changes—for example, going from version 5.7.16 to 5.7.21.

Amazon RDS currently supports the following versions of MySQL:

Major Version	Minor Version
MySQL 8.0	• 8.0.17 • 8.0.16 • 8.0.15 • 8.0.13 • 8.0.11
MySQL 5.7	• 5.7.28 • 5.7.26 • 5.7.25 • 5.7.24 • 5.7.23 • 5.7.22 • 5.7.21 • 5.7.19 • 5.7.17 • 5.7.16
MySQL 5.6	• 5.6.46 • 5.6.44 • 5.6.43 • 5.6.41 • 5.6.40 • 5.6.39 • 5.6.37 • 5.6.35 • 5.6.34
MySQL 5.5	• 5.5.61 • 5.5.59 • 5.5.57 • 5.5.54 • 5.5.53 • 5.5.46

You can specify any currently supported MySQL version when creating a new DB instance. You can specify the major version (such as MySQL 5.7), and any supported minor version for the specified major version. If no version is specified, Amazon RDS defaults to a supported version, typically the most recent version. If a major version is specified but a minor version is not, Amazon RDS defaults to a recent release of the major version you have specified. To see a list of supported versions, as well as defaults for newly created DB instances, use the `describe-db-engine-versions` AWS CLI command.

With Amazon RDS, you control when to upgrade your MySQL instance to a new version supported by Amazon RDS. You can maintain compatibility with specific MySQL versions, test new versions with your application before deploying in production, and perform version upgrades at times that best fit your schedule.

Unless you specify otherwise, your DB instance will automatically be upgraded to new MySQL minor versions as they are supported by Amazon RDS. This patching occurs during your scheduled maintenance window. You can modify a DB instance to turn off automatic minor version upgrades.

If you opt out of automatically scheduled upgrades, you can manually upgrade to a supported minor version release by following the same procedure as you would for a major version update. For information, see Upgrading a DB Instance Engine Version (p. 241).

Amazon RDS currently supports the major version upgrades from MySQL version 5.5 to version 5.6, from MySQL version 5.6 to version 5.7, and from MySQL version 5.7 to version 8.0. Because major version upgrades involve some compatibility risk, they do not occur automatically; you must make a request to modify the DB instance. You should thoroughly test any upgrade before upgrading your production instances. For information about upgrading a MySQL DB instance, see Upgrading the MySQL DB Engine (p. 733).

You can test a DB instance against a new version before upgrading by creating a DB snapshot of your existing DB instance, restoring from the DB snapshot to create a new DB instance, and then initiating a version upgrade for the new DB instance. You can then experiment safely on the upgraded clone of your DB instance before deciding whether or not to upgrade your original DB instance.

For information about the Amazon RDS deprecation policy for MySQL, see Amazon RDS FAQs.

MySQL Features Not Supported By Amazon RDS

Amazon RDS doesn't currently support the following MySQL features:

- Authentication Plugin
- Error Logging to the System Log
- Group Replication Plugin
- InnoDB Tablespace Encryption
- MariaDB Audit Plugin (not supported for Amazon RDS MySQL version 8.0 only)

  The MariaDB Audit Plugin is supported for Amazon RDS MySQL version 5.5, 5.6, and 5.7.
- Password Strength Plugin
- Persisted system variables
- Replication filters
- Semisynchronous replication
- Transportable tablespace
- X Plugin

Note
Global transaction IDs are supported for MySQL 5.7.23 and later MySQL 5.7 versions. Global transaction IDs are not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

IAM database authentication is supported for MySQL 5.6 and 5.7. IAM database authentication is not supported for MySQL 5.5 or 8.0.
Amazon RDS Performance Insights is supported for MySQL 5.6, 5.7, and 8.0. Amazon RDS Performance Insights is not supported for MySQL 5.5.

To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances. It also restricts access to certain system procedures and tables that require advanced privileges. Amazon RDS supports access to databases on a DB instance using any standard SQL client application. Amazon RDS doesn't allow direct host access to a DB instance by using Telnet, Secure Shell (SSH), or Windows Remote Desktop Connection. When you create a DB instance, you are assigned to the *db_owner* role for all databases on that instance, and you have all database-level permissions except for those used for backups. Amazon RDS manages backups for you.

Supported Storage Engines for MySQL on Amazon RDS

While MySQL supports multiple storage engines with varying capabilities, not all of them are optimized for recovery and data durability. Amazon RDS fully supports the InnoDB storage engine for MySQL DB instances. Amazon RDS features such as Point-In-Time restore and snapshot restore require a recoverable storage engine and are supported for the InnoDB storage engine only. You must be running an instance of MySQL 5.6 or later to use the InnoDB `memcached` interface. For more information, see MySQL memcached Support (p. 798).

The Federated Storage Engine is currently not supported by Amazon RDS for MySQL.

For user-created schemas, the MyISAM storage engine does not support reliable recovery and can result in lost or corrupt data when MySQL is restarted after a recovery, preventing Point-In-Time restore or snapshot restore from working as intended. However, if you still choose to use MyISAM with Amazon RDS, snapshots can be helpful under some conditions.

Note
System tables in the `mysql` schema can be in MyISAM storage.

If you want to convert existing MyISAM tables to InnoDB tables, you can use the `ALTER TABLE` command (for example, `alter table TABLE_NAME engine=innodb;`). Bear in mind that MyISAM and InnoDB have different strengths and weaknesses, so you should fully evaluate the impact of making this switch on your applications before doing so.

MySQL 5.1 is no longer supported in Amazon RDS. However, you can restore existing MySQL 5.1 snapshots. When you restore a MySQL 5.1 snapshot, the instance is automatically upgraded to MySQL 5.5.

MySQL Security on Amazon RDS

Security for Amazon RDS MySQL DB instances is managed at three levels:

- AWS Identity and Access Management controls who can perform Amazon RDS management actions on DB instances. When you connect to AWS using IAM credentials, your IAM account must have IAM policies that grant the permissions required to perform Amazon RDS management operations. For more information, see Identity and Access Management in Amazon RDS (p. 1371).
- When you create a DB instance, you use either a VPC security group or a DB security group to control which devices and Amazon EC2 instances can open connections to the endpoint and port of the DB instance. These connections can be made using Secure Sockets Layer (SSL). In addition, firewall rules at

your company can control whether devices running at your company can open connections to the DB instance.

- To authenticate login and permissions for a MySQL DB instance, you can take either of the following approaches, or a combination of them.

  You can take the same approach as with a stand-alone instance of MySQL. Commands such as `CREATE USER`, `RENAME USER`, `GRANT`, `REVOKE`, and `SET PASSWORD` work just as they do in on-premises databases, as does directly modifying database schema tables. For information, see Access Control and Account Management in the MySQL documentation.

  You can also use IAM database authentication. With IAM database authentication, you authenticate to your DB instance by using an IAM user or IAM role and an authentication token. An *authentication token* is a unique value that is generated using the Signature Version 4 signing process. By using IAM database authentication, you can use the same credentials to control access to your AWS resources and your databases. For more information, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).

When you create an Amazon RDS DB instance, the master user has the following default privileges:

- `alter`
- `alter routine`
- `create`
- `create routine`
- `create temporary tables`
- `create user`
- `create view`
- `delete`
- `drop`
- `event`
- `execute`
- `grant option`
- `index`
- `insert`
- `lock tables`
- `process`
- `references`
- `replication client`
- `replication slave (MySQL 5.6 and later)`
- `select`
- `show databases`
- `show view`
- `trigger`
- `update`

Note
Although it is possible to delete the master user on the DB instance, it is not recommended. To recreate the master user, use the ModifyDBInstance RDS API operation or the modify-db-instance AWS CLI command and specify a new master user password with the appropriate parameter. If the master user does not exist in the instance, the master user is created with the specified password.

To provide management services for each DB instance, the rdsadmin user is created when the DB instance is created. Attempting to drop, rename, change the password, or change privileges for the rdsadmin account will result in an error.

To allow management of the DB instance, the standard kill and kill_query commands have been restricted. The Amazon RDS commands rds_kill and rds_kill_query are provided to allow you to terminate user sessions or queries on DB instances.

Using the Password Validation Plugin

MySQL provides the validate_password plugin for improved security. The plugin enforces password policies using parameters in the DB parameter group for your MySQL DB instance. The plugin is supported for DB instances running MySQL version 5.6, 5.7, and 8.0. For more information about the validate_password plugin, see The Password Validation Plugin in the MySQL documentation.

To enable the validate_password plugin for a MySQL DB instance

1. Connect to your MySQL DB instance and run the following command.

```
INSTALL PLUGIN validate_password SONAME 'validate_password.so';
```

2. Configure the parameters for the plugin in the DB parameter group used by the DB instance.

   For more information about the parameters, see Password Validation Plugin Options and Variables in the MySQL documentation.

   For more information about modifying DB instance parameters, see Modifying Parameters in a DB Parameter Group (p. 204).

After installing and enabling the password_validate plugin, reset existing passwords to comply with your new validation policies.

Amazon RDS doesn't validate passwords. The MySQL DB instance performs password validation. If you set a user password with the AWS Management Console, the modify-db-instance AWS CLI command, or the ModifyDBInstance RDS API operation, the change can succeed even if the new password doesn't satisfy your password policies. However, a new password is set in the MySQL DB instance only if it satisfies the password policies. In this case, Amazon RDS records the following event.

```
"RDS-EVENT-0067" - An attempt to reset the master password for the DB instance has failed.
```

For more information about Amazon RDS events, see Using Amazon RDS Event Notification (p. 429).

Using SSL with a MySQL DB Instance

Amazon RDS supports Secure Sockets Layer (SSL) connections with DB instances running the MySQL database engine.

Amazon RDS creates an SSL certificate and installs the certificate on the DB instance when Amazon RDS provisions the instance. These certificates are signed by a certificate authority. The SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks.

An SSL certificate created by Amazon RDS is the trusted root entity and should work in most cases but might fail if your application does not accept certificate chains. If your application does not accept certificate chains, you might need to use an intermediate certificate to connect to your AWS Region. For example, you must use an intermediate certificate to connect to the AWS GovCloud (US-West) Region using SSL.

For information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For more information about using SSL with MySQL, see Updating Applications to Connect to MySQL DB Instances Using New SSL/TLS Certificates (p. 728).

MySQL uses yaSSL for secure connections in the following versions:

- MySQL version 5.7.19 and earlier 5.7 versions
- MySQL version 5.6.37 and earlier 5.6 versions
- MySQL version 5.5.57 and earlier 5.5 versions

MySQL uses OpenSSL for secure connections in the following versions:

- MySQL version 8.0
- MySQL version 5.7.21 and later 5.7 versions
- MySQL version 5.6.39 and later 5.6 versions
- MySQL version 5.5.59 and later 5.5 versions

Amazon RDS for MySQL supports Transport Layer Security (TLS) versions 1.0, 1.1, and 1.2. The following table shows the TLS support for MySQL versions.

MySQL Version	TLS 1.0	TLS 1.1	TLS 1.2
MySQL 8.0	Supported	Supported	Supported
MySQL 5.7	Supported	Supported	Supported for MySQL 5.7.21 and later
MySQL 5.6	Supported	Not supported	Not supported
MySQL 5.5	Supported	Not supported	Not supported

To encrypt connections using the default `mysql` client, launch the mysql client using the `--ssl-ca` parameter to reference the public key, as shown in the examples following.

The following example shows how to launch the client using the `--ssl-ca` parameter for MySQL 5.7 and later.

```
mysql -h myinstance.c9akciq32.rds-us-east-1.amazonaws.com
--ssl-ca=[full path]rds-combined-ca-bundle.pem --ssl-mode=VERIFY_IDENTITY
```

The following example shows how to launch the client using the `--ssl-ca` parameter for MySQL 5.6 and earlier.

```
mysql -h myinstance.c9akciq32.rds-us-east-1.amazonaws.com
--ssl-ca=[full path]rds-combined-ca-bundle.pem --ssl-verify-server-cert
```

You can require SSL connections for specific users accounts. For example, you can use one of the following statements, depending on your MySQL version, to require SSL connections on the user account `encrypted_user`.

For MySQL 5.7 and later, use the following statement.

```
ALTER USER 'encrypted_user'@'%' REQUIRE SSL;
```

For MySQL 5.6 and earlier, use the following statement.

```
GRANT USAGE ON *.* TO 'encrypted_user'@'%' REQUIRE SSL;
```

For more information on SSL connections with MySQL, see the Using Encrypted Connections in the MySQL documentation.

Using memcached and Other Options with MySQL

Most Amazon RDS DB engines support option groups that allow you to select additional features for your DB instance. DB instances on MySQL version 5.6 and later support the `memcached` option, a simple, key-based cache. For more information about `memcached` and other options, see Options for MySQL DB Instances (p. 794). For more information about working with option groups, see Working with Option Groups (p. 186).

InnoDB Cache Warming

InnoDB cache warming can provide performance gains for your MySQL DB instance by saving the current state of the buffer pool when the DB instance is shut down, and then reloading the buffer pool from the saved information when the DB instance starts up. This bypasses the need for the buffer pool to "warm up" from normal database use and instead preloads the buffer pool with the pages for known common queries. The file that stores the saved buffer pool information only stores metadata for the pages that are in the buffer pool, and not the pages themselves. As a result, the file does not require much storage space. The file size is about 0.2 percent of the cache size. For example, for a 64 GiB cache, the cache warming file size is 128 MiB. For more information on InnoDB cache warming, see Saving and Restoring the Buffer Pool State in the MySQL documentation.

MySQL on Amazon RDS supports InnoDB cache warming for MySQL version 5.6 and later. To enable InnoDB cache warming, set the `innodb_buffer_pool_dump_at_shutdown` and `innodb_buffer_pool_load_at_startup` parameters to 1 in the parameter group for your DB instance. Changing these parameter values in a parameter group will affect all MySQL DB instances that use that parameter group. To enable InnoDB cache warming for specific MySQL DB instances, you might need to create a new parameter group for those instances. For information on parameter groups, see Working with DB Parameter Groups (p. 202).

InnoDB cache warming primarily provides a performance benefit for DB instances that use standard storage. If you use PIOPS storage, you do not commonly see a significant performance benefit.

Important
If your MySQL DB instance does not shut down normally, such as during a failover, then the buffer pool state will not be saved to disk. In this case, MySQL loads whatever buffer pool file is available when the DB instance is restarted. No harm is done, but the restored buffer pool might not reflect the most recent state of the buffer pool prior to the restart. To ensure that you have

a recent state of the buffer pool available to warm the InnoDB cache on startup, we recommend that you periodically dump the buffer pool "on demand." You can dump or load the buffer pool on demand if your DB instance is running MySQL version 5.6.19 or later.
You can create an event to dump the buffer pool automatically and on a regular interval. For example, the following statement creates an event named `periodic_buffer_pool_dump` that dumps the buffer pool every hour.

```
CREATE EVENT periodic_buffer_pool_dump
ON SCHEDULE EVERY 1 HOUR
DO CALL mysql.rds_innodb_buffer_pool_dump_now();
```

For more information on MySQL events, see Event Syntax in the MySQL documentation.

Dumping and Loading the Buffer Pool on Demand

For MySQL version 5.6.19 and later, you can save and load the InnoDB cache "on demand."

- To dump the current state of the buffer pool to disk, call the mysql.rds_innodb_buffer_pool_dump_now (p. 838) stored procedure.
- To load the saved state of the buffer pool from disk, call the mysql.rds_innodb_buffer_pool_load_now (p. 838) stored procedure.
- To cancel a load operation in progress, call the mysql.rds_innodb_buffer_pool_load_abort (p. 838) stored procedure.

Local Time Zone for MySQL DB Instances

By default, the time zone for an RDS MySQL DB instance is Universal Time Coordinated (UTC). You can set the time zone for your DB instance to the local time zone for your application instead.

To set the local time zone for a DB instance, set the `time_zone` parameter in the parameter group for your DB instance to one of the supported values listed later in this section. When you set the `time_zone` parameter for a parameter group, all DB instances and read replicas that are using that parameter group change to use the new local time zone. For information on setting parameters in a parameter group, see Working with DB Parameter Groups (p. 202).

After you set the local time zone, all new connections to the database reflect the change. If you have any open connections to your database when you change the local time zone, you won't see the local time zone update until after you close the connection and open a new connection.

You can set a different local time zone for a DB instance and one or more of its read replicas. To do this, use a different parameter group for the DB instance and the replica or replicas and set the `time_zone` parameter in each parameter group to a different local time zone.

If you are replicating across AWS Regions, then the replication master DB instance and the read replica use different parameter groups (parameter groups are unique to an AWS Region). To use the same local time zone for each instance, you must set the `time_zone` parameter in the instance's and read replica's parameter groups.

When you restore a DB instance from a DB snapshot, the local time zone is set to UTC. You can update the time zone to your local time zone after the restore is complete. If you restore a DB instance to a point in time, then the local time zone for the restored DB instance is the time zone setting from the parameter group of the restored DB instance.

You can set your local time zone to one of the following values.

Africa/Cairo	Asia/Bangkok	Australia/Darwin

Africa/Casablanca	Asia/Beirut	Australia/Hobart
Africa/Harare	Asia/Calcutta	Australia/Perth
Africa/Monrovia	Asia/Damascus	Australia/Sydney
Africa/Nairobi	Asia/Dhaka	Brazil/East
Africa/Tripoli	Asia/Irkutsk	Canada/Newfoundland
Africa/Windhoek	Asia/Jerusalem	Canada/Saskatchewan
America/Araguaina	Asia/Kabul	Europe/Amsterdam
America/Asuncion	Asia/Karachi	Europe/Athens
America/Bogota	Asia/Kathmandu	Europe/Dublin
America/Caracas	Asia/Krasnoyarsk	Europe/Helsinki
America/Chihuahua	Asia/Magadan	Europe/Istanbul
America/Cuiaba	Asia/Muscat	Europe/Kaliningrad
America/Denver	Asia/Novosibirsk	Europe/Moscow
America/Fortaleza	Asia/Riyadh	Europe/Paris
America/Guatemala	Asia/Seoul	Europe/Prague
America/Halifax	Asia/Shanghai	Europe/Sarajevo
America/Manaus	Asia/Singapore	Pacific/Auckland
America/Matamoros	Asia/Taipei	Pacific/Fiji
America/Monterrey	Asia/Tehran	Pacific/Guam
America/Montevideo	Asia/Tokyo	Pacific/Honolulu
America/Phoenix	Asia/Ulaanbaatar	Pacific/Samoa
America/Santiago	Asia/Vladivostok	US/Alaska
America/Tijuana	Asia/Yakutsk	US/Central
Asia/Amman	Asia/Yerevan	US/Eastern
Asia/Ashgabat	Atlantic/Azores	US/East-Indiana
Asia/Baghdad	Australia/Adelaide	US/Pacific
Asia/Baku	Australia/Brisbane	UTC

Known Issues and Limitations for MySQL on Amazon RDS

There are some known issues and limitations for working with MySQL on Amazon RDS. For more information, see Known Issues and Limitations for MySQL on Amazon RDS (p. 816).

Connecting to a DB Instance Running the MySQL Database Engine

Before you can connect to a DB instance running the MySQL database engine, you must create a DB instance. For information, see Creating an Amazon RDS DB Instance (p. 136). After Amazon RDS provisions your DB instance, you can use any standard MySQL client application or utility to connect to the instance. In the connection string, you specify the DNS address from the DB instance endpoint as the host parameter, and specify the port number from the DB instance endpoint as the port parameter.

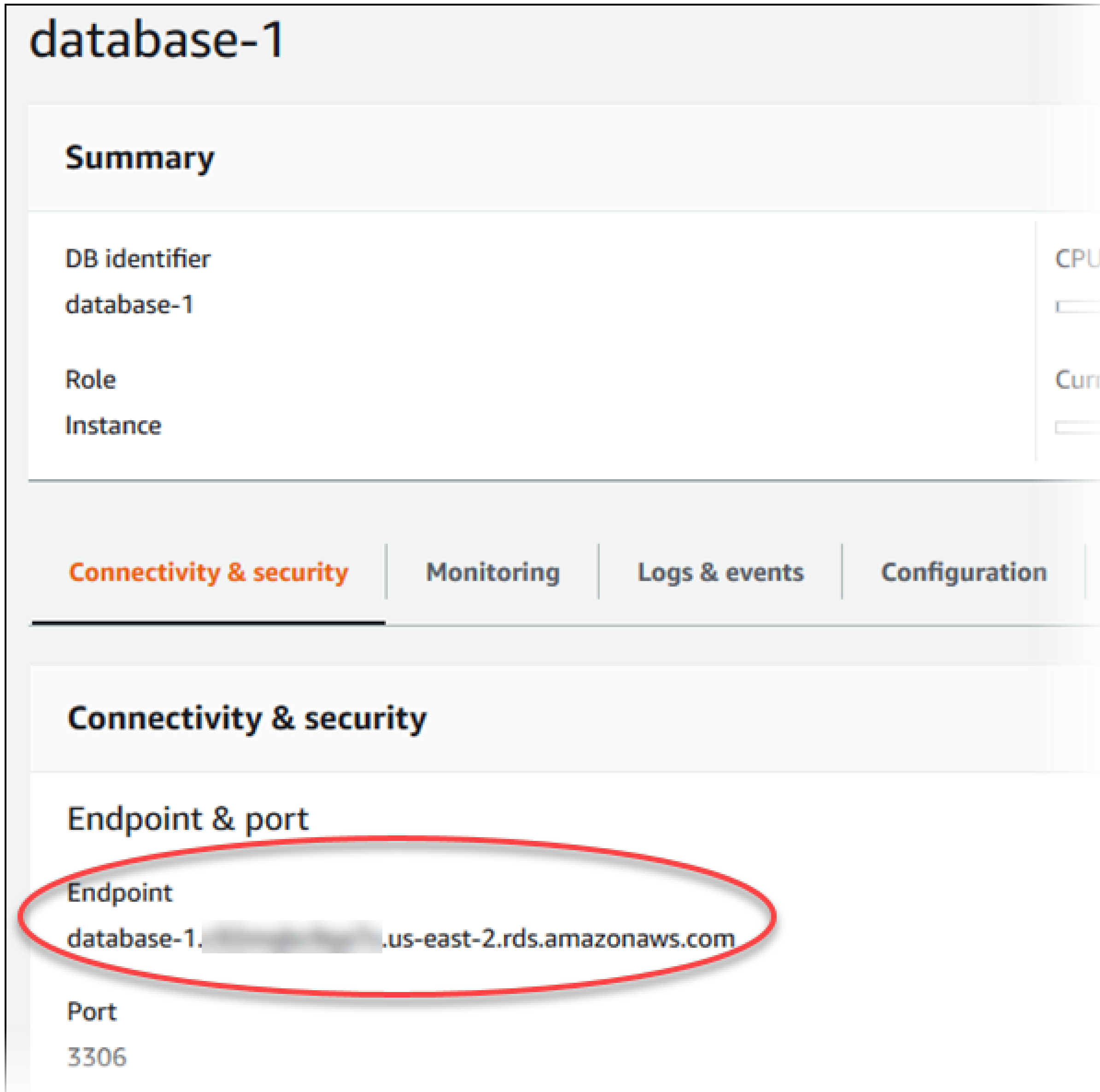
To authenticate to your RDS DB instance, you can use one of the authentication methods for MySQL and IAM database authentication.

- To learn how to authenticate to MySQL using one of the authentication methods for MySQL, see Authentication Method in the MySQL documentation.
- To learn how to authenticate to MySQL using IAM database authentication, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).

You can use the AWS Management Console, the AWS CLI describe-db-instances command, or the Amazon RDS API DescribeDBInstances operation to list the details of an Amazon RDS DB instance, including its endpoint.

To find the endpoint for a MySQL DB instance in the AWS Management Console:

1. Open the RDS console and then choose **Databases** to display a list of your DB instances.
2. Choose the MySQL DB instance name to display its details.
3. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



If an endpoint value is `mysql-instance1.123456789012.us-east-1.rds.amazonaws.com` and the port value is `3306`, then you would specify the following values in a MySQL connection string:

- For host or host name, specify `mysql-instance1.123456789012.us-east-1.rds.amazonaws.com`
- For port, specify `3306`

You can connect to an Amazon RDS MySQL DB instance by using tools like the MySQL command line utility. For more information on using the MySQL client, go to mysql - The MySQL Command Line Tool in the MySQL documentation. One GUI-based application you can use to connect is MySQL Workbench. For more information, go to the Download MySQL Workbench page. For information about installing MySQL (including the MySQL client), see Installing and Upgrading MySQL.

You can use SSL encryption on connections to an Amazon RDS MySQL DB instance. For information, see Using SSL with a MySQL DB Instance (p. 717). If you are using IAM database authentication, you must use an SSL connection. For information, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).

You can also connect to a DB instance from a web server. For more information, see Tutorial: Create a Web Server and an Amazon RDS Database (p. 100).

> **Note**
> For information on connecting to a MariaDB DB instance, see Connecting to a DB Instance Running the MariaDB Database Engine (p. 509).

Connecting from the MySQL Client

To connect to a DB instance using the MySQL client, type the following command at a command prompt to connect to a DB instance using the MySQL client. For the -h parameter, substitute the DNS name (endpoint) for your DB instance. For the -P parameter, substitute the port for your DB instance. Enter the master user password when prompted.

```
mysql -h mysql-instance1.123456789012.us-east-1.rds.amazonaws.com -P 3306 -u mymasteruser -
p
```

After you enter the password for the user, you will see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 350
Server version: 5.6.40-log MySQL Community Server (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

Connecting with SSL

Amazon RDS creates an SSL certificate for your DB instance when the instance is created. If you enable SSL certificate verification, then the SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks. To connect to your DB instance using SSL, you can use native password authentication or IAM database authentication. To connect to your DB instance using IAM database authentication, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387). To connect to your DB instance using native password authentication, you can follow these steps:

To connect to a DB instance with SSL using the MySQL client

1. Download a root certificate that works for all AWS Regions.

   For information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Enter the following command at a command prompt to connect to a DB instance with SSL using the MySQL client. For the -h parameter, substitute the DNS name for your DB instance. For the --ssl-ca parameter, substitute the SSL certificate file name as appropriate.

   ```
   mysql -h mysql-instance1.123456789012.us-east-1.rds.amazonaws.com --ssl-ca=rds-ca-2015-
   root.pem -p
   ```
3. You can require that the SSL connection verifies the DB instance endpoint against the endpoint in the SSL certificate.

For MySQL 5.7 and later:

```
mysql -h mysql-instance1.123456789012.us-east-1.rds.amazonaws.com --ssl-ca=rds-ca-2015-root.pem --ssl-mode=VERIFY_IDENTITY -p
```

For MySQL 5.6 and earlier:

```
mysql -h mysql-instance1.123456789012.us-east-1.rds.amazonaws.com --ssl-ca=rds-ca-2015-root.pem --ssl-verify-server-cert -p
```

4. Enter the master user password when prompted.

You will see output similar to the following.

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 350
Server version: 5.6.40-log MySQL Community Server (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql>
```

Connecting from MySQL Workbench

To connect from MySQL Workbench

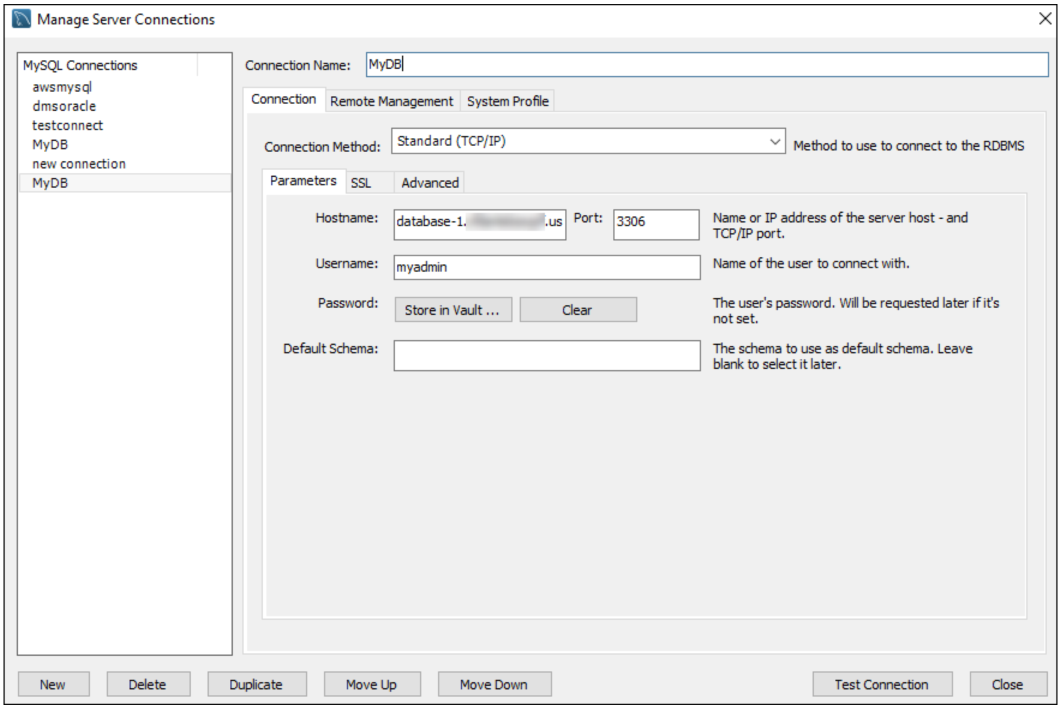
1. Download and install MySQL Workbench at Download MySQL Workbench.
2. Open MySQL Workbench.

3. From **Database**, choose **Manage Connections**.
4. In the **Manage Server Connections** window, choose **New**.
5. In the **Connect to Database** window, enter the following information:

   - **Stored Connection** – Enter a name for the connection, such as **`MyDB`**.

- **Hostname** – Enter the DB instance endpoint.
- **Port** – Enter the port used by the DB instance.
- **Username** – Enter the username of a valid database user, such as the master user.
- **Password** – Optionally, choose **Store in Vault** and then enter and save the password for the user.

The window looks similar to the following:



You can use the features of MySQL Workbench to customize connections. For example, you can use the **SSL** tab to configure SSL connections. For information about using MySQL Workbench, see the MySQL Workbench documentation.

6. Optionally, choose **Test Connection** to confirm that the connection to the DB instance is successful.
7. Choose **Close**.
8. From **Database**, choose **Connect to Database**.
9. From **Stored Connection**, choose your connection.
10. Choose **OK**.

Troubleshooting Connections to Your MySQL DB Instance

Two common causes of connection failures to a new DB instance are:

- The DB instance was created using a security group that doesn't authorize connections from the device or Amazon EC2 instance where the MySQL application or utility is running. If the DB instance was created in a VPC, it must have a VPC security group that authorizes the connections. For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

  You can add or edit an inbound rule in the security group. For **Source**, choose **My IP**. This allows access to the DB instance from the IP address detected in your browser.

If the DB instance was created outside of a VPC, it must have a DB security group that authorizes the connections.

- The DB instance was created using the default port of 3306, and your company has firewall rules blocking connections to that port from devices in your company network. To fix this failure, recreate the instance with a different port.

For more information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Updating Applications to Connect to MySQL DB Instances Using New SSL/TLS Certificates

As of September 19, 2019, Amazon RDS has published new Certificate Authority (CA) certificates for connecting to your RDS DB instances using Secure Socket Layer or Transport Layer Security (SSL/TLS). Following, you can find information about updating your applications to use the new certificates.

This topic can help you to determine whether any client applications use SSL/TLS to connect to your DB instances. If they do, you can further check whether those applications require certificate verification to connect.

Note

Some applications are configured to connect to MySQL DB instances only if they can successfully verify the certificate on the server. For such applications, you must update your client application trust stores to include the new CA certificates.

You can specify the following SSL modes: `disabled`, `preferred`, and `required`. When you use the `preferred` SSL mode and the CA certificate doesn't exist or isn't up to date, the following behavior applies:

- For newer MySQL minor versions, the connection falls back to not using SSL and still connects successfully.

  Because these later versions use the OpenSSL protocol, an expired server certificate doesn't prevent successful connections unless the `required` SSL mode is specified.

  The following MySQL minor versions use the OpenSSL protocol:
  - All MySQL 8.0 versions
  - MySQL 5.7.21 and later MySQL 5.7 versions
  - MySQL 5.6.39 and later MySQL 5.6 versions
  - MySQL 5.5.59 and later MySQL 5.5 versions
- For older MySQL minor versions, an error is returned.

  Because these older versions use the yaSSL protocol, certificate verification is strictly enforced and the connection is unsuccessful.

  The following MySQL minor versions use the yaSSL protocol:
  - MySQL 5.7.19 and earlier MySQL 5.7 versions
  - MySQL 5.6.37 and earlier MySQL 5.6 versions
  - MySQL 5.5.57 and earlier MySQL 5.5 versions

After you update your CA certificates in the client application trust stores, you can rotate the certificates on your DB instances. We strongly recommend testing these procedures in a development or staging environment before implementing them in your production environments.

For more information about certificate rotation, see Rotating Your SSL/TLS Certificate (p. 1363). For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For information about using SSL/TLS with MySQL DB instances, see Using SSL with a MySQL DB Instance (p. 717).

Topics

Determining Whether any Applications are Connecting to Your MySQL DB Instance Using SSL

If you are using Amazon RDS for MySQL version 5.7 or 8.0 and the Performance Schema is enabled, run the following query to check if connections are using SSL/TLS. For information about enabling the Performance Schema, see Performance Schema Quick Start in the MySQL documentation.

```
mysql> SELECT id, user, host, connection_type
       FROM performance_schema.threads pst
       INNER JOIN information_schema.processlist isp
       ON pst.processlist_id = isp.id;
```

In this sample output, you can see both your own session (`admin`) and an application logged in as `webapp1` are using SSL.

```
+----+-----------------+------------------+-----------------+
| id | user            | host             | connection_type |
+----+-----------------+------------------+-----------------+
|  8 | admin           | 10.0.4.249:42590 | SSL/TLS         |
|  4 | event_scheduler | localhost        | NULL            |
| 10 | webapp1         | 159.28.1.1:42189 | SSL/TLS         |
+----+-----------------+------------------+-----------------+
3 rows in set (0.00 sec)
```

If you are using Amazon RDS for MySQL versions 5.5 or 5.6, then you can't determine from the server side whether applications are connecting with or without SSL. For those versions, you can determine whether SSL is used by examining the application's connection method. In the following section, you can find more information on examining the client connection configuration.

Determining Whether a Client Requires Certificate Verification to Connect

You can check whether JDBC clients and MySQL clients require certificate verification to connect.

JDBC

The following example with MySQL Connector/J 8.0 shows one way to check an application's JDBC connection properties to determine whether successful connections require a valid certificate. For more information on all of the JDBC connection options for MySQL, see Configuration Properties in the MySQL documentation.

When using the MySQL Connector/J 8.0, an SSL connection requires verification against the server CA certificate if your connection properties have `sslMode` set to `VERIFY_CA` or `VERIFY_IDENTITY`, as in the following example.

```
Properties properties = new Properties();
properties.setProperty("sslMode", "VERIFY_IDENTITY");
properties.put("user", DB_USER);
properties.put("password", DB_PASSWORD);
```

Note

If you use either the MySQL Java Connector v5.1.38 or later, or the MySQL Java Connector v8.0.9 or later to connect to your databases, even if you haven't explicitly configured your applications to use SSL/TLS when connecting to your databases, these client drivers default to using SSL/TLS. In addition, when using SSL/TLS, they perform partial certificate verification and fail to connect if the database server certificate is expired.

MySQL

The following examples with the MySQL Client show two ways to check a script's MySQL connection to determine whether successful connections require a valid certificate. For more information on all of the connection options with the MySQL Client, see Client-Side Configuration for Encrypted Connections in the MySQL documentation.

When using the MySQL 5.7 or MySQL 8.0 Client, an SSL connection requires verification against the server CA certificate if for the `--ssl-mode` option you specify `VERIFY_CA` or `VERIFY_IDENTITY`, as in the following example.

```
mysql -h mysql-database.rds.amazonaws.com -uadmin -ppassword --ssl-ca=/tmp/ssl-cert.pem --
ssl-mode=VERIFY_CA
```

When using the MySQL 5.6 Client, an SSL connection requires verification against the server CA certificate if you specify the `--ssl-verify-server-cert` option, as in the following example.

```
mysql -h mysql-database.rds.amazonaws.com -uadmin -ppassword --ssl-ca=/tmp/ssl-cert.pem --
ssl-verify-server-cert
```

Updating Your Application Trust Store

For information about updating the trust store for MySQL applications, see Installing SSL Certificates in the MySQL documentation.

Note

When you update the trust store, you can retain older certificates in addition to adding the new certificates.

Updating Your Application Trust Store for JDBC

You can update the trust store for applications that use JDBC for SSL/TLS connections.

To update the trust store for JDBC applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in the trust store directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

2. Convert the certificate to .der format using the following command.

```
openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
```

   Replace the file name with the one that you downloaded.
3. Import the certificate into the key store using the following command.

```
keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
```

4. Confirm that the key store was updated successfully.

```
keytool -list -v -keystore clientkeystore.jks
```

   Enter the key store password when you are prompted for it.

   Your output should contain the following.

```
rds-root,date, trustedCertEntry,
Certificate fingerprint (SHA1):
 D4:0D:DB:29:E3:75:0D:FF:A6:71:C3:14:0B:BF:5F:47:8D:1C:80:96
# This fingerprint should match the output from the below command
openssl x509 -fingerprint -in rds-ca-2019-root.pem -noout
```

If you are using the mysql JDBC driver in an application, set the following properties in the application.

```
System.setProperty("javax.net.ssl.trustStore", certs);
System.setProperty("javax.net.ssl.trustStorePassword", "password");
```

When you start the application, set the following properties.

```
java -Djavax.net.ssl.trustStore=/path_to_truststore/MyTruststore.jks -
Djavax.net.ssl.trustStorePassword=my_truststore_password com.companyName.MyApplication
```

Example Java Code for Establishing SSL Connections

The following code example shows how to set up the SSL connection that validates the server certificate using JDBC.

```
public class MySQLSSLTest {
```

```
        private static final String DB_USER = "username";
        private static final String DB_PASSWORD = "password";
        // This key store has only the prod root ca.
        private static final String KEY_STORE_FILE_PATH = "file-path-to-keystore";
        private static final String KEY_STORE_PASS = "keystore-password";

        public static void test(String[] args) throws Exception {
            Class.forName("com.mysql.jdbc.Driver");

            System.setProperty("javax.net.ssl.trustStore", KEY_STORE_FILE_PATH);
            System.setProperty("javax.net.ssl.trustStorePassword", KEY_STORE_PASS);

            Properties properties = new Properties();
            properties.setProperty("sslMode", "VERIFY_IDENTITY");
            properties.put("user", DB_USER);
            properties.put("password", DB_PASSWORD);


            Connection connection = null;
            Statement stmt = null;
            ResultSet rs = null;
            try {
                connection =
 DriverManager.getConnection("jdbc:mysql://mydatabase.123456789012.us-
east-1.rds.amazonaws.com:3306",properties);
                stmt = connection.createStatement();
                rs=stmt.executeQuery("SELECT 1 from dual");
            } finally {
                if (rs != null) {
                    try {
                        rs.close();
                    } catch (SQLException e) {
                    }
                }
                if (stmt != null) {
                   try {
                        stmt.close();
                    } catch (SQLException e) {
                   }
                }
                if (connection != null) {
                    try {
                        connection.close();
                    } catch (SQLException e) {
                        e.printStackTrace();
                    }
                }
            }
            return;
        }
    }
```

Important

After you have determined that your database connections use SSL/TLS and have updated your application trust store, you can update your database to use the rds-ca-2019 certificates. For instructions, see step 3 in Updating Your CA Certificate by Modifying Your DB Instance (p. 1363).

Upgrading the MySQL DB Engine

When Amazon RDS supports a new version of a database engine, you can upgrade your DB instances to the new version. There are two kinds of upgrades: major version upgrades and minor version upgrades. In general, a major engine version upgrade can introduce changes that are not compatible with existing applications. In contrast, a minor version upgrade includes only changes that are backward-compatible with existing applications.

To perform a major version upgrade, modify the DB instance manually. Minor version upgrades occur automatically if you enable auto minor version upgrades on your DB instance. In all other cases, modify the DB instance manually to perform a minor version upgrade.

Topics

Overview of Upgrading

Amazon RDS takes two DB snapshots during the upgrade process. The first DB snapshot is of the DB instance before any upgrade changes have been made. If the upgrade doesn't work for your databases, you can restore this snapshot to create a DB instance running the old version. The second DB snapshot is taken when the upgrade completes.

> **Note**
> Amazon RDS only takes DB snapshots if you have set the backup retention period for your DB instance to a number greater than 0. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220).

After the upgrade is complete, you can't revert to the previous version of the database engine. If you want to return to the previous version, restore the first DB snapshot taken to create a new DB instance.

You control when to upgrade your DB instance to a new version supported by Amazon RDS. This level of control helps you maintain compatibility with specific database versions and test new versions with your application before deploying in production. When you are ready, you can perform version upgrades at the times that best fit your schedule.

If your DB instance is using read replication, upgrade all of the read replicas before upgrading the source instance.

If your DB instance is in a Multi-AZ deployment, both the primary and standby DB instances are upgraded. The primary and standby DB instances are upgraded at the same time and you experience an outage until the upgrade is complete. The time for the outage varies based on the size of your DB instance.

Major Version Upgrades for MySQL

Amazon RDS supports the following in-place upgrades for major versions of the MySQL database engine:

- MySQL 5.5 to MySQL 5.6
- MySQL 5.6 to MySQL 5.7
- MySQL 5.7 to MySQL 8.0

Note
You can only create MySQL version 5.7 and 8.0 DB instances with latest-generation and current-generation DB instance classes, in addition to the db.m3 previous-generation DB instance class. In some cases, you want to upgrade a MySQL version 5.6 DB instance running on a previous-generation DB instance class (other than db.m3) to a MySQL version 5.7 DB instance. In these cases, first modify the DB instance to use a latest-generation or current-generation DB instance class. After you do this, you can then modify the DB instance to use the MySQL version 5.7 database engine. For information on Amazon RDS DB instance classes, see DB Instance Classes (p. 7).

Topics

Overview of MySQL Major Version Upgrades

Major version upgrades can contain database changes that are not backward-compatible with existing applications. As a result, Amazon RDS doesn't apply major version upgrades automatically; you must manually modify your DB instance. We recommend that you thoroughly test any upgrade before applying it to your production instances.

To perform a major version upgrade for a MySQL version 5.5 DB instance on Amazon RDS to MySQL version 5.6 or later, first perform any available OS updates. After OS updates are complete, upgrade to each major version: 5.5 to 5.6, then 5.6 to 5.7, and then 5.7 to 8.0. MySQL DB instances created before April 24, 2014, show an available OS update until the update has been applied. For more information on OS updates, see Applying Updates for a DB Instance (p. 236).

During a major version upgrade of MySQL, Amazon RDS runs the MySQL binary `mysql_upgrade` to upgrade tables, if necessary. Also, Amazon RDS empties the `slow_log` and `general_log` tables during a major version upgrade. To preserve log information, save the log contents before the major version upgrade.

MySQL major version upgrades typically complete in about 10 minutes. Some upgrades might take longer because of the DB instance class size or because the instance doesn't follow certain operational guidelines in Best Practices for Amazon RDS (p. 125). If you upgrade a DB instance from the Amazon RDS console, the status of the DB instance indicates when the upgrade is complete. If you upgrade using the AWS Command Line Interface (AWS CLI), use the describe-db-instances command and check the `Status` value.

If you use a custom parameter group, for the new DB engine version you either specify a default parameter group or create your own custom parameter group. Associating the new parameter group with the DB instance requires a customer-initiated database reboot after the upgrade completes. The DB instance's parameter group status shows `pending-reboot` if the DB instance needs to be rebooted to apply the parameter group changes. You can view a DB instance's parameter group status in the console or by using a call such as `describe-db-instances`.

Upgrades to MySQL Version 5.7 Might Be Slow

MySQL version 5.6.4 introduced a new date and time format for the `datetime`, `time`, and `timestamp` columns that allows fractional components in date and time values. When upgrading a DB instance to MySQL version 5.7, MySQL forces the conversion of all date and time column types to the new format.

Because this conversion rebuilds your tables, it might take a considerable amount of time to complete the DB instance upgrade. The forced conversion occurs for any DB instances that are running a version before MySQL version 5.6.4. It also occurs for any DB instances that were upgraded from a version before MySQL version 5.6.4 to a version other than 5.7.

If your DB instance runs a version before MySQL version 5.6.4, or was upgraded from a version before 5.6.4, we recommend an extra step. In these cases, we recommend that you convert the `datetime`, `time`, and `timestamp` columns in your database before upgrading your DB instance to MySQL version 5.7. This conversion can significantly reduce the amount of time required to upgrade the DB instance to MySQL version 5.7. To upgrade your date and time columns to the new format, issue the `ALTER TABLE` *<table_name>* `FORCE;` command for each table that contains date or time columns. Because altering a table locks the table as read-only, we recommend that you perform this update during a maintenance window.

To find all tables in your database that have `datetime`, `time`, or `timestamp` columns and create an `ALTER TABLE` *<table_name>* `FORCE;` command for each table, use the following query.

```
SELECT DISTINCT CONCAT('ALTER TABLE `',
      REPLACE(is_tables.TABLE_SCHEMA, '`', '``'), '`.`',
      REPLACE(is_tables.TABLE_NAME, '`', '``'), '` FORCE;')
    FROM information_schema.TABLES is_tables
      INNER JOIN information_schema.COLUMNS col ON col.TABLE_SCHEMA =
 is_tables.TABLE_SCHEMA
        AND col.TABLE_NAME = is_tables.TABLE_NAME
      LEFT OUTER JOIN information_schema.INNODB_SYS_TABLES systables ON
        SUBSTRING_INDEX(systables.NAME, '#', 1) =
 CONCAT(is_tables.TABLE_SCHEMA,'/',is_tables.TABLE_NAME)
      LEFT OUTER JOIN information_schema.INNODB_SYS_COLUMNS syscolumns ON
        syscolumns.TABLE_ID = systables.TABLE_ID AND syscolumns.NAME = col.COLUMN_NAME
    WHERE col.COLUMN_TYPE IN ('time','timestamp','datetime')
      AND is_tables.TABLE_TYPE = 'BASE TABLE'
      AND is_tables.TABLE_SCHEMA NOT IN ('mysql','information_schema','performance_schema')
      AND (is_tables.ENGINE = 'InnoDB' AND syscolumns.MTYPE = 6);
```

Prechecks for Upgrades from MySQL 5.7 to 8.0

MySQL 8.0 includes a number of incompatibilities with MySQL 5.7. These incompatibilities can cause problems during an upgrade from MySQL 5.7 to MySQL 8.0. So, some preparation might be required on your database for the upgrade to be successful. The following is a general list of these incompatibilities:

- There must be no tables that use obsolete data types or functions.
- There must be no orphan *.frm files.
- Triggers must not have a missing or empty definer or an invalid creation context.
- There must be no partitioned table that uses a storage engine that does not have native partitioning support.
- There must be no keyword or reserved word violations. Some keywords might be reserved in MySQL 8.0 that were not reserved previously.

  For more information, see Keywords and Reserved Words in the MySQL documentation.
- There must be no tables in the MySQL 5.7 `mysql` system database that have the same name as a table used by the MySQL 8.0 data dictionary.
- There must be no obsolete SQL modes defined in your `sql_mode` system variable setting.
- There must be no tables or stored procedures with individual `ENUM` or `SET` column elements that exceed 255 characters or 1020 bytes in length.
- Before upgrading to MySQL 8.0.13 or higher, there must be no table partitions that reside in shared InnoDB tablespaces.
- There must be no queries and stored program definitions from MySQL 8.0.12 or lower that use `ASC` or `DESC` qualifiers for `GROUP BY` clauses.

- Your MySQL 5.7 installation must not use features that are not supported in MySQL 8.0.

  For more information, see Features Removed in MySQL 8.0 in the MySQL documentation.
- There must be no foreign key constraint names longer than 64 characters.
- For improved Unicode support, consider converting objects that use the `utf8mb3` charset to use the `utf8mb4` charset. The `utf8mb3` character set is deprecated. Also, consider using `utf8mb4` for character set references instead of `utf8`, because currently `utf8` is an alias for the `utf8mb3` charset.

  For more information, see The utf8mb3 Character Set (3-Byte UTF-8 Unicode Encoding) in the MySQL documentation.

When you start an upgrade from MySQL 5.7 to 8.0, Amazon RDS runs prechecks automatically to detect these incompatibilities. For information about upgrading to MySQL 8.0, see Upgrading MySQL in the MySQL documentation.

These prechecks are mandatory. You can't choose to skip them. The prechecks provide the following benefits:

- They enable you to avoid unplanned downtime during the upgrade.
- If there are incompatibilities, Amazon RDS prevents the upgrade and provides a log for you to learn about them. You can then use the log to prepare your database for the upgrade to MySQL 8.0 by eliminating the incompatibilities. For detailed information about removing incompatibilities, see Preparing Your Installation for Upgrade in the MySQL documentation and Upgrading to MySQL 8.0? Here is what you need to know… on the MySQL Server Blog.

The prechecks include some that are included with MySQL and some that were created specifically by the Amazon RDS team. For information about the prechecks provided by MySQL, see Upgrade Checker Utility.

The prechecks run before the DB instance is stopped for the upgrade, meaning that they don't cause any downtime when they run. If the prechecks find an incompatibility, Amazon RDS automatically cancels the upgrade before the DB instance is stopped. Amazon RDS also generates an event for the incompatibility. For more information about Amazon RDS events, see Using Amazon RDS Event Notification (p. 429).

Amazon RDS records detailed information about each incompatibility in the log file `PrePatchCompatibility.log`. In most cases, the log entry includes a link to the MySQL documentation for correcting the incompatibility. For more information about viewing log files, see Viewing and Listing Database Log Files (p. 453).

Due to the nature of the prechecks, they analyze the objects in your database. This analysis results in resource consumption and increases the time for the upgrade to complete.

> **Note**
> Amazon RDS runs prechecks only for an upgrade from MySQL 5.7 to MySQL 8.0. They aren't run for upgrades to releases lower than MySQL 8.0. For example, prechecks aren't run for an upgrade from MySQL 5.6 to MySQL 5.7.

Testing an Upgrade

Before you perform a major version upgrade on your DB instance, thoroughly test your database for compatibility with the new version. In addition, thoroughly test all applications that access the database for compatibility with the new version. We recommend that you use the following procedure.

To test a major version upgrade

1. Review the upgrade documentation for the new version of the database engine to see if there are compatibility issues that might affect your database or applications:

- Changes in MySQL 5.6
- Changes in MySQL 5.7
- Changes in MySQL 8.0

2. If your DB instance is a member of a custom DB parameter group, create a new DB parameter group with your existing settings that is compatible with the new major version. Specify the new DB parameter group when you upgrade your test instance, so your upgrade testing ensures that it works correctly. For more information about creating a DB parameter group, see Working with DB Parameter Groups (p. 202).
3. Create a DB snapshot of the DB instance to be upgraded. For more information, see Creating a DB Snapshot (p. 301).
4. Restore the DB snapshot to create a new test DB instance. For more information, see Restoring from a DB Snapshot (p. 303).
5. Modify this new test DB instance to upgrade it to the new version, using one of the methods detailed following. If you created a new parameter group in step 2, specify that parameter group.
6. Evaluate the storage used by the upgraded instance to determine if the upgrade requires additional storage.
7. Run as many of your quality assurance tests against the upgraded DB instance as needed to ensure that your database and application work correctly with the new version. Implement any new tests needed to evaluate the impact of any compatibility issues that you identified in step 1. Test all stored procedures and functions. Direct test versions of your applications to the upgraded DB instance.
8. If all tests pass, then perform the upgrade on your production DB instance. We recommend that you don't allow write operations to the DB instance until you confirm that everything is working correctly.

Upgrading a MySQL DB Instance

For information about manually or automatically upgrading a MySQL DB instance, see Upgrading a DB Instance Engine Version (p. 241).

Upgrading a MySQL Database with Reduced Downtime

If your MySQL DB instance is currently in use with a production application, you can use the following procedure to upgrade the database version for your DB instance. This procedure can reduce the amount of downtime for your application.

The following procedure shows an example of upgrading from MySQL version 5.5 to MySQL version 5.6. You can use the same general steps for upgrades to other major versions.

To upgrade an MySQL database while a DB instance is in use

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Create a read replica of your MySQL 5.5 DB instance. This process creates an upgradable copy of your database.

   a. On the console, choose **Databases**, and then choose the DB instance that you want to upgrade.
   b. For **Actions**, choose **Create read replica**.
   c. Provide a value for **DB instance identifier** for your read replica and ensure that the **DB instance class** and other settings match your MySQL 5.5 DB instance.

   d. Choose **Create read replica**.

3. When the read replica has been created and **Status** shows **Available**, upgrade the read replica to MySQL 5.6:

   a. On the console, choose **Databases**, and then choose the read replica that you just created.
   b. Choose **Modify**.
   c. For **DB engine version**, choose the MySQL 5.6 version to upgrade to, and then choose **Continue**.
   d. For **Scheduling of Modifications**, choose **Apply immediately**.
   e. Choose **Modify DB instance** to start the upgrade.

4. When the upgrade is complete and **Status** shows **Available**, verify that the upgraded read replica is up-to-date with the master MySQL 5.5 DB instance. You can do this by connecting to the read replica and issuing the `SHOW SLAVE STATUS` command. If the `Seconds_Behind_Master` field is `0`, then replication is up-to-date.
5. Make your MySQL 5.6 read replica a master DB instance.

   Important

   When you promote your MySQL 5.6 read replica to a standalone, single-AZ DB instance, it no longer is a replication replica to your MySQL 5.5 DB instance. We recommend that you promote your MySQL 5.6 read replica during a maintenance window when your source MySQL 5.5 DB instance is in read-only mode and all write operations are suspended. When the promotion is completed, you can direct your write operations to the upgraded MySQL 5.6 DB instance to ensure that no write operations are lost.

   In addition, we recommend that before promoting your MySQL 5.6 read replica you perform all necessary data definition language (DDL) operations on your MySQL 5.6 read replica. An example is creating indexes. This approach avoids negative effects on the performance of the MySQL 5.6 read replica after it has been promoted. To promote a read replica, use the following procedure.

   a. On the console, choose **Databases**, and then choose the read replica that you just upgraded.
   b. For **Actions**, choose **Promote**.
   c. Choose **Yes** to enable automated backups for the read replica instance. For more information, see Working With Backups (p. 291).
   d. Choose **Continue**.
   e. Choose **Promote Read Replica**.

6. You now have an upgraded version of your MySQL database. At this point, you can direct your applications to the new MySQL 5.6 DB instance, add read replicas, set up Multi-AZ support, and so on.

Upgrading a MySQL DB Snapshot

With Amazon RDS, you can create a storage volume DB snapshot of your MySQL DB instance. When you create a DB snapshot, the snapshot is based on the engine version used by your Amazon RDS instance. In addition to upgrading the DB engine version of your DB instance, you can also upgrade the engine version for your DB snapshots. For example, you can upgrade DB snapshots created from the MySQL 5.1 engine to DB snapshots for the MySQL 5.5 engine. After restoring a DB snapshot upgraded to a new engine version, you should test that the upgrade was successful. To learn how to test a major version upgrade, see Testing an Upgrade (p. 736). To learn how to restore a DB snapshot, see Restoring from a DB Snapshot (p. 303).

Amazon RDS supports upgrading a MySQL DB snapshot from MySQL 5.1 to MySQL 5.5.

Upgrading a MySQL DB Snapshot

You can upgrade manual DB snapshots, which can be encrypted or not encrypted, from MySQL 5.1 to MySQL 5.5 within the same AWS Region. You can't upgrade automated DB snapshots that are created during the automated backup process.

Console

To upgrade a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. For **Actions**, choose **Modify Snapshot**. The **Modify DB Snapshot** page appears.
4. Choose **Modify Snapshot** to upgrade the snapshot. During the upgrade process, all snapshot actions are disabled. Also, the DB snapshot status changes from **available** to **upgrading**, and then changes to **active** upon completion. If the DB snapshot can't be upgraded because of snapshot corruption issues, the status changes to **unavailable**. You can't recover the snapshot from this state.

AWS CLI

To upgrade a DB snapshot to a new database engine version, use the AWS CLI modify-db-snapshot command.

Parameters

- `--db-snapshot-identifier` – The identifier of the DB snapshot to upgrade. The identifier must be a unique Amazon Resource Name (ARN). For more information, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).
- `--engine-version` – The engine version to upgrade the DB snapshot to.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-snapshot \
    --db-snapshot-identifier <mydbsnapshot> \
    --engine-version <new_version>
```

For Windows:

```
aws rds modify-db-snapshot ^
    --db-snapshot-identifier <mydbsnapshot> ^
    --engine-version <new_version>
```

RDS API

To upgrade a DB snapshot to a new database engine version, call the Amazon RDS API ModifyDBSnapshot operation.

- `DBSnapshotIdentifier` – The identifier of the DB snapshot to upgrade. The identifier must be a unique Amazon Resource Name (ARN). For more information, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).
- `EngineVersion` – The engine version to upgrade the DB snapshot to.

Example

```
https://rds.us-west-2.amazonaws.com/
   ?Action=ModifyDBSnapshot
   &DBSnapshotIdentifier=mydbsnapshot
   &EngineVersion=newversion
   &SignatureVersion=4
   &Version=2014-10-31
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20161222/us-west-1/rds/aws4_request
   &X-Amz-Date=20161222T233051Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=8052a76dfb18469393c5f0182cdab0ebc224a9c7c5c949155376c1c250fc7ec3
```

Importing Data into a MySQL DB Instance

You can use several different techniques to import data into an Amazon RDS for MySQL DB instance. The best approach depends on the source of the data, the amount of data, and whether the import is done one time or is ongoing. If you are migrating an application along with the data, also consider the amount of downtime that you are willing to experience.

Overview

Find techniques to import data into an Amazon RDS for MySQL DB instance in the following table.

Source	Amount of Data	One Time or Ongoing	Application Downtime	Technique	More Information
Existing MySQL database on premises or on Amazon EC2	Any	One time	Some	Create a backup of your on-premises database, store it on Amazon S3, and then restore the backup file to a new Amazon RDS DB instance running MySQL.	Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747)
Any existing database	Any	One time or ongoing	Minimal	Use AWS Database Migration Service to migrate the database with minimal downtime and, for many database DB engines, continue ongoing replication.	What is AWS Database Migration Service in the *AWS Database Migration Service User Guide*
Existing Amazon RDS MySQL DB instance	Any	One time or ongoing	Minimal	Create a read replica for ongoing replication. Promote the read replica for one-time creation of a new DB instance.	Working with Read Replicas (p. 250)
Existing MySQL or MariaDB database	Small	One time	Some	Copy the data directly to your Amazon RDS MySQL DB instance using a command-line utility.	Importing Data from a MySQL or MariaDB DB to an Amazon RDS MySQL or MariaDB

Source	Amount of Data	One Time or Ongoing	Application Downtime	Technique	More Information
					DB Instance (p. 754)
Data not stored in an existing database	Medium	One time	Some	Create flat files and import them using the `mysqlimport` utility.	Importing Data From Any Source to a MySQL or MariaDB DB Instance (p. 768)
Existing MySQL or MariaDB database on premises or on Amazon EC2	Any	Ongoing	Minimal	Configure replication with an existing MySQL database as the replication source.	Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783) or Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756)

Note
The `'mysql'` system database contains authentication and authorization information required to log in to your DB instance and access your data. Dropping, altering, renaming, or truncating tables, data, or other contents of the `'mysql'` database in your DB instance can result in error and might render the DB instance and your data inaccessible. If this occurs, you can restore the DB instance from a snapshot using the AWS CLI `restore-db-instance-from-db-snapshot` command. You can recover the DB instance using the AWS CLI `restore-db-instance-to-point-in-time` command.

Importing Data Considerations

Following, you can find additional technical information related to loading data into MySQL. This information is intended for advanced users who are familiar with the MySQL server architecture. All comments related to LOAD DATA LOCAL INFILE also apply to `mysqlimport`.

Binary Log

Data loads incur a performance penalty and require additional free disk space (up to four times more) when binary logging is enabled versus loading the same data with binary logging turned off. The severity of the performance penalty and the amount of free disk space required is directly proportional to the size of the transactions used to load the data.

Transaction Size

Transaction size plays an important role in MySQL data loads. It has a major influence on resource consumption, disk space utilization, resume process, time to recover, and input format (flat files or SQL). This section describes how transaction size affects binary logging and makes the case for disabling binary logging during large data loads. As noted earlier, binary logging is enabled and disabled by setting the Amazon RDS automated backup retention period. Non-zero values enable binary logging, and zero disables it. We also describe the impact of large transactions on InnoDB and why it's important to keep transaction sizes small.

Small Transactions

For small transactions, binary logging doubles the number of disk writes required to load the data. This effect can severely degrade performance for other database sessions and increase the time required to load the data. The degradation experienced depends in part upon the upload rate, other database activity taking place during the load, and the capacity of your Amazon RDS DB instance.

The binary logs also consume disk space roughly equal to the amount of data loaded until they are backed up and removed. Fortunately, Amazon RDS minimizes this by backing up and removing binary logs on a frequent basis.

Large Transactions

Large transactions incur a 3X penalty for IOPS and disk consumption with binary logging enabled. This is due to the binary log cache spilling to disk, consuming disk space and incurring additional IO for each write. The cache cannot be written to the binlog until the transaction commits or rolls back, so it consumes disk space in proportion to the amount of data loaded. When the transaction commits, the cache must be copied to the binlog, creating a third copy of the data on disk.

Because of this, there must be at least three times as much free disk space available to load the data compared to loading with binary logging disabled. For example, 10 GiB of data loaded as a single transaction consumes at least 30 GiB disk space during the load. It consumes 10 GiB for the table + 10 GiB for the binary log cache + 10 GiB for the binary log itself. The cache file remains on disk until the session that created it terminates or the session fills its binary log cache again during another transaction. The binary log must remain on disk until backed up, so it might be some time before the extra 20 GiB is freed.

If the data was loaded using LOAD DATA LOCAL INFILE, yet another copy of the data is created if the database has to be recovered from a backup made before the load. During recovery, MySQL extracts the data from the binary log into a flat file. MySQL then executes LOAD DATA LOCAL INFILE, just as in the original transaction. However, this time the input file is local to the database server. Continuing with the example preceding, recovery fails unless there is at least 40 GiB free disk space available.

Disable Binary Logging

Whenever possible, disable binary logging during large data loads to avoid the resource overhead and addition disk space requirements. In Amazon RDS, disabling binary logging is as simple as setting the backup retention period to zero. If you do this, we recommend that you take a DB snapshot of the database instance immediately before the load. By doing this, you can quickly and easily undo changes made during loading if you need to.

After the load, set the backup retention period back to an appropriate (no zero) value.

You can't set the backup retention period to zero if the DB instance is a source DB instance for read replicas.

InnoDB

The information in this section provides a strong argument for keeping transaction sizes small when using InnoDB.

Undo

InnoDB generates undo to support features such as transaction rollback and MVCC. Undo is stored in the InnoDB system tablespace (usually ibdata1) and is retained until removed by the purge thread. The purge thread cannot advance beyond the undo of the oldest active transaction, so it is effectively blocked until the transaction commits or completes a rollback. If the database is processing other transactions during the load, their undo also accumulates in the system tablespace and cannot be removed even if they commit and no other transaction needs the undo for MVCC. In this situation, all transactions (including read-only transactions) that access any of the rows changed by any transaction (not just the load transaction) slow down. The slowdown occurs because transactions scan through undo that could have been purged if not for the long-running load transaction.

Undo is stored in the system tablespace, and the system tablespace never shrinks in size. Thus, large data load transactions can cause the system tablespace to become quite large, consuming disk space that you can't reclaim without recreating the database from scratch.

Rollback

InnoDB is optimized for commits. Rolling back a large transaction can take a very, very long time. In some cases, it might be faster to perform a point-in-time recovery or restore a DB snapshot.

Input Data Format

MySQL can accept incoming data in one of two forms: flat files and SQL. This section points out some key advantages and disadvantages of each.

Flat Files

Loading flat files with LOAD DATA LOCAL INFILE can be the fastest and least costly method of loading data as long as transactions are kept relatively small. Compared to loading the same data with SQL, flat files usually require less network traffic, lowering transmission costs and load much faster due to the reduced overhead in the database.

One Big Transaction

LOAD DATA LOCAL INFILE loads the entire flat file as one transaction. This isn't necessarily a bad thing. If the size of the individual files can be kept small, this has a number of advantages:

- Resume capability – Keeping track of which files have been loaded is easy. If a problem arises during the load, you can pick up where you left off with little effort. Some data might have to be retransmitted to Amazon RDS, but with small files, the amount retransmitted is minimal.

- Load data in parallel – If you've got IOPS and network bandwidth to spare with a single file load, loading in parallel might save time.
- Throttle the load rate – Data load having a negative impact on other processes? Throttle the load by increasing the interval between files.

Be Careful

The advantages of LOAD DATA LOCAL INFILE diminish rapidly as transaction size increases. If breaking up a large set of data into smaller ones isn't an option, SQL might be the better choice.

SQL

SQL has one main advantage over flat files: it's easy to keep transaction sizes small. However, SQL can take significantly longer to load than flat files and it can be difficult to determine where to resume the load after a failure. For example, mysqldump files are not restartable. If a failure occurs while loading a mysqldump file, the file requires modification or replacement before the load can resume. The alternative is to restore to the point in time before the load and replay the file after the cause of the failure has been corrected.

Take Checkpoints Using Amazon RDS Snapshots

If you have a load that's going to take several hours or even days, loading without binary logging isn't a very attractive prospect unless you can take periodic checkpoints. This is where the Amazon RDS DB snapshot feature comes in very handy. A DB snapshot creates a point-in-time consistent copy of your database instance which can be used restore the database to that point in time after a crash or other mishap.

To create a checkpoint, simply take a DB snapshot. Any previous DB snapshots taken for checkpoints can be removed without affecting durability or restore time.

Snapshots are fast too, so frequent checkpointing doesn't add significantly to load time.

Decreasing Load Time

Here are some additional tips to reduce load times:

- Create all secondary indexes before loading. This is counter-intuitive for those familiar with other databases. Adding or modifying a secondary index causes MySQL to create a new table with the index changes, copy the data from the existing table to the new table, and drop the original table.
- Load data in PK order. This is particularly helpful for InnoDB tables, where load times can be reduced by 75–80 percent and data file size cut in half.
- Disable foreign key constraints foreign_key_checks=0. For flat files loaded with LOAD DATA LOCAL INFILE, this is required in many cases. For any load, disabling FK checks provides significant performance gains. Just be sure to enable the constraints and verify the data after the load.
- Load in parallel unless already near a resource limit. Use partitioned tables when appropriate.
- Use multi-value inserts when loading with SQL to minimize statement execution overhead. When using mysqldump, this is done automatically.
- Reduce InnoDB log IO innodb_flush_log_at_trx_commit=0
- If you are loading data into a DB instance that does not have read replicas, set the sync_binlog parameter to 0 while loading data. When data loading is complete, set the sync_binlog parameter to back to 1.
- Load data before converting the DB instance to a Multi-AZ deployment. However, if the DB instance already uses a Multi-AZ deployment, switching to a Single-AZ deployment for data loading is not recommended, because doing so only provides marginal improvements.

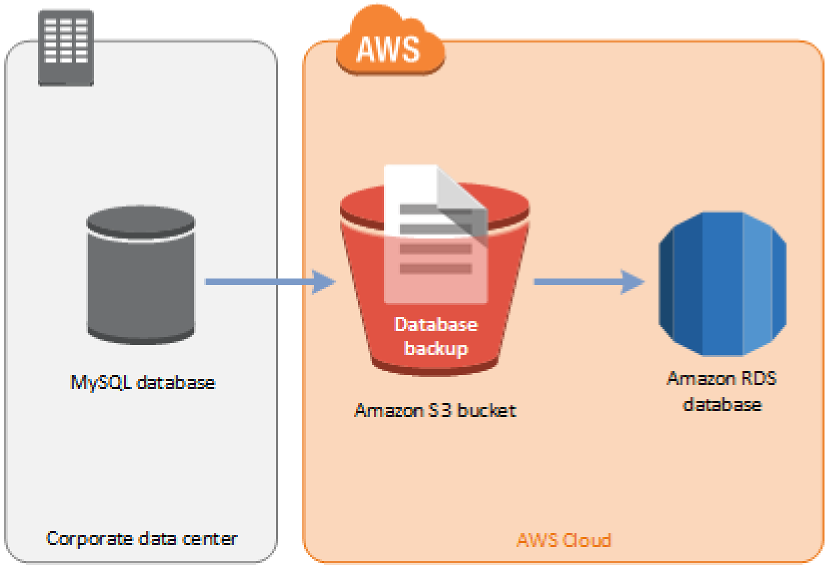
Note
Using innodb_flush_log_at_trx_commit=0 causes InnoDB to flush its logs every second instead of at each commit. This provides a significant speed advantage, but can lead to data loss during a crash. Use with caution.

Topics

Restoring a Backup into an Amazon RDS MySQL DB Instance

Amazon RDS supports importing MySQL databases by using backup files. You can create a backup of your on-premises database, store it on Amazon S3, and then restore the backup file onto a new Amazon RDS DB instance running MySQL.

You can find the supported scenario in the following diagram.



Importing backup files from Amazon S3 is supported for MySQL version 5.6 and 5.7. Importing backup files from Amazon S3 is available in all AWS Regions.

We recommend that you import your database to Amazon RDS by using backup files if your database can be offline while the backup file is created, copied, and restored. If your on-premises database can't be offline, you can use binlog replication to update your database after you have migrated to Amazon RDS through Amazon S3 as explained in this topic. For more information, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783). You can also use the AWS Database Migration Service to migrate your database to Amazon RDS. For more information, see What Is AWS Database Migration Service?

Limitations and Recommendations for Importing Backup Files from Amazon S3 to Amazon RDS

The following are some limitations and recommendations for importing backup files from Amazon S3:

- You can only import your data to a new DB instance, not an existing DB instance.
- You must use Percona XtraBackup to create the backup of your on-premises database.
- You can't migrate from a source database that has tables defined outside of the default MySQL data directory.
- You can't import a MySQL 5.5 or 8.0 database.
- You can't import an on-premises MySQL 5.6 database to an Amazon RDS MySQL 5.7 or 8.0 database. You can upgrade your DB instance after you complete the import.
- You can't restore databases larger than the maximum database size supported by Amazon RDS for MySQL. For more information about storage limits, see General Purpose SSD Storage (p. 29) and Provisioned IOPS SSD Storage (p. 31).

- You can't restore from an encrypted source database, but you can restore to an encrypted Amazon RDS DB instance.
- You can't restore from an encrypted backup in the Amazon S3 bucket.
- You can't restore from an Amazon S3 bucket in a different AWS Region than your Amazon RDS DB instance.
- Importing from Amazon S3 is not supported on the db.t2.micro DB instance class. However, you can restore to a different DB instance class, and then change the instance class later. For more information about instance classes, see Hardware Specifications for All Available DB Instance Classes (p. 9).
- Amazon S3 limits the size of a file uploaded to an Amazon S3 bucket to 5 TB. If a backup file exceeds 5 TB, then you must split the backup file into smaller files.
- When you restore the database, the backup is copied and then extracted on your DB instance. Therefore, provision storage space for your DB instance that is equal to or greater than the sum of the backup size, plus the original database's size on disk.
- Amazon RDS limits the number of files uploaded to an Amazon S3 bucket to 1 million. If the backup data for your database, including all full and incremental backups, exceeds 1 million files, use a tarball (.tar.gz) file to store full and incremental backup files in the Amazon S3 bucket.
- User accounts are not imported automatically. Save your user accounts from your source database and add them to your new DB instance later.
- Functions are not imported automatically. Save your functions from your source database and add them to your new DB instance later.
- Stored procedures are not imported automatically. Save your stored procedures from your source database and add them to your new DB instance later.
- Time zone information is not imported automatically. Record the time zone information for your source database, and set the time zone of your new DB instance later. For more information, see Local Time Zone for MySQL DB Instances (p. 720).
- Backward migration is not supported for both major versions and minor versions. For example, you can't migrate from version 5.7 to version 5.6, and you can't migrate from version 5.6.39 to version 5.6.37.
- The `innodb_data_file_path` parameter must be configured with only one data file that uses the default data file name `"ibdata1"`. Databases with two data files, or with a data file with a different name, can't be migrated using this method.

  The following are examples of file names that are not allowed: `"innodb_data_file_path=ibdata1:50M; ibdata2:50M:autoextend"` and `"innodb_data_file_path=ibdata01:50M:autoextend"`.

Overview of Setting Up to Import Backup Files from Amazon S3 to Amazon RDS

These are the components you need to set up to import backup files from Amazon S3 to Amazon RDS:

- An Amazon S3 bucket to store your backup files.
- A backup of your on-premises database created by Percona XtraBackup.
- An AWS Identity and Access Management (IAM) role to allow Amazon RDS to access the bucket.

If you already have an Amazon S3 bucket, you can use that. If you don't have an Amazon S3 bucket, you can create a new one. If you want to create a new bucket, see Creating a Bucket.

Use the Percona XtraBackup tool to create your backup. For more information, see Creating Your Database Backup (p. 749).

If you already have an IAM role, you can use that. If you don't have an IAM role, you can create a new one manually. Alternatively, you can choose to have a new IAM role created for you in your account by the wizard when you restore the database by using the AWS Management Console. If you want to create a new IAM role manually, or attach trust and permissions policies to an existing IAM role, see Creating an IAM Role Manually (p. 750). If you want to have a new IAM role created for you, follow the procedure in Console (p. 752).

Creating Your Database Backup

Use the Percona XtraBackup software to create your backup. You can install Percona XtraBackup from Download Percona XtraBackup.

> **Note**
> For MySQL 5.7 migration, you must use Percona XtraBackup 2.4. For earlier MySQL versions, use Percona XtraBackup 2.3 or 2.4.

You can create a full backup of your MySQL database files using Percona XtraBackup. Alternatively, if you already use Percona XtraBackup to back up your MySQL database files, you can upload your existing full and incremental backup directories and files.

For more information about backing up your database with Percona XtraBackup, see Percona XtraBackup - Documentation and The xtrabackup Binary on the Percona website.

Creating a Full Backup With Percona XtraBackup

To create a full backup of your MySQL database files that can be restored from Amazon S3, use the Percona XtraBackup utility (`xtrabackup`) to back up your database.

For example, the following command creates a backup of a MySQL database and stores the files in the folder `/on-premises/s3-restore/backup` folder.

```
xtrabackup --backup --user=<myuser> --password=<password> --target-dir=</on-premises/s3-
restore/backup>
```

If you want to compress your backup into a single file (which can be split later, if needed), you can save your backup in one of the following formats:

- Gzip (.gz)
- tar (.tar)
- Percona xbstream (.xbstream)

The following command creates a backup of your MySQL database split into multiple Gzip files.

```
xtrabackup --backup --user=<myuser> --password=<password> --stream=tar \
   --target-dir=</on-premises/s3-restore/backup> | gzip - | split -d --bytes=500MB \
   - </on-premises/s3-restore/backup/backup>.tar.gz
```

The following command creates a backup of your MySQL database split into multiple tar files.

```
xtrabackup --backup --user=<myuser> --password=<password> --stream=tar \
   --target-dir=</on-premises/s3-restore/backup> | split -d --bytes=500MB \
   - </on-premises/s3-restore/backup/backup>.tar
```

The following command creates a backup of your MySQL database split into multiple xbstream files.

```
xtrabackup --backup --user=<myuser> --password=<password> --stream=xbstream \
   --target-dir=</on-premises/s3-restore/backup> | split -d --bytes=500MB \
   - </on-premises/s3-restore/backup/backup>.xbstream
```

Using Incremental Backups With Percona XtraBackup

If you already use Percona XtraBackup to perform full and incremental backups of your MySQL database files, you don't need to create a full backup and upload the backup files to Amazon S3. Instead, you can save a significant amount of time by copying your existing backup directories and files to your Amazon S3 bucket. For more information about creating incremental backups using Percona XtraBackup, see Incremental Backup.

When copying your existing full and incremental backup files to an Amazon S3 bucket, you must recursively copy the contents of the base directory. Those contents include the full backup and also all incremental backup directories and files. This copy must preserve the directory structure in the Amazon S3 bucket. Amazon RDS iterates through all files and directories. Amazon RDS uses the `xtrabackup-checkpoints` file that is included with each incremental backup to identify the base directory, and to order incremental backups by log sequence number (LSN) range.

Backup Considerations for Percona XtraBackup

Amazon RDS consumes your backup files based on the file name. Name your backup files with the appropriate file extension based on the file format—for example, `.xbstream` for files stored using the Percona xbstream format.

Amazon RDS consumes your backup files in alphabetical order and also in natural number order. Use the `split` option when you issue the `xtrabackup` command to ensure that your backup files are written and named in the proper order.

Amazon RDS doesn't support partial backups created using Percona XtraBackup. You can't use the following options to create a partial backup when you back up the source files for your database: `--tables`, `--tables-exclude`, `--tables-file`, `--databases`, `--databases-exclude`, or `--databases-file`.

Amazon RDS supports incremental backups created using Percona XtraBackup. For more information about creating incremental backups using Percona XtraBackup, see Incremental Backup.

Creating an IAM Role Manually

If you don't have an IAM role, you can create a new one manually. Alternatively, you can choose to have a new IAM role created for you by the wizard when you restore the database by using the AWS Management Console. If you want to have a new IAM role created for you, follow the procedure in Console (p. 752).

To manually create a new IAM role for importing your database from Amazon S3, create a role to delegate permissions from Amazon RDS to your Amazon S3 bucket. When you create an IAM role, you attach trust and permissions policies. To import your backup files from Amazon S3, use trust and permissions policies similar to the examples following. For more information about creating the role, see Creating a Role to Delegate Permissions to an AWS Service.

Alternatively, you can choose to have a new IAM role created for you by the wizard when you restore the database by using the AWS Management Console. If you want to have a new IAM role created for you, follow the procedure in Console (p. 752)

The trust and permissions policies require that you provide an Amazon Resource Name (ARN). For more information about ARN formatting, see Amazon Resource Names (ARNs) and AWS Service Namespaces.

Example Trust Policy for Importing from Amazon S3

```
{
    "Version": "2012-10-17",
    "Statement":
    [{
        "Effect": "Allow",
        "Principal": {"Service":  "rds.amazonaws.com"},
        "Action": "sts:AssumeRole"
    }]
}
```

Example Permissions Policy for Importing from Amazon S3 — IAM User Permissions

```
{
    "Version":"2012-10-17",
    "Statement":
    [
        {
            "Sid":"AllowS3AccessRole",
            "Effect":"Allow",
            "Action":"iam:PassRole",
            "Resource":"arn:aws:iam::IAM User ID:role/S3Access"
        }
    ]
}
```

Example Permissions Policy for Importing from Amazon S3 — Role Permissions

```
{
    "Version": "2012-10-17",
    "Statement":
    [
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:ListBucket",
                "s3:GetBucketLocation"
            ],
        "Resource": "arn:aws:s3:::bucket_name"
        },
        {
        "Effect": "Allow",
        "Action":
            [
                "s3:GetObject"
            ],
        "Resource": "arn:aws:s3:::bucket_name/prefix*"
        }
    ]
}
```

> **Note**
> If you include a file name prefix, include the asterisk (*) after the prefix. If you don't want to specify a prefix, specify only an asterisk.

Importing Data From Amazon S3 to a New MySQL DB Instance

You can import data from Amazon S3 to a new MySQL DB instance using the AWS Management Console, AWS CLI, or RDS API.

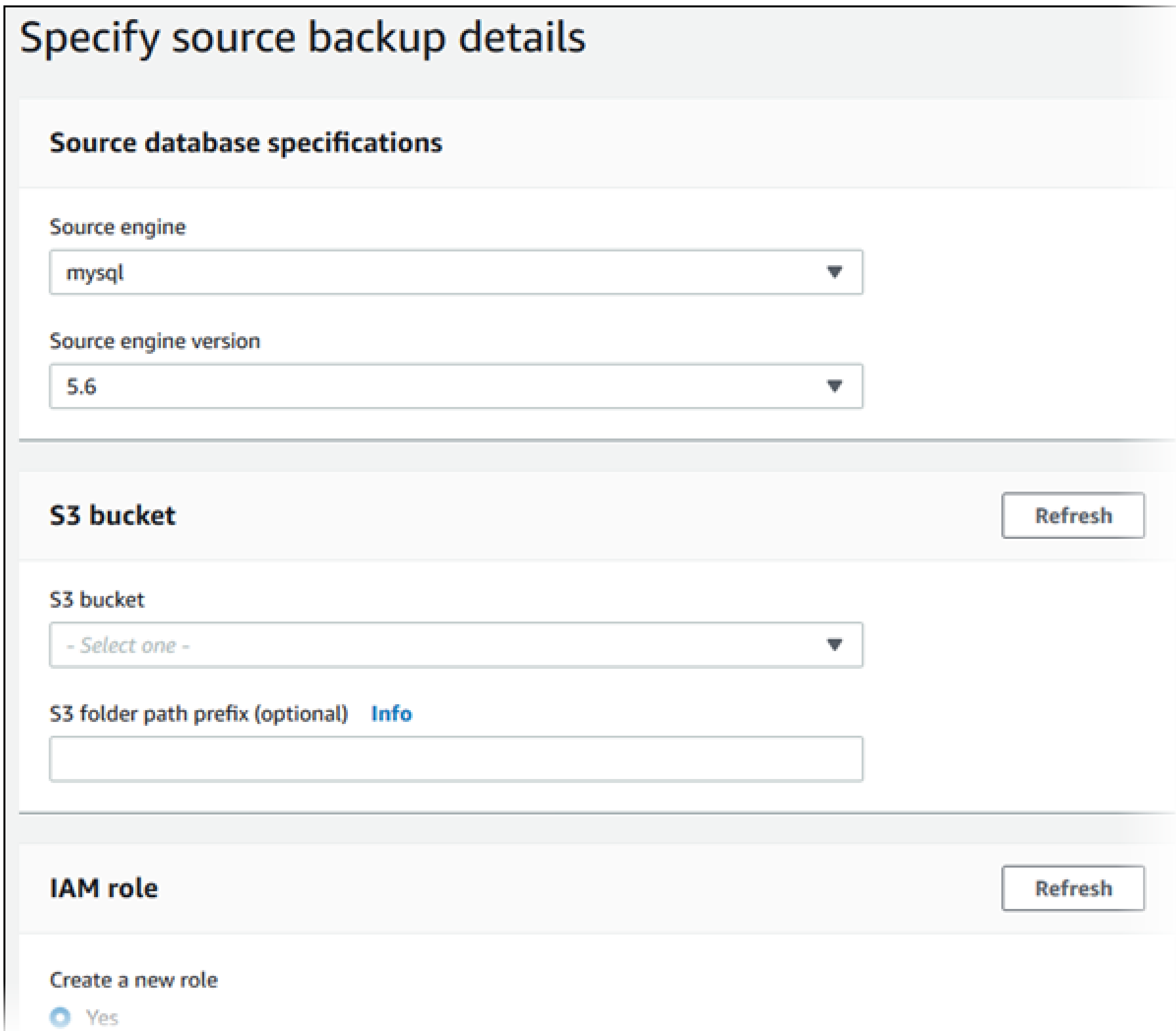
Console

To import data from Amazon S3 to a new MySQL DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the top right corner of the Amazon RDS console, choose the AWS Region in which to create your DB instance. Choose the same AWS Region as the Amazon S3 bucket that contains your database backup.
3. In the navigation pane, choose **Databases**.
4. Choose **Restore from S3** to launch the wizard.

   The wizard opens on the **Select engine** page.
5. On the **Select engine** page, choose **MySQL**, and then choose **Next**.

   The **Specify source backup details** page appears.



6. On the **Specify source backup details** page, specify your backup information.

   a. For **Source engine**, choose **mysql**.

   b. For **Source engine version**, choose the MySQL version of your source database.

c. For **S3 bucket**, choose your Amazon S3 bucket.

d. (Optional) For **S3 folder path prefix**, enter a file path prefix for the files stored in your Amazon S3 bucket. If you don't specify a prefix, then RDS creates your DB instance using all of the files and folders in the root folder of the S3 bucket. If you do specify a prefix, then RDS creates your DB instance using the files and folders in the S3 bucket where the path for the file begins with the specified prefix. For example, suppose that you store your backup files on S3 in a subfolder named backups, and you have multiple sets of backup files, each in its own directory (gzip_backup1, gzip_backup2, and so on). In this case, you specify a prefix of backups/gzip_backup1 to restore from the files in the gzip_backup1 folder.

e. For **Create a new role**, choose **Yes** to create a new IAM role in your account, or choose **No** to select an existing IAM role.

f. For **IAM role**, select an existing IAM role, or for **IAM role name**, specify the name for a new IAM role. You can choose to have a new IAM role created for you by choosing **Yes** for **Create a new role**.

7. Choose **Next** to continue. The **Specify DB details** page appears.

   On the **Specify DB details** page, specify your DB instance information. For information about each setting, see Settings for DB Instances (p. 141).

   Note
   Be sure to allocate enough memory for your new DB instance so that the restore can succeed. You can also allocate additional memory for future growth.

8. Choose **Next** to continue. The **Configure advanced settings** page appears.

   Provide additional information that Amazon RDS needs to launch the DB instance. For information about each setting, see Settings for DB Instances (p. 141).

9. Choose **Create database**.

AWS CLI

To import data from Amazon S3 to a new MySQL DB instance by using the AWS CLI, call the restore-db-instance-from-s3 command with the parameters following. For information about each setting, see Settings for DB Instances (p. 141).

Note
Be sure to allocate enough memory for your new DB instance so that the restore can succeed. You can also allocate additional memory for future growth.

- `--allocated-storage`
- `--db-instance-identifier`
- `--db-instance-class`
- `--engine`
- `--master-username`
- `--master-user-password`
- `--s3-bucket-name`
- `--s3-ingestion-role-arn`
- `--s3-prefix`
- `--source-engine`
- `--source-engine-version`

Example

For Linux, macOS, or Unix:

```
aws rds restore-db-instance-from-s3 \
--allocated-storage 250 \
--db-instance-identifier myidentifier \
--db-instance-class db.m4.large \
--engine mysql \
--master-username masterawsuser \
--master-user-password masteruserpassword \
--s3-bucket-name mybucket \
--s3-ingestion-role-arn arn:aws:iam::account-number:role/rolename \
--s3-prefix bucketprefix \
--source-engine mysql \
--source-engine-version 5.6.40
```

For Windows:

```
aws rds restore-db-instance-from-s3 ^
--allocated-storage 250 ^
--db-instance-identifier myidentifier ^
--db-instance-class db.m4.large ^
--engine mysql ^
--master-username masterawsuser ^
--master-user-password masteruserpassword ^
--s3-bucket-name mybucket ^
--s3-ingestion-role-arn arn:aws:iam::account-number:role/rolename ^
--s3-prefix bucketprefix ^
--source-engine mysql ^
--source-engine-version 5.6.40
```

RDS API

To import data from Amazon S3 to a new MySQL DB instance by using the Amazon RDS API, call the RestoreDBInstanceFromS3 operation.

Importing Data from a MySQL or MariaDB DB to an Amazon RDS MySQL or MariaDB DB Instance

If your scenario supports it, it is easier to move data in and out of Amazon RDS by using backup files and Amazon S3. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).

You can also import data from an existing MySQL or MariaDB database to an Amazon RDS MySQL or MariaDB DB instance. You do so by copying the database with mysqldump and piping it directly into the Amazon RDS MySQL or MariaDB DB instance. The `mysqldump` command-line utility is commonly used to make backups and transfer data from one MySQL or MariaDB server to another. It is included with MySQL and MariaDB client software.

A typical `mysqldump` command to move data from an external database to an Amazon RDS DB instance looks similar to the following:

```
mysqldump -u <local_user> \
    --databases <database_name> \
    --single-transaction \
    --compress \
    --order-by-primary  \
    -p<local_password> | mysql -u <RDS_user> \
        --port=<port_number> \
        --host=<host_name> \
```

```
        -p<RDS_password>
```

Important

Make sure not to leave a space between the `-p` option and the entered password.

Note

- Exclude the following schemas from the dump file: `sys`, `performance_schema`, and `information_schema`. The `mysqldump` utility excludes these schemas by default.
- If you need to migrate users and privileges, consider using a tool that generates the data control language (DCL) for recreating them, such as the pt-show-grants utility.

The parameters used are as follows:

- `-u <local_user>` – Use to specify a user name. In the first usage of this parameter, you specify the name of a user account on the local MySQL or MariaDB database identified by the `--databases` parameter.
- `--databases <database_name>` – Use to specify the name of the database on the local MySQL or MariaDB instance that you want to import into Amazon RDS.
- `--single-transaction` – Use to ensure that all of the data loaded from the local database is consistent with a single point in time. If there are other processes changing the data while `mysqldump` is reading it, using this option helps maintain data integrity.
- `--compress` – Use to reduce network bandwidth consumption by compressing the data from the local database before sending it to Amazon RDS.
- `--order-by-primary` – Use to reduce load time by sorting each table's data by its primary key.
- `-p<local_password>` – Use to specify a password. In the first usage of this parameter, you specify the password for the user account identified by the first `-u` parameter.
- `-u <RDS_user>` – Use to specify a user name. In the second usage of this parameter, you specify the name of a user account on the default database for the Amazon RDS MySQL or MariaDB DB instance identified by the `--host` parameter.
- `--port <port_number>` – Use to specify the port for your Amazon RDS MySQL or MariaDB DB instance. By default, this is 3306 unless you changed the value when creating the instance.
- `--host <host_name>` – Use to specify the DNS name from the Amazon RDS DB instance endpoint, for example, `myinstance.123456789012.us-east-1.rds.amazonaws.com`. You can find the endpoint value in the instance details in the Amazon RDS Management Console.
- `-p<RDS_password>` – Use to specify a password. In the second usage of this parameter, you specify the password for the user account identified by the second `-u` parameter.

You must create any stored procedures, triggers, functions, or events manually in your Amazon RDS database. If you have any of these objects in the database that you are copying, then exclude them when you run `mysqldump` by including the following parameters with your `mysqldump` command: `--routines=0 --triggers=0 --events=0`.

The following example copies the `world` sample database on the local host to an Amazon RDS MySQL DB instance.

For Linux, macOS, or Unix:

```
sudo mysqldump -u localuser \
    --databases world \
    --single-transaction \
    --compress \
    --order-by-primary  \
```

```
    -plocalpassword | mysql -u rdsuser \
        --port=3306 \
        --host=myinstance.123456789012.us-east-1.rds.amazonaws.com \
        -prdspassword
```

For Windows, the following command needs to be run in a command prompt that has been opened by right-clicking **Command Prompt** on the Windows programs menu and choosing **Run as administrator**:

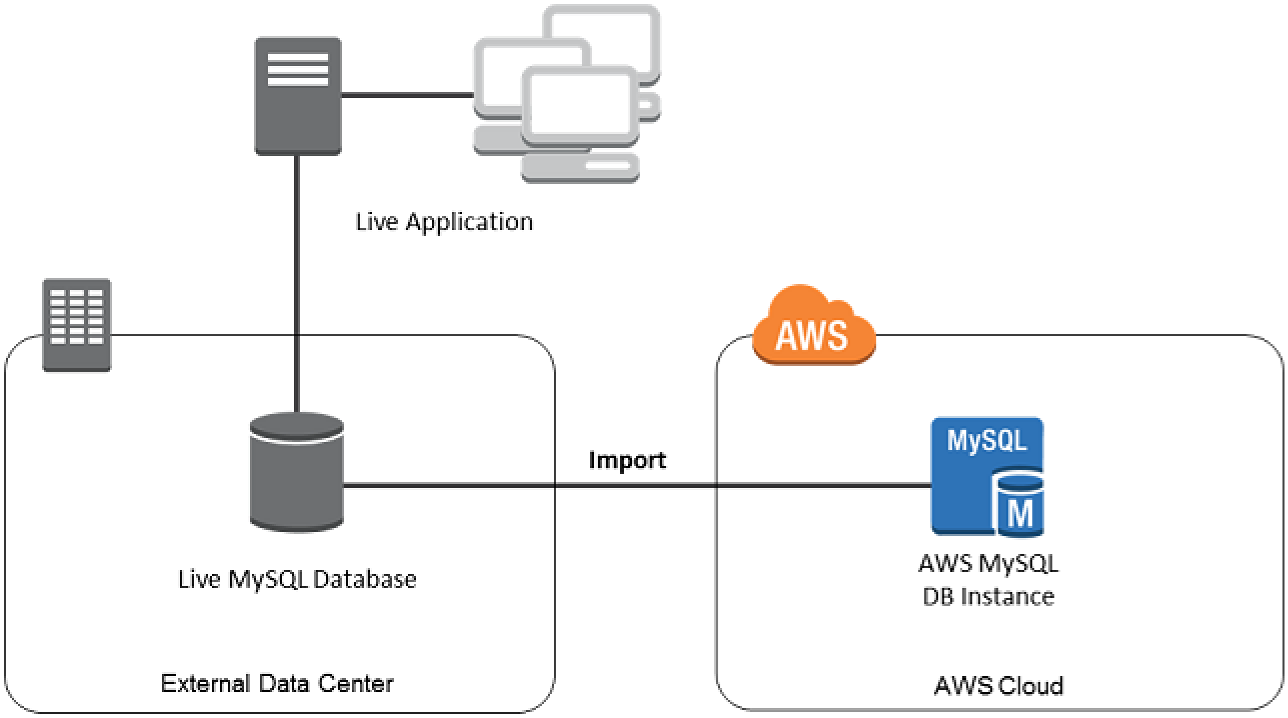
```
mysqldump -u localuser ^
    --databases world ^
    --single-transaction ^
    --compress ^
    --order-by-primary  ^
    -plocalpassword | mysql -u rdsuser ^
        --port=3306 ^
        --host=myinstance.123456789012.us-east-1.rds.amazonaws.com ^
        -prdspassword
```

Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime

If your scenario supports it, it is easier to move data in and out of Amazon RDS by using backup files and Amazon S3. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).

In some cases, you might need to import data from an external MySQL or MariaDB database that supports a live application to an Amazon RDS MySQL or MariaDB DB instance. In these cases, you can use the following procedure to minimize the impact on application availability. This procedure can also help if you are working with a very large database. Here, the procedure helps because you can reduce the cost of the import by reducing the amount of data that is passed across the network to AWS.

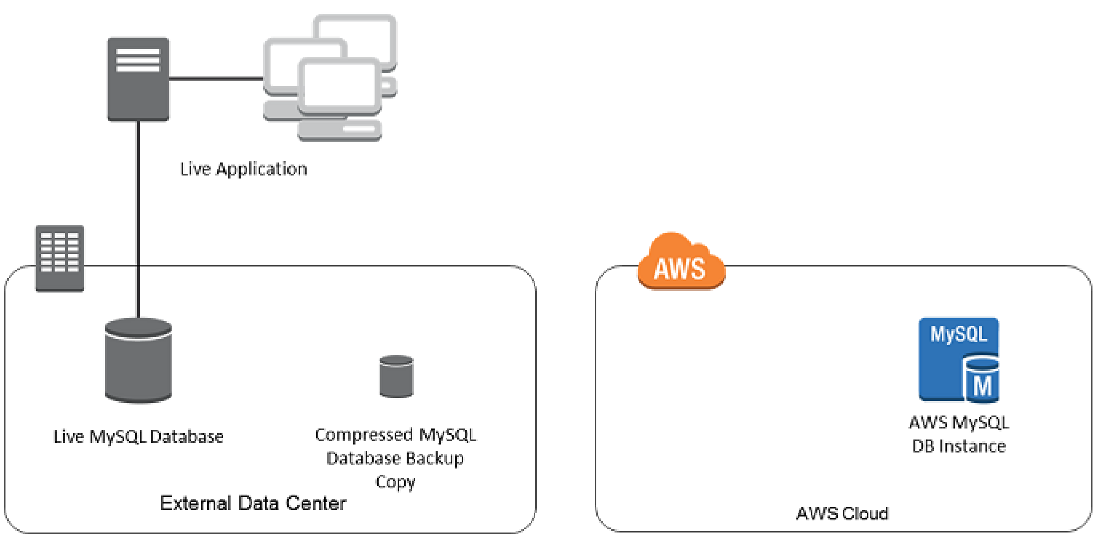
In this procedure, you transfer a copy of your database data to an Amazon EC2 instance and import the data into a new Amazon RDS DB instance. You then use replication to bring the Amazon RDS DB instance up-to-date with your live external instance, before redirecting your application to the Amazon RDS DB instance. You configure MariaDB replication based on global transaction identifiers (GTIDs) if the external instance is MariaDB 10.0.2 or greater and the target instance is Amazon RDS MariaDB; otherwise, you configure replication based on binary log coordinates. We recommend GTID-based replication if your external database supports it due to its enhanced crash-safety features. For more information, see Global Transaction ID in the MariaDB documentation.



Note
We don't recommend that you use this procedure with source MySQL databases from MySQL versions earlier than version 5.1, due to potential replication issues. For more information, see Replication Compatibility Between MySQL Versions in the MySQL documentation.

Create a Copy of Your Existing Database

The first step in the process of migrating a large amount of data to an Amazon RDS MySQL or MariaDB DB instance with minimal downtime is to create a copy of the source data.



You can use the `mysqldump` utility to create a database backup in either SQL or delimited-text format. You should do a test run with each format in a nonproduction environment to see which method minimizes the amount of time that `mysqldump` runs.

You should also weigh `mysqldump` performance against the benefit offered by using the delimited-text format for loading. A backup using delimited-text format creates a tab-separated text file for each table being dumped. You can load these files in parallel using the `LOAD DATA LOCAL INFILE` command to reduce the amount of time required to import your database. For more information about choosing a `mysqldump` format and then loading the data, see Using mysqldump For Backups in the MySQL documentation.

Before you start the backup operation, you must set the replication options on the MySQL or MariaDB database that you are copying to Amazon RDS. The replication options include enabling binary logging and setting a unique server ID. Setting these options causes your server to start logging database transactions and prepares it to be a replication master later in this process.

Note

- Your database needs to be stopped to set the replication options and be in read-only mode while the backup copy is created, so you need to schedule a maintenance window for these operations.
- Exclude the following schemas from the dump file: `sys`, `performance_schema`, and `information_schema`. The `mysqldump` utility excludes these schemas by default.
- If you need to migrate users and privileges, consider using a tool that generates the data control language (DCL) for recreating them, such as the pt-show-grants utility.

To Set Replication Options

1. Edit the my.cnf file (this file is usually under `/etc`).

```
sudo vi /etc/my.cnf
```

   Add the `log_bin` and `server_id` options to the `[mysqld]` section. The `log_bin` option provides a file name identifier for binary log files. The `server_id` option provides a unique identifier for the server in master-replica relationships.

   The following example shows the updated `[mysqld]` section of a my.cnf file:

```
[mysqld]
log-bin=mysql-bin
server-id=1
```

   For more information, see Setting the Replication Master Configuration in the MySQL documentation.
2. Restart the `mysql` service.

```
sudo service mysqld restart
```

To Create a Backup Copy of Your Existing Database

1. Create a backup of your data using the `mysqldump` utility, specifying either SQL or delimited-text format.

   You must specify `--master-data=2` in order to create a backup file that can be used to start replication between servers. For more information, see the mysqldump documentation.

   To improve performance and ensure data integrity, use the `--order-by-primary` and `--single-transaction` options of `mysqldump`.

To avoid including the MySQL system database in the backup, do not use the `--all-databases` option with `mysqldump`. For more information, see Creating a Dump Snapshot Using mysqldump in the MySQL documentation.

Use `chmod` if necessary to make sure that the directory where the backup file is being created is writeable.

Important
On Windows, run the command window as an administrator.

- To produce SQL output, use the following command.

  For Linux, macOS, or Unix:

```
sudo mysqldump \
    --databases <database_name> \
    --master-data=2  \
    --single-transaction \
    --order-by-primary \
    -r backup.sql \
    -u <local_user> \
    -p <password>
```

  For Windows:

```
mysqldump ^
    --databases <database_name> ^
    --master-data=2  ^
    --single-transaction ^
    --order-by-primary ^
    -r backup.sql ^
    -u <local_user> ^
    -p <password>
```

- To produce delimited-text output, use the following command.

  For Linux, macOS, or Unix:

```
sudo mysqldump \
    --tab=<target_directory> \
    --fields-terminated-by ',' \
    --fields-enclosed-by '"' \
    --lines-terminated-by 0x0d0a \
    <database_name> \
    --master-data=2 \
    --single-transaction \
    --order-by-primary \
    -p <password>
```

  For Windows:

```
mysqldump ^
    --tab=<target_directory> ^
    --fields-terminated-by ',' ^
    --fields-enclosed-by '"' ^
    --lines-terminated-by 0x0d0a ^
    <database_name> ^
    --master-data=2 ^
    --single-transaction ^
    --order-by-primary ^
```

```
    -p <password>
```

Note
You must create any stored procedures, triggers, functions, or events manually in your Amazon RDS database. If you have any of these objects in the database that you are copying, exclude them when you run `mysqldump` by including the following arguments with your `mysqldump` command: `--routines=0 --triggers=0 --events=0`.

When using the delimited-text format, a CHANGE MASTER TO comment is returned when you run `mysqldump`. This comment contains the master log file name and position. If the external instance is other than MariaDB version 10.0.2 or greater, note the values for MASTER_LOG_FILE and MASTER_LOG_POS; you need these values when setting up replication.

```
-- Position to start replication or point-in-time recovery from
--
-- CHANGE MASTER TO MASTER_LOG_FILE='mysql-bin-changelog.000031', MASTER_LOG_POS=107;
```

If you are using SQL format, you can get the master log file name and position in step 4 of the procedure at Replicate Between Your External Database and New Amazon RDS DB Instance (p. 765). If the external instance is MariaDB version 10.0.2 or greater, you can get the GTID in the next step.

2. If the external instance you are using is MariaDB version 10.0.2 or greater, you use GTID-based replication. Run `SHOW MASTER STATUS` on the external MariaDB instance to get the binary log file name and position, then convert them to a GTID by running `BINLOG_GTID_POS` on the external MariaDB instance.

```
SELECT BINLOG_GTID_POS('<binary log file name>', <binary log file position>);
```

Note the GTID returned; you need it to configure replication.

3. Compress the copied data to reduce the amount of network resources needed to copy your data to the Amazon RDS DB instance. Take note of the size of the backup file; you need this information when determining how large an Amazon EC2 instance to create. When you are done, compress the backup file using GZIP or your preferred compression utility.

   - To compress SQL output, use the following command.

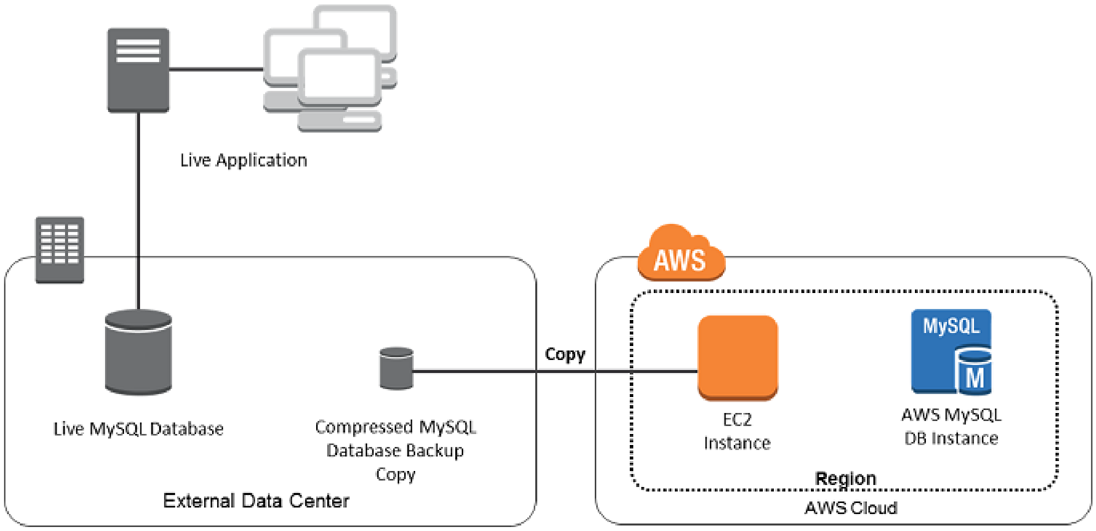
```
gzip backup.sql
```

   - To compress delimited-text output, use the following command.

```
tar -zcvf backup.tar.gz <target_directory>
```

Create an Amazon EC2 Instance and Copy the Compressed Database

Copying your compressed database backup file to an Amazon EC2 instance takes fewer network resources than doing a direct copy of uncompressed data between database instances. After your data is in Amazon EC2, you can copy it from there directly to your Amazon RDS MySQL or MariaDB DB instance. For you to save on the cost of network resources, your Amazon EC2 instance must be in the same AWS Region as your Amazon RDS DB instance. Having the Amazon EC2 instance in the same AWS Region as your Amazon RDS DB instance also reduces network latency during the import.



To Create an Amazon EC2 Instance and Copy Your Data

1. In the AWS Region where you plan to create the RDS DB instance to run your MySQL database engine, create a VPC, a VPC security group, and a VPC subnet. Ensure that the inbound rules for your VPC security group allow the IP addresses required for your application to connect to AWS. This can be a range of IP addresses (for example, `203.0.113.0/24`), or another VPC security group. You can use the Amazon VPC Management Console to create and manage VPCs, subnets, and security groups. For more information, see Getting Started with Amazon VPC in the *Amazon Virtual Private Cloud Getting Started Guide*.

   Note
   Older AWS accounts can also launch instances in Amazon EC2-Classic mode. In this case, make sure that the inbound rules in the DB security group for your Amazon RDS instance allow access for your EC2-Classic instance using the Amazon EC2 private IP address. For more information, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).

2. Open the Amazon EC2 Management Console and select the AWS Region to contain both your Amazon EC2 instance and your Amazon RDS DB instance. Launch an Amazon EC2 instance using the VPC, subnet, and security group that you created in Step 1. Ensure that you select an instance type with enough storage for your database backup file when it is uncompressed. For details on Amazon EC2 instances, see Getting Started with Amazon EC2 Linux Instances in the *Amazon Elastic Compute Cloud User Guide for Linux*.

3. To connect to your Amazon RDS DB instance from your Amazon EC2 instance, you need to edit your VPC security group, and add an inbound rule specifying the private IP address of your EC2 instance. You can find the private IP address on the **Details** tab of the **Instance** pane in the EC2 console window. To edit the VPC security group and add an inbound rule, choose **Security Groups** in the EC2 console navigation pane, choose your security group, and then add an inbound rule for MySQL/Aurora specifying the private IP address of your EC2 instance. To learn how to add an inbound rule to a VPC security group, see Adding and Removing Rules.

4. Copy your compressed database backup file from your local system to your Amazon EC2 instance. Use `chmod` if necessary to make sure you have write permission for the target directory of the Amazon EC2 instance. You can use `scp` or an SSH client to copy the file. The following is an example:

```
$ scp -r -i <key pair>.pem backup.sql.gz ec2-user@<EC2 DNS>:/<target_directory>/
backup.sql.gz
```

   Important
   Be sure to copy sensitive data using a secure network transfer protocol.

5. Connect to your Amazon EC2 instance and install the latest updates and the MySQL client tools using the following commands:

```
sudo yum update -y
sudo yum install mysql -y
```

   For more information, see Connect to Your Instance in the *Amazon Elastic Compute Cloud User Guide for Linux*.
6. While connected to your Amazon EC2 instance, decompress your database backup file. For example:
   - To decompress SQL output, use the following command:

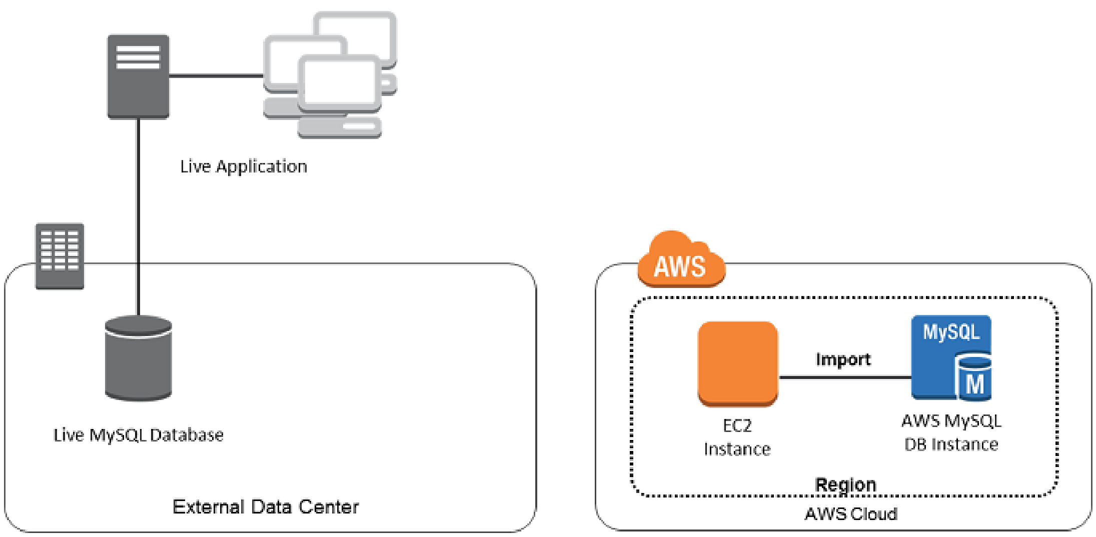
```
gzip backup.sql.gz -d
```

   - To decompress delimited-text output, use the following command:

```
tar xzvf backup.tar.gz
```

Create an Amazon RDS MySQL or MariaDB DB instance and Import Data from Your Amazon EC2 Instance

By creating an Amazon RDS MySQL or MariaDB DB instance in the same AWS Region as your Amazon EC2 instance, you can import the database backup file from EC2 faster than over the internet.



To Create an Amazon RDS MySQL or MariaDB DB Instance and Import Your Data

1. Determine which DB instance class and what amount of storage space is required to support the expected workload for this Amazon RDS DB instance. As part of this process, decide what is sufficient space and processing capacity for your data load procedures, and also what is required to handle the production workload. You can estimate this based on the size and resources of the source MySQL or MariaDB database. For more information, see DB Instance Classes (p. 7).
2. Determine if Amazon RDS provisioned input/output operations per second (IOPS) is required to support the workloads. Provisioned IOPS storage delivers fast throughput for online transaction processing (OLTP) workloads, which are I/O intensive. For more information, see Provisioned IOPS SSD Storage (p. 31).

3. Open the Amazon RDS console. In the upper-right corner, choose the AWS Region that contains your Amazon EC2 instance.
4. In the navigation pane, choose **Databases**.
5. Choose **Create database**, and then go through the steps to choose options for your DB instance:

   a. Make sure that **Standard Create** is chosen.
   b. In the **Engine options** section, choose **MySQL** or **MariaDB**, as appropriate.
   c. For **Version**, choose the version that is compatible with your source MySQL instance, as follows:

      - If your source instance is MySQL 5.1.x, the Amazon RDS DB instance must be MySQL 5.5.x.
      - If your source instance is MySQL 5.5.x, the Amazon RDS DB instance must be MySQL 5.5.x or greater.
      - If your source instance is MySQL 5.6.x, the Amazon RDS DB instance must be MySQL 5.6.x or MariaDB.
      - If your source instance is MySQL 5.7.x, the Amazon RDS DB instance must be MySQL 5.7.x, 5.6.x, or MariaDB.
      - If your source instance is MySQL 8.0.x, the Amazon RDS DB instance must be MySQL 8.0.x.
      - If your source instance is MariaDB 5.1, 5.2, or 5.3, the Amazon RDS DB instance must be MySQL 5.1.x.
      - If your source instance is MariaDB 5.5 or greater, the Amazon RDS DB instance must be MariaDB.
   d. In the **Templates** section, choose **Dev/Test** to skip configuring Multi-AZ deployment and provisioned IOPS storage.
   e. In the **Settings** section, specify the requested **DB instance identifier** and user information.
   f. In the **DB instance class** and **Storage** sections, specify the DB instance class and allocated storage size that you want.
   g. In the **Availability & durability** section, choose **Do not create a standby instance** for **Multi-AZ deployment**.
   h. In the **Connectivity** section, choose the same virtual private cloud (VPC) and VPC security group as for your Amazon EC2 instance. This approach ensures that your Amazon EC2 instance and your Amazon RDS instance are visible to each other over the network. Set **Publicly accessible** to **Yes**. To set up replication with your source database as described later, your DB instance must be publicly accessible.

      Use the default values for the other settings in this section.

      In the **Backup** section, set the backup retention period to **0 days**.

      Use the default values for the other settings in this section.
   i. Open the **Additional configuration** section, and specify an **Initial database name**.

      Set the **Backup retention period** to **0 days**

      Use the default values for the other settings in this section.
   j. Choose **Create database**.

      Your new DB instance appears in the **Databases** list with the status **Creating**. Wait for the **Status** of your new DB instance to show as **Available**.

Don't configure multiple Availability Zones, backup retention, or read replicas until after you have imported the database backup. When that import is done, you can set Multi-AZ and backup retention the way you want them for the production instance. For a detailed walkthrough of creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

6. Review the default configuration options for the Amazon RDS DB instance. In the RDS console navigation pane, choose **Parameter groups**, and then choose the magnifying glass icon next to the **default.mysqlx.x** or **default.mariadbx.x** parameter group. If this parameter group doesn't have the configuration options that you want, find a different one that does or create a new parameter group. For more information on creating a parameter group, see Working with DB Parameter Groups (p. 202).

   If you decide to use a different parameter group than the default, associate it with your Amazon RDS DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
7. Connect to the new Amazon RDS DB instance as the master user, and create the users required to support the administrators, applications, and services that need to access the instance. The host name for the Amazon RDS DB instance is the **Endpoint** value for this instance without including the port number, for example `mysampledb.claxc2oy9ak1.us-west-2.rds.amazonaws.com`. You can find the endpoint value in the instance details in the Amazon RDS Management Console.
8. Connect to your Amazon EC2 instance. For more information, see Connect to Your Instance in the *Amazon Elastic Compute Cloud User Guide for Linux*.
9. Connect to your Amazon RDS DB instance as a remote host from your Amazon EC2 instance using the `mysql` command. The following is an example.

```
mysql -h <host_name> -P 3306 -u <db_master_user> -p
```

   The host name is the DNS name from the Amazon RDS DB instance endpoint.
10. At the `mysql` prompt, run the `source` command and pass it the name of your database dump file to load the data into the Amazon RDS DB instance:

    - For SQL format, use the following command.

```
mysql> source backup.sql;
```

    - For delimited-text format, first create the database (if it isn't the default database you created when setting up the Amazon RDS DB instance).

```
mysql> create database <database_name>;
$ mysql> use <database_name>;
```

      Then create the tables.

```
mysql> source <table1>.sql
$ mysql> source <table2>.sql
etc…
```

      Then import the data.

```
mysql> LOAD DATA LOCAL INFILE 'table1.txt' INTO TABLE table1 FIELDS TERMINATED BY ','
 ENCLOSED BY '"' LINES TERMINATED BY '0x0d0a';
$ mysql> LOAD DATA LOCAL INFILE 'table2.txt' INTO TABLE table2 FIELDS TERMINATED BY
 ',' ENCLOSED BY '"' LINES TERMINATED BY '0x0d0a';
etc…
```

      To improve performance, you can perform these operations in parallel from multiple connections so that all of your tables get created and then loaded at the same time.

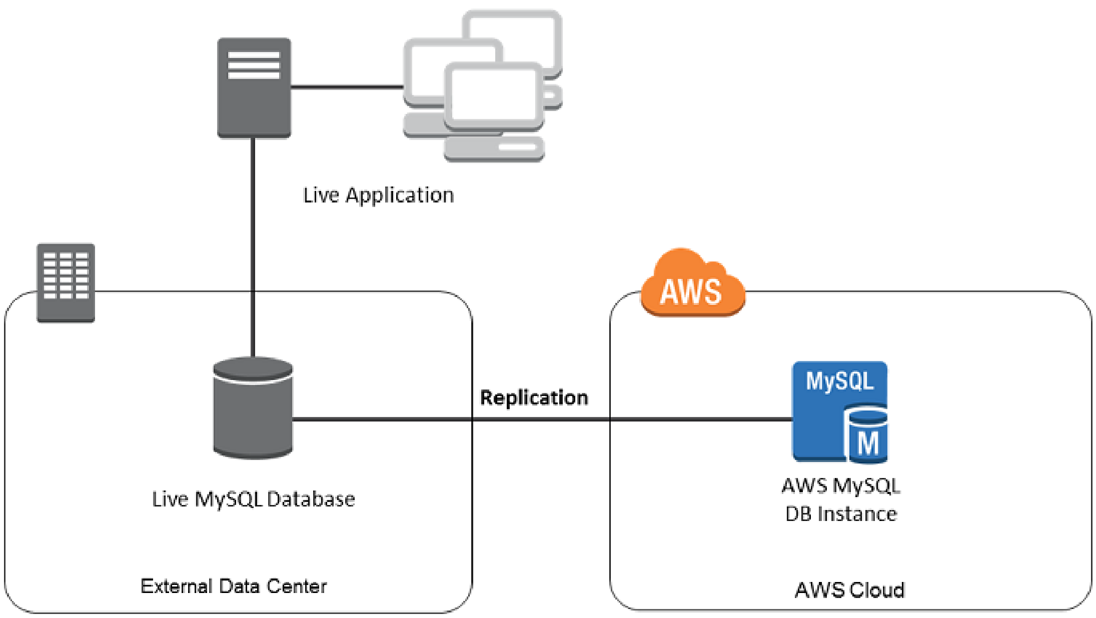
Note
If you used any data-formatting options with `mysqldump` when you initially dumped the table, you must use the same options with `mysqlimport` or LOAD DATA LOCAL INFILE to ensure proper interpretation of the data file contents.

11. Run a simple SELECT query against one or two of the tables in the imported database to verify that the import was successful.

Note
If you no longer need the Amazon EC2 instance used in this procedure, terminate the EC2 instance to reduce your AWS resource usage. To terminate an EC2 instance, see Terminating an Instance.

Replicate Between Your External Database and New Amazon RDS DB Instance

Your source database was likely updated during the time that it took to copy and transfer the data to the Amazon RDS MySQL or MariaDB DB instance. That being the case, you can use replication to bring the copied database up-to-date with the source database.



Note
The permissions required to start replication on an Amazon RDS DB instance are restricted and not available to your Amazon RDS master user. Because of this, you must use either the Amazon RDS mysql.rds_set_external_master (p. 822) command or the mysql.rds_set_external_master_gtid (p. 539) command to configure replication, and the mysql.rds_start_replication (p. 832) command to start replication between your live database and your Amazon RDS database.

To Start Replication

Earlier, you enabled binary logging and set a unique server ID for your source database. Now you can set up your Amazon RDS DB instance as a replica with your live database as the replication master.

1. In the Amazon RDS Management Console, add the IP address of the server that hosts the source database to the VPC security group for the Amazon RDS DB instance. For more information on

modifying a VPC security group, see Security Groups for Your VPC in the *Amazon Virtual Private Cloud User Guide*.

You might also need to configure your local network to permit connections from the IP address of your Amazon RDS DB instance, so that it can communicate with your source instance. To find the IP address of the Amazon RDS DB instance, use the `host` command.

```
host <db_instance_endpoint>
```

The host name is the DNS name from the Amazon RDS DB instance endpoint, for example `myinstance.123456789012.us-east-1.rds.amazonaws.com`. You can find the endpoint value in the instance details in the Amazon RDS Management Console.

2. Using the client of your choice, connect to the source instance and create a user to be used for replication. This account is used solely for replication and must be restricted to your domain to improve security. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY '<password>';
```

3. For the source instance, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. For example, to grant the `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the '`repl_user`' user for your domain, issue the following command.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
 IDENTIFIED BY '<password>';
```

4. If you used SQL format to create your backup file and the external instance is not MariaDB 10.0.2 or greater, look at the contents of that file.

```
cat backup.sql
```

The file includes a CHANGE MASTER TO comment that contains the master log file name and position. This comment is included in the backup file when you use the `--master-data` option with `mysqldump`. Note the values for MASTER_LOG_FILE and MASTER_LOG_POS.

```
--
-- Position to start replication or point-in-time recovery from
--

-- CHANGE MASTER TO MASTER_LOG_FILE='mysql-bin-changelog.000031', MASTER_LOG_POS=107;
```

If you used delimited text format to create your backup file and the external instance is not MariaDB 10.0.2 or greater, you should already have binary log coordinates from step 1 of the procedure at To Create a Backup Copy of Your Existing Database (p. 758).

If the external instance is MariaDB 10.0.2 or greater, you should already have the GTID from which to start replication from step 2 of the procedure at To Create a Backup Copy of Your Existing Database (p. 758).

5. Make the Amazon RDS DB instance the replica. If the external instance is not MariaDB 10.0.2 or greater, connect to the Amazon RDS DB instance as the master user and identify the source database as the replication master by using the mysql.rds_set_external_master (p. 822) command. Use the master log file name and master log position that you determined in the previous step if you have a SQL format backup file. Alternatively, use the name and position that you determined when creating the backup files if you used delimited-text format. The following is an example.

```
CALL mysql.rds_set_external_master ('mymasterserver.mydomain.com', 3306,
```

```
    'repl_user', '<password>', 'mysql-bin-changelog.000031', 107, 0);
```

If the external instance is MariaDB 10.0.2 or greater, connect to the Amazon RDS DB instance as the master user and identify the source database as the replication master by using the mysql.rds_set_external_master_gtid (p. 539) command. Use the GTID that you determined in step 2 of the procedure at To Create a Backup Copy of Your Existing Database (p. 758). The following is an example.

```
CALL mysql.rds_set_external_master_gtid ('<master_server_ip_address>', 3306,
 'ReplicationUser', '<password>', '<GTID>', 0);
```

The `master_server_ip_address` is the IP address of master MySQL instance. An EC2 private DNS address is currently not supported.

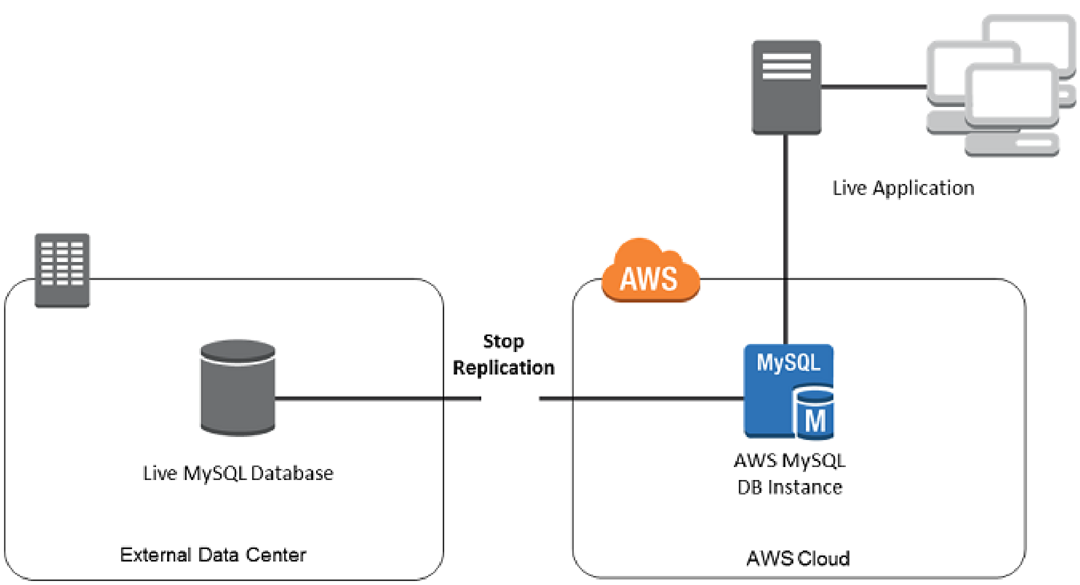
6. On the Amazon RDS DB instance, issue the mysql.rds_start_replication (p. 832) command to start replication.

```
CALL mysql.rds_start_replication;
```

7. On the Amazon RDS DB instance, run the SHOW SLAVE STATUS command to determine when the replica is up-to-date with the replication master. The results of the SHOW SLAVE STATUS command include the Seconds_Behind_Master field. When the Seconds_Behind_Master field returns 0, then the replica is up-to-date with the master.
8. After the Amazon RDS DB instance is up-to-date, enable automated backups so you can restore that database if needed. You can enable or modify automated backups for your Amazon RDS DB instance using the Amazon RDS Management Console. For more information, see Working With Backups (p. 291).

Redirect Your Live Application to Your Amazon RDS Instance

After the Amazon RDS MySQL or MariaDB DB instance is up-to-date with the replication master, you can now update your live application to use the Amazon RDS instance.



To Redirect Your Live Application to Your Amazon RDS MySQL or MariaDB DB Instance and Stop Replication

1. To add the VPC security group for the Amazon RDS DB instance, add the IP address of the server that hosts the application. For more information on modifying a VPC security group, see Security Groups for Your VPC in the *Amazon Virtual Private Cloud User Guide*.
2. Verify that the Seconds_Behind_Master field in the SHOW SLAVE STATUS command results is 0, which indicates that the replica is up-to-date with the replication master.

```
SHOW SLAVE STATUS;
```

3. Close all connections to the source when their transactions complete.
4. Update your application to use the Amazon RDS DB instance. This update typically involves changing the connection settings to identify the host name and port of the Amazon RDS DB instance, the user account and password to connect with, and the database to use.
5. Stop replication for the Amazon RDS instance using the mysql.rds_stop_replication (p. 834) command.

```
CALL mysql.rds_stop_replication;
```

6. Run the mysql.rds_reset_external_master (p. 828) command on your Amazon RDS DB instance to reset the replication configuration so this instance is no longer identified as a replica.

```
CALL mysql.rds_reset_external_master;
```

7. Enable additional Amazon RDS features such as Multi-AZ support and read replicas. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41) and Working with Read Replicas (p. 250).

Note

If you no longer need the Amazon RDS instance used in this procedure, you should delete the RDS instance to reduce your Amazon AWS resource usage. To delete an RDS instance, see Deleting a DB Instance (p. 286).

Importing Data From Any Source to a MySQL or MariaDB DB Instance

If you have more than 1 GiB of data to load, or if your data is coming from somewhere other than a MySQL or MariaDB database, we recommend creating flat files and loading them with mysqlimport. mysqlimport is another command line utility bundled with the MySQL and MariaDB client software whose purpose is to load flat files into MySQL or MariaDB. For information about mysqlimport, see mysqlimport - A Data Import Program in the MySQL documentation.

We also recommend creating DB snapshots of the target Amazon RDS DB instance before and after the data load. Amazon RDS DB snapshots are complete backups of your DB instance that can be used to restore your DB instance to a known state. When you initiate a DB snapshot, I/O operations to your database instance are momentarily suspended while your database is backed up.

Creating a DB snapshot immediately before the load lets you restore the database to its state before the load, if you need to. A DB snapshot taken immediately after the load protects you from having to load the data again in case of a mishap and can also be used to seed new database instances.

The following list shows the steps to take. Each step is discussed in more detail below.

1. Create flat files containing the data to be loaded.

2. Stop any applications accessing the target DB instance.
3. Create a DB snapshot.
4. Consider disabling Amazon RDS automated backups.
5. Load the data using mysqlimport.
6. Enable automated backups again.

Step 1: Create Flat Files Containing the Data to be Loaded

Use a common format, such as CSV (Comma-Separated Values), to store the data to be loaded. Each table must have its own file; data for multiple tables cannot be combined in the same file. Give each file the same name as the table it corresponds to. The file extension can be anything you like. For example, if the table name is "sales", the file name could be "sales.csv" or "sales.txt", but not "sales_01.csv".

Whenever possible, order the data by the primary key of the table being loaded. This drastically improves load times and minimizes disk storage requirements.

The speed and efficiency of this procedure is dependent upon keeping the size of the files small. If the uncompressed size of any individual file is larger than 1 GiB, split it into multiple files and load each one separately.

On Unix-like systems (including Linux), use the 'split' command. For example, the following command splits the sales.csv file into multiple files of less than 1 GiB, splitting only at line breaks (-C 1024m). The new files are named sales.part_00, sales.part_01, and so on.

```
split -C 1024m -d sales.csv sales.part_
```

Similar utilities are available on other operating systems.

Step 2: Stop Any Applications Accessing the Target DB Instance

Before starting a large load, stop all application activity accessing the target DB instance that you plan to load to. We recommend this particularly if other sessions will be modifying the tables being loaded or tables they reference. Doing this reduces the risk of constraint violations occurring during the load and improves load performance. It also makes it possible to restore the database instance to the point just before the load without losing changes made by processes not involved in the load.

Of course, this might not be possible or practical. If you are unable to stop applications from accessing the DB instance before the load, take steps to ensure the availability and integrity of your data. The specific steps required vary greatly depending upon specific use cases and site requirements.

Step 3: Create a DB Snapshot

If you plan to load data into a new DB instance that contains no data, you can skip this step. Otherwise, creating a DB snapshot of your DB instance allows you to restore the DB instance to the point just before the load, if it becomes necessary. As previously mentioned, when you initiate a DB snapshot, I/O operations to your database instance are suspended for a few minutes while the database is backed up.

In the example below, we use the AWS CLI `create-db-snapshot` command to create a DB snapshot of our AcmeRDS instance and give the DB snapshot the identifier "preload".

For Linux, macOS, or Unix:

```
aws rds create-db-snapshot \
    --db-instance-identifier AcmeRDS \
```

```
    --db-snapshot-identifier preload
```

For Windows:

```
aws rds create-db-snapshot ^
    --db-instance-identifier AcmeRDS ^
    --db-snapshot-identifier preload
```

You can also use the restore from DB snapshot functionality in order to create test database instances for dry runs or to "undo" changes made during the load.

Keep in mind that restoring a database from a DB snapshot creates a new DB instance that, like all DB instances, has a unique identifier and endpoint. If you need to restore the database instance without changing the endpoint, you must first delete the DB instance so that the endpoint can be reused.

For example, to create a DB instance for dry runs or other testing, you would give the DB instance its own identifier. In the example, "AcmeRDS-2" is the identifier and we would connect to the database instance using the endpoint associated with AcmeRDS-2.

For Linux, macOS, or Unix:

```
aws rds restore-db-instance-from-db-snapshot \
    --db-instance-identifier AcmeRDS-2 \
    --db-snapshot-identifier preload
```

For Windows:

```
aws rds restore-db-instance-from-db-snapshot ^
    --db-instance-identifier AcmeRDS-2 ^
    --db-snapshot-identifier preload
```

To reuse the existing endpoint, we must first delete the database instance and then give the restored database the same identifier.

For Linux, macOS, or Unix:

```
aws rds delete-db-instance \
    --db-instance-identifier AcmeRDS \
    --final-db-snapshot-identifier AcmeRDS-Final

aws rds restore-db-instance-from-db-snapshot \
    --db-instance-identifier AcmeRDS \
    --db-snapshot-identifier preload
```

For Windows:

```
aws rds delete-db-instance ^
    --db-instance-identifier AcmeRDS ^
    --final-db-snapshot-identifier AcmeRDS-Final

aws rds restore-db-instance-from-db-snapshot ^
    --db-instance-identifier AcmeRDS ^
    --db-snapshot-identifier preload
```

The example takes a final DB snapshot of the database instance before deleting it. This is optional, but recommended.

Step 4: Consider Disabling Amazon RDS Automated Backups

Warning
Do not disable automated backups if you need the ability to perform point-in-time recovery.

Disabling automated backups erases all existing backups, so point-in-time recovery is not possible after automated backups have been disabled. Disabling automated backups is a performance optimization and is not required for data loads. DB snapshots are not affected by disabling automated backups. All existing DB snapshots are still available for restore.

Disabling automated backups reduces load time by about 25 percent and reduce the amount of storage space required during the load. If you plan to load data into a new DB instance that contains no data, disabling backups is an easy way to speed up the load and avoid using the additional storage needed for backups. However, if you plan to load into a DB instance that already contains data, weigh the benefits of disabling backups against the impact of losing the ability to perform point-in-time-recovery.

DB instances have automated backups enabled by default (with a one day retention period). In order to disable automated backups, you must set the backup retention period to zero. After the load, you can re-enable backups by setting the backup retention period to a non-zero value. In order to enable or disable backups, Amazon RDS must shut the DB instance down and restart it in order to turn MySQL or MariaDB logging on or off.

Use the AWS CLI `modify-db-instance` command to set the backup retention to zero and apply the change immediately. Setting the retention period to zero requires a DB instance restart, so wait until the restart has completed before proceeding.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier AcmeRDS \
    --apply-immediately \
    --backup-retention-period 0
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier AcmeRDS ^
    --apply-immediately ^
    --backup-retention-period 0
```

You can check the status of your DB instance with the AWS CLI `describe-db-instances` command. The example displays the status of the AcmeRDS database instance and includes the --headers option to show column headings.

For Linux, macOS, or Unix:

```
aws rds describe-db-instances \
    --db-instance-identifier AcmeRDS \
    --headers
```

For Windows:

```
aws rds describe-db-instances ^
    --db-instance-identifier AcmeRDS ^
    --headers
```

When the Status column shows that the database is available, you're ready to proceed.

Step 5: Load the Data

Use the mysqlimport utility to load the flat files into Amazon RDS. In the example we tell mysqlimport to load all of the files named "sales" with an extension starting with "part_". This is a convenient way to load all of the files created in the "split" example. Use the --compress option to minimize network traffic. The --fields-terminated-by=',' option is used for CSV files and the --local option specifies that the incoming data is located on the client. Without the --local option, the Amazon RDS DB instance looks for the data on the database host, so always specify the --local option.

For Linux, macOS, or Unix:

```
mysqlimport --local \
    --compress \
    --user=username \
    --password \
    --host=hostname \
    --fields-terminated-by=',' Acme sales.part_*
```

For Windows:

```
mysqlimport --local ^
    --compress ^
    --user=username ^
    --password ^
    --host=hostname ^
    --fields-terminated-by=',' Acme sales.part_*
```

For very large data loads, take additional DB snapshots periodically between loading files and note which files have been loaded. If a problem occurs, you can easily resume from the point of the last DB snapshot, avoiding lengthy reloads.

Step 6: Enable Amazon RDS Automated Backups

After the load is finished, re-enable Amazon RDS automated backups by setting the backup retention period back to its pre-load value. As noted earlier, Amazon RDS restarts the DB instance, so be prepared for a brief outage.

In the example, we use the AWS CLI modify-db-instance command to enable automated backups for the AcmeRDS DB instance and set the retention period to 1 day.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier AcmeRDS \
    --backup-retention-period 1 \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier AcmeRDS ^
    --backup-retention-period 1 ^
    --apply-immediately
```

Working with MySQL Replication in Amazon RDS

You usually use read replicas to configure replication between Amazon RDS DB instances. For general information about read replicas, see Working with Read Replicas (p. 250). For specific information about working with read replicas on Amazon RDS MySQL, see Working with MySQL Read Replicas (p. 773).

You can use global transaction identifiers (GTIDs) for replication with Amazon RDS MySQL. For more information, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

You can also set up replication between an Amazon RDS MySQL DB instance and a MySQL or MariaDB instance that is external to Amazon RDS. For information about configuring replication with an external source, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).

For any of these replication options, you can use either row-based replication, statement-based, or mixed replication. Row-based replication only replicates the changed rows that result from a SQL statement. Statement-based replication replicates the entire SQL statement. Mixed replication uses statement-based replication when possible, but switches to row-based replication when SQL statements that are unsafe for statement-based replication are executed. In most cases, mixed replication is recommended. The binary log format of the DB instance determines whether replication is row-based, statement-based, or mixed. For information about setting the binary log format, see Binary Logging Format (p. 473).

> **Note**
> You can configure replication to import databases from a MySQL or MariaDB instance that is external to Amazon RDS, or to export databases to such instances. For more information, see Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756) and Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

Topics

Working with MySQL Read Replicas

This section contains specific information about working with read replicas on Amazon RDS MySQL. For general information about read replicas and instructions for using them, see Working with Read Replicas (p. 250).

Topics

Read Replica Configuration with MySQL

Before a MySQL DB instance can serve as a replication source, make sure to enable automatic backups on the source DB instance. To do this, set the backup retention period to a value other than 0. This requirement also applies to a read replica that is the source DB instance for another read replica. Automatic backups are supported only for read replicas running any version of MySQL 5.6 and later. You can configure replication based on binary log coordinates for a MySQL DB instance.

On Amazon RDS MySQL version 5.7.23 and later MySQL 5.7 versions, you can configure replication using global transaction identifiers (GTIDs). For more information, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

You can create up to five read replicas from one DB instance. For replication to operate effectively, each read replica should have the same amount of compute and storage resources as the source DB instance. If you scale the source DB instance, also scale the read replicas.

If a read replica is running any version of MySQL 5.6 and later, you can specify it as the source DB instance for another read replica. For example, you can create ReadReplica1 from MyDBInstance, and then create ReadReplica2 from ReadReplica1. Updates made to MyDBInstance are replicated to ReadReplica1 and then replicated from ReadReplica1 to ReadReplica2. You can't have more than four instances involved in a replication chain. For example, you can create ReadReplica1 from MySourceDBInstance, and then create ReadReplica2 from ReadReplica1, and then create ReadReplica3 from ReadReplica2, but you can't create a ReadReplica4 from ReadReplica3.

If you promote a MySQL read replica that is in turn replicating to other read replicas, those read replicas remain active. Consider an example where MyDBInstance1 replicates to MyDBInstance2, and MyDBInstance2 replicates to MyDBInstance3. If you promote MyDBInstance2, replication from MyDBInstance1 to MyDBInstance2 no longer occurs, but MyDBInstance2 still replicates to MyDBInstance3.

To enable automatic backups on a read replica for Amazon RDS MySQL version 5.6 and later, first create the read replica. Then modify the read replica to enable automatic backups.

You can run multiple read replica create or delete actions at the same time that reference the same source DB instance. To do this, stay within the limit of five read replicas for each source instance.

Preparing MySQL DB Instances That Use MyISAM

If your MySQL DB instance uses a nontransactional engine such as MyISAM, you need to perform the following steps to successfully set up your read replica. These steps are required to make sure that the read replica has a consistent copy of your data. These steps are not required if all of your tables use a transactional engine such as InnoDB.

1. Stop all data manipulation language (DML) and data definition language (DDL) operations on non-transactional tables in the source DB instance and wait for them to complete. SELECT statements can continue running.
2. Flush and lock the tables in the source DB instance.
3. Create the read replica using one of the methods in the following sections.
4. Check the progress of the read replica creation using, for example, the `DescribeDBInstances` API operation. Once the read replica is available, unlock the tables of the source DB instance and resume normal database operations.

Configuring Delayed Replication with MySQL

You can use delayed replication as a strategy for disaster recovery. With delayed replication, you specify the minimum amount of time, in seconds, to delay replication from the source to the read replica. In the event of a disaster, such as a table deleted unintentionally, you complete the following steps to recover from the disaster quickly:

- Stop replication to the read replica before the change that caused the disaster is sent to it.

Use the mysql.rds_stop_replication (p. 834) stored procedure to stop replication.

- Start replication and specify that replication stops automatically at a log file location.

  You specify a location just before the disaster using the mysql.rds_start_replication_until (p. 832) stored procedure.
- Promote the read replica to be the new source DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

Note

- On Amazon RDS MySQL 5.7, delayed replication is supported for MySQL 5.7.22 and later. On Amazon RDS MySQL 5.6, delayed replication is supported for MySQL 5.6.40 and later. Delayed replication is not supported on Amazon RDS MySQL 8.0.
- Use stored procedures to configure delayed replication. You can't configure delayed replication with the AWS Management Console, the AWS CLI, or the Amazon RDS API.
- On Amazon RDS MySQL 5.7.23 and later MySQL 5.7 versions, you can use GTID-based replication in a delayed replication configuration. If you use GTID-based replication, use the mysql.rds_start_replication_until_gtid (p. 833) stored procedure instead of the mysql.rds_start_replication_until (p. 832) stored procedure. For more information about GTID-based replication, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

Topics

Configuring Delayed Replication During Read Replica Creation

To configure delayed replication for any future read replica created from a DB instance, run the mysql.rds_set_configuration (p. 839) stored procedure with the `target delay` parameter.

To configure delayed replication during read replica creation

1. Using a MySQL client, connect to the MySQL DB instance to be the source for read replicas as the master user.
2. Run the mysql.rds_set_configuration (p. 839) stored procedure with the `target delay` parameter.

   For example, run the following stored procedure to specify that replication is delayed by at least one hour (3,600 seconds) for any read replica created from the current DB instance.

```
call mysql.rds_set_configuration('target delay', 3600);
```

Note
After running this stored procedure, any read replica you create using the AWS CLI or Amazon RDS API is configured with replication delayed by the specified number of seconds.

Modifying Delayed Replication for an Existing Read Replica

To modify delayed replication for an existing read replica, run the mysql.rds_set_source_delay (p. 831) stored procedure.

To modify delayed replication for an existing read replica

1. Using a MySQL client, connect to the read replica as the master user.
2. Use the mysql.rds_stop_replication (p. 834) stored procedure to stop replication.
3. Run the mysql.rds_set_source_delay (p. 831) stored procedure.

   For example, run the following stored procedure to specify that replication to the read replica is delayed by at least one hour (3600 seconds).

   ```
   call mysql.rds_set_source_delay(3600);
   ```
4. Use the mysql.rds_start_replication (p. 832) stored procedure to start replication.

Setting a Location to Stop Replication to a Read Replica

After stopping replication to the read replica, you can start replication and then stop it at a specified binary log file location using the mysql.rds_start_replication_until (p. 832) stored procedure.

To start replication to a read replica and stop replication at a specific location

1. Using a MySQL client, connect to the source MySQL DB instance as the master user.
2. Run the mysql.rds_start_replication_until (p. 832) stored procedure.

   The following example initiates replication and replicates changes until it reaches location `120` in the `mysql-bin-changelog.000777` binary log file. In a disaster recovery scenario, assume that location `120` is just before the disaster.

   ```
   call mysql.rds_start_replication_until(
     'mysql-bin-changelog.000777',
     120);
   ```

Replication stops automatically when the stop point is reached. The following RDS event is generated: `Replication has been stopped since the replica reached the stop point specified by the rds_start_replication_until stored procedure.`

After replication is stopped, in a disaster recovery scenario, you can Promoting a Read Replica to Be a Standalone DB Instance (p. 255) promote the read replica to be the new source DB instance. For information about promoting the read replica, see Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

Read Replica Updates with MySQL

Read replicas are designed to support read queries, but you might need occasional updates. For example, you might need to add an index to optimize the specific types of queries accessing the replica. You can enable updates by setting the `read_only` parameter to `0` in the DB parameter group for the read replica. Be careful when disabling read-only on a read replica because it can cause problems if the read replica becomes incompatible with the source DB instance. Change the value of the `read_only` parameter back to `1` as soon as possible.

Multi-AZ Read Replica Deployments with MySQL

You can create a read replica from either single-AZ or Multi-AZ DB instance deployments. You use Multi-AZ deployments to improve the durability and availability of critical data, but you can't use the Multi-AZ secondary to serve read-only queries. Instead, you can create read replicas from high-traffic Multi-AZ DB instances to offload read-only queries. If the source instance of a Multi-AZ deployment fails over to the secondary, any associated read replicas automatically switch to use the secondary (now primary) as their replication source. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

You can create a read replica as a Multi-AZ DB instance. Amazon RDS creates a standby of your replica in another Availability Zone for failover support for the replica. Creating your read replica as a Multi-AZ DB instance is independent of whether the source database is a Multi-AZ DB instance.

Note
To create a read replica as a Multi-AZ DB instance, the DB instance must be MySQL 5.6 or later.

Monitoring MySQL Read Replicas

For MySQL read replicas, you can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric. The `ReplicaLag` metric reports the value of the `Seconds_Behind_Master` field of the `SHOW SLAVE STATUS` command.

Common causes for replication lag for MySQL are the following:

- A network outage.
- Writing to tables that have different indexes on a read replica. If the `read_only` parameter is set to `0` on the read replica, replication can break if the read replica becomes incompatible with the source DB instance. After you've performed maintenance tasks on the read replica, we recommend that you set the `read_only` parameter back to `1`.
- Using a nontransactional storage engine such as MyISAM. Replication is only supported for the InnoDB storage engine on MySQL.

When the `ReplicaLag` metric reaches 0, the replica has caught up to the source DB instance. If the `ReplicaLag` metric returns -1, then replication is currently not active. `ReplicaLag` = -1 is equivalent to `Seconds_Behind_Master` = `NULL`.

Starting and Stopping Replication with MySQL Read Replicas

You can stop and restart the replication process on an Amazon RDS DB instance by calling the system stored procedures mysql.rds_stop_replication (p. 834) and mysql.rds_start_replication (p. 832). You can do this when replicating between two Amazon RDS instances for long-running operations such as creating large indexes. You also need to stop and start replication when importing or exporting databases. For more information, see Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756) and Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

If replication is stopped for more than 30 consecutive days, either manually or due to a replication error, Amazon RDS terminates replication between the source DB instance and all read replicas. It does so to prevent increased storage requirements on the source DB instance and long failover times. The read replica DB instance is still available. However, replication can't be resumed because the binary logs required by the read replica are deleted from the source DB instance after replication is terminated. You can create a new read replica for the source DB instance to reestablish replication.

Deleting Read Replicas with MySQL

To delete read replicas, do so explicitly using the same mechanisms as for deleting a DB instance. If you delete the source DB instance without deleting the replicas, each replica is promoted to a standalone DB instance.

Troubleshooting a MySQL Read Replica Problem

For MySQL DB instances, in some cases read replicas present replication errors or data inconsistencies between the read replica and its source DB instance. This problem occurs when some binary log (binlog) events or InnoDB redo logs aren't flushed during a failure of the read replica or the source DB instance. In these cases, manually delete and recreate the read replicas. You can reduce the chance of this happening by setting the following dynamic variable values: `sync_binlog=1`, `innodb_flush_log_at_trx_commit=1`, and `innodb_support_xa=1`. These settings might reduce performance, so test their impact before implementing the changes in a production environment. For MySQL 5.5, `sync_binlog` defaults to `0`, but in MySQL 5.6 and later, problems are less likely to occur because these parameters are all set to the recommended values by default.

The replication technologies for MySQL are asynchronous. Because they are asynchronous, occasional `BinLogDiskUsage` increases on the source DB instance and `ReplicaLag` on the read replica are to be expected. For example, a high volume of write operations to the source DB instance can occur in parallel. In contrast, write operations to the read replica are serialized using a single I/O thread, which can lead to a lag between the source instance and read replica. For more information about read-only replicas in the MySQL documentation, see Replication Implementation Details.

You can do several things to reduce the lag between updates to a source DB instance and the subsequent updates to the read replica, such as the following:

- Sizing a read replica to have a storage size and DB instance class comparable to the source DB instance.
- Ensuring that parameter settings in the DB parameter groups used by the source DB instance and the read replica are compatible. For more information and an example, see the discussion of the `max_allowed_packet` parameter later in this section.

Amazon RDS monitors the replication status of your read replicas and updates the `Replication State` field of the read replica instance to `Error` if replication stops for any reason. An example might be if DML queries run on your read replica conflict with the updates made on the source DB instance.

You can review the details of the associated error thrown by the MySQL engine by viewing the `Replication Error` field. Events that indicate the status of the read replica are also generated, including RDS-EVENT-0045 (p. 434), RDS-EVENT-0046 (p. 434), and RDS-EVENT-0047 (p. 432). For more information about events and subscribing to events, see Using Amazon RDS Event Notification (p. 429). If a MySQL error message is returned, review the error number in the MySQL error message documentation.

One common issue that can cause replication errors is when the value for the `max_allowed_packet` parameter for a read replica is less than the `max_allowed_packet` parameter for the source DB instance. The `max_allowed_packet` parameter is a custom parameter that you can set in a DB parameter group. You use `max_allowed_packet` to specify the maximum size of DML code that can be executed on the database. In some cases, the `max_allowed_packet` value in the DB parameter group associated with a source DB instance is smaller than the `max_allowed_packet` value in the DB parameter group associated with the source's read replica. In these cases, the replication process can throw the error `Packet bigger than 'max_allowed_packet' bytes` and stop replication. To fix the error, have the source and read replica use DB parameter groups with the same `max_allowed_packet` parameter values.

Other common situations that can cause replication errors include the following:

- Writing to tables on a read replica. In some cases, you might create indexes on a read replica that are different from the indexes on the source DB instance. If you do, set the `read_only` parameter to `0` to create the indexes. If you write to tables on the read replica, it might break replication if the read replica becomes incompatible with the source DB instance. After you perform maintenance tasks on the read replica, we recommend that you set the `read_only` parameter back to `1`.
- Using a non-transactional storage engine such as MyISAM. Read replicas require a transactional storage engine. Replication is only supported for the InnoDB storage engine on MySQL.
- Using unsafe nondeterministic queries such as `SYSDATE()`. For more information, see Determination of Safe and Unsafe Statements in Binary Logging.

If you decide that you can safely skip an error, you can follow the steps described in the section Skipping the Current Replication Error (p. 802). Otherwise, you can first delete the read replica. Then you create an instance using the same DB instance identifier so that the endpoint remains the same as that of your old read replica. If a replication error is fixed, the `Replication State` changes to *replicating*.

Using GTID-Based Replication for Amazon RDS MySQL

Following, you can learn how to use global transaction identifiers (GTIDs) with binary log (binlog) replication among Amazon RDS MySQL DB instances.

If you use binlog replication and aren't familiar with GTID-based replication with MySQL, see Replication with Global Transaction Identifiers in the MySQL documentation for background.

> **Note**
> GTID-based replication is supported for RDS MySQL version 5.7.23 and later MySQL 5.7 versions. All RDS MySQL DB instances in a replication configuration must meet this requirement. GTID-based replication isn't supported for RDS MySQL 5.5, 5.6, or 8.0.

Topics

> **Note**
> For information about configuring GTID-based replication with an external database, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).

Overview of Global Transaction Identifiers (GTIDs)

Global transaction identifiers (GTIDs) are unique identifiers generated for committed MySQL transactions. You can use GTIDs to make binlog replication simpler and easier to troubleshoot.

MySQL uses two different types of transactions for binlog replication:

- *GTID transactions* – Transactions that are identified by a GTID.
- *Anonymous transactions* – Transactions that don't have a GTID assigned.

In a replication configuration, GTIDs are unique across all DB instances. GTIDs simplify replication configuration because when you use them, you don't have to refer to log file positions. GTIDs also make it easier to track replicated transactions and determine whether masters and replicas are consistent.

You can use GTID-based replication to replicate data with Amazon RDS MySQL read replicas or with an external MySQL database. For RDS MySQL read replicas, you can configure GTID-based replication when you are creating new read replicas, or you can convert existing read replicas to use GTID-based replication.

You can also use GTID-based replication in a delayed replication configuration with RDS MySQL . For more information, see Configuring Delayed Replication with MySQL (p. 774).

Parameters for GTID-Based Replication

Use the following parameters to configure GTID-based replication.

Parameter	Valid Values	Description
`gtid_mode`	`OFF`, `OFF_PERMISSIVE`, `ON_PERMISSIVE`, `ON`	`OFF` specifies that new transactions are anonymous transactions (that is, don't have GTIDs), and a transaction must be anonymous to be replicated. `OFF_PERMISSIVE` specifies that new transactions are anonymous transactions, but all transactions can be replicated. `ON_PERMISSIVE` specifies that new transactions are GTID transactions, but all transactions can be replicated. `ON` specifies that new transactions are GTID transactions, and a transaction must be a GTID transaction to be replicated.
`enforce_gtid_consistency`	`OFF`, `ON`, `WARN`	`OFF` allows transactions to violate GTID consistency. `ON` prevents transactions from violating GTID consistency. `WARN` allows transactions to violate GTID consistency but generates a warning when a violation occurs.

For GTID-based replication, use these settings for the parameter group for your DB instance or read replica:

- `ON` and `ON_PERMISSIVE` apply only to outgoing replication from an RDS DB instance or Aurora MySQL cluster. Both of these values cause your RDS DB instance or Aurora DB cluster to use GTIDs for transactions that are replicated to an external database. `ON` requires that the external database also use GTID-based replication. `ON_PERMISSIVE` makes GTID-based replication optional on the external database.
- `OFF_PERMISSIVE`, if set, means that your RDS DB instances or Aurora DB cluster can accept incoming replication from an external database. It can do this whether the external database uses GTID-based replication or not.
- `OFF`, if set, means that your RDS DB instances or Aurora DB cluster only accept incoming replication from external databases that don't use GTID-based replication.

For more information about parameter groups, see Working with DB Parameter Groups (p. 202).

> **Note**
> In the AWS Management Console, the `gtid_mode` parameter appears as `gtid-mode`.

Configuring GTID-Based Replication for New Read Replicas

When GTID-based replication is enabled for an RDS MySQL DB instance, GTID-based replication is configured automatically for read replicas of the DB instance.

To enable GTID-based replication for new read replicas

1. Make sure that the parameter group associated with the DB instance has the following parameter settings:

- `gtid_mode` – `ON` or `ON_PERMISSIVE`
- `enforce_gtid_consistency` – `ON`

For more information about setting configuration parameters using parameter groups, see Working with DB Parameter Groups (p. 202).
2. If you changed the parameter group of the DB instance, reboot the DB instance. For more information on how to do so, see Rebooting a DB Instance (p. 247).
3. Create one or more read replicas of the DB instance. For more information on how to do so, see Creating a Read Replica (p. 253).

Amazon RDS attempts to establish GTID-based replication between the MySQL DB instance and the read replicas using the `MASTER_AUTO_POSITION`. If the attempt fails, Amazon RDS uses log file positions for replication with the read replicas. For more information about the `MASTER_AUTO_POSITION`, see GTID Auto-Positioning in the MySQL documentation.

Configuring GTID-Based Replication for Existing Read Replicas

For an existing RDS MySQL DB instance with read replicas that doesn't use GTID-based replication, you can configure GTID-based replication between the DB instance and the read replicas.

To enable GTID-based replication for existing read replicas

1. If the DB instance or any read replica is using RDS MySQL version 5.7.22 or lower, upgrade the DB instance or read replica. Upgrade to RDS MySQL version 5.7.23 or a later MySQL 5.7 version.

   For more information, see Upgrading the MySQL DB Engine (p. 733).
2. (Optional) Reset the GTID parameters and test the behavior of the DB instance and read replicas:

   a. Make sure that the parameter group associated with the DB instance and each read replica has the `enforce_gtid_consistency` parameter set to `WARN`.

      For more information about setting configuration parameters using parameter groups, see Working with DB Parameter Groups (p. 202).

   b. If you changed the parameter group of the DB instance, reboot the DB instance. If you changed the parameter group for a read replica, reboot the read replica.

      For more information, see Rebooting a DB Instance (p. 247).

   c. Run your DB instance and read replicas with your normal workload and monitor the log files.

      If you see warnings about GTID-incompatible transactions, adjust your application so that it only uses GTID-compatible features. Make sure that the DB instance is not generating any warnings about GTID-incompatible transactions before proceeding to the next step.
3. Reset the GTID parameters for GTID-based replication that allows anonymous transactions until the read replicas have processed all of them.

   a. Make sure that the parameter group associated with the DB instance and each read replica has the following parameter settings:

      - `gtid_mode` – `ON_PERMISSIVE`
      - `enforce_gtid_consistency` – `ON`

   b. If you changed the parameter group of the DB instance, reboot the DB instance. If you changed the parameter group for a read replica, reboot the read replica.
4. Wait for all of your anonymous transactions to be replicated. To check that these are replicated, do the following:

a. Run the following statement on your primary DB instance.

```
SHOW MASTER STATUS;
```

Note the values in the `File` and `Position` columns.

b. On each read replica, use the file and position information from its master in the previous step to run the following query.

```
SELECT MASTER_POS_WAIT(file, position);
```

For example, if the file name is `mysql-bin-changelog.000031` and the position is `107`, run the following statement.

```
SELECT MASTER_POS_WAIT(mysql-bin-changelog.000031, 107);
```

If the read replica is past the specified position, the query returns immediately. Otherwise, the function waits. Proceed to the next step when the query returns for all read replicas.

5. Reset the GTID parameters for GTID-based replication only.

   a. Make sure that the parameter group associated with the DB instance and each read replica has the following parameter settings:

      - `gtid_mode` – `ON`
      - `enforce_gtid_consistency` – `ON`

   b. Reboot the DB instance and each read replica.

6. On each read replica, run the following procedure.

```
CALL mysql.rds_set_master_auto_position(1);
```

Disabling GTID-Based Replication for an RDS MySQL DB Instance with Read Replicas

You can disable GTID-based replication for an RDS MySQL DB instance with read replicas.

To disable GTID-based replication for an RDS MySQL DB instance with read replicas

1. On each read replica, run the following procedure.

```
CALL mysql.rds_set_master_auto_position(0);
```

2. Reset the `gtid_mode` to `ON_PERMISSIVE`.

   a. Make sure that the parameter group associated with the RDS MySQL DB instance and each read replica has `gtid_mode` set to `ON_PERMISSIVE`.

      For more information about setting configuration parameters using parameter groups, see Working with DB Parameter Groups (p. 202).

   b. Reboot the RDS MySQL DB instance and each read replica. For more information about rebooting, see Rebooting a DB Instance (p. 247).

3. Reset the `gtid_mode` to `OFF_PERMISSIVE`:

   a. Make sure that the parameter group associated with the RDS MySQL DB instance and each read replica has `gtid_mode` set to `OFF_PERMISSIVE`.

   b. Reboot the RDS MySQL DB instance and each read replica.

4. Wait for all of the GTID transactions to be applied on all of the read replicas. To check that these are applied, do the following:

   Wait for all of the GTID transactions to be applied on the Aurora primary instance. To check that these are applied, do the following:

   a. On the RDS MySQL DB instance, run the `SHOW MASTER STATUS` command.

      Your output should be similar to the following.

```
File                        Position
------------------------------------
mysql-bin-changelog.000031      107
------------------------------------
```

      Note the file and position in your output.

   b. On each read replica, use the file and position information from its master in the previous step to run the following query.

```
SELECT MASTER_POS_WAIT(file, position);
```

      For example, if the file name is `mysql-bin-changelog.000031` and the position is `107`, run the following statement.

```
SELECT MASTER_POS_WAIT(mysql-bin-changelog.000031, 107);
```

      If the read replica is past the specified position, the query returns immediately. Otherwise, the function waits. When the query returns for all read replicas, go to the next step.

5. Reset the GTID parameters to disable GTID-based replication:

   a. Make sure that the parameter group associated with the RDS MySQL DB instance and each read replica has the following parameter settings:

      - `gtid_mode` – `OFF`
      - `enforce_gtid_consistency` – `OFF`

   b. Reboot the RDS MySQL DB instance and each read replica.

Replication with a MySQL or MariaDB Instance Running External to Amazon RDS

You can set up replication between an Amazon RDS MySQL or MariaDB DB instance and a MySQL or MariaDB instance that is external to Amazon RDS.

Topics

Before You Begin

You can configure replication using the binary log file position of replicated transactions. On Amazon RDS MySQL 5.7.23 and later MySQL 5.7 versions, you can also configure replication using global transaction identifiers (GTIDs).

The permissions required to start replication on an Amazon RDS DB instance are restricted and not available to your Amazon RDS master user. Because of this, make sure that you use the Amazon RDS mysql.rds_set_external_master (p. 822) and mysql.rds_start_replication (p. 832) commands to set up replication between your live database and your Amazon RDS database.

To set the binary logging format for a MySQL or MariaDB database, update the `binlog_format` parameter. If your DB instance uses the default DB instance parameter group, create a new DB parameter group to modify `binlog_format` settings. We recommend that you use the default setting for `binlog_format`, which is `MIXED`. However, you can also set `binlog_format` to `ROW` or `STATEMENT` if you need a specific binlog format. Reboot your DB instance for the change to take effect.

For information about setting the `binlog_format` parameter, see Binary Logging Format (p. 473). For information about the implications of different MySQL replication types, see Advantages and Disadvantages of Statement-Based and Row-Based Replication in the MySQL documentation.

> **Note**
> Use the procedure in this topic to configure replication in all cases except when the external instance is MariaDB version 10.0.2 or greater and the Amazon RDS instance is MariaDB. In that case, use the procedure at Configuring GTID-Based Replication into an Amazon RDS MariaDB DB instance (p. 526) to set up GTID-based replication.

Configuring Binary Log File Position Replication with an External Master Instance

Follow these guidelines when you set up an external replication master and a replica on Amazon RDS:

- Monitor failover events for the Amazon RDS DB instance that is your replica. If a failover occurs, then the DB instance that is your replica might be recreated on a new host with a different network address. For information on how to monitor failover events, see Using Amazon RDS Event Notification (p. 429).
- Maintain the binary logs (binlogs) on your master instance until you have verified that they have been applied to the replica. This maintenance makes sure that you can restore your master instance in the event of a failure.
- Turn on automated backups on your Amazon RDS DB instance. Turning on automated backups makes sure that you can restore your replica to a particular point in time if you need to re-synchronize your master and replica. For information on backups and point-in-time restore, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To configure binary log file replication with an external master instance

1. Make the source MySQL or MariaDB instance read-only.

```
mysql> FLUSH TABLES WITH READ LOCK;
mysql> SET GLOBAL read_only = ON;
```

2. Run the `SHOW MASTER STATUS` command on the source MySQL or MariaDB instance to determine the binlog location.

   You receive output similar to the following example.

```
File                        Position
------------------------------------
 mysql-bin-changelog.000031      107
------------------------------------
```

3. Copy the database from the external instance to the Amazon RDS DB instance using `mysqldump`. For very large databases, you might want to use the procedure in Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756).

   For Linux, macOS, or Unix:

```
mysqldump --databases <database_name> \
    --single-transaction \
    --compress \
    --order-by-primary \
    -u <local_user> \
    -p<local_password> | mysql \
        --host=hostname \
        --port=3306 \
        -u <RDS_user_name> \
        -p<RDS_password>
```

   For Windows:

```
mysqldump --databases <database_name> ^
    --single-transaction ^
    --compress ^
    --order-by-primary ^
    -u <local_user> ^
    -p<local_password> | mysql ^
        --host=hostname ^
        --port=3306 ^
        -u <RDS_user_name> ^
        -p<RDS_password>
```

   Note
   Make sure that there isn't a space between the `-p` option and the entered password.

   To specify the host name, user name, port, and password to connect to your Amazon RDS DB instance, use the `--host`, `--user (-u)`, `--port` and `-p` options in the `mysql` command. The host name is the Domain Name Service (DNS) name from the Amazon RDS DB instance endpoint, for example, `myinstance.123456789012.us-east-1.rds.amazonaws.com`. You can find the endpoint value in the instance details in the AWS Management Console.

4. Make the source MySQL or MariaDB instance writeable again.

```
mysql> SET GLOBAL read_only = OFF;
mysql> UNLOCK TABLES;
```

   For more information on making backups for use with replication, see Backing Up a Master or Slave by Making It Read Only in the MySQL documentation.

5. In the AWS Management Console, add the IP address of the server that hosts the external database to the VPC security group for the Amazon RDS DB instance. For more information on modifying a VPC security group, see Security Groups for Your VPC in the *Amazon Virtual Private Cloud User Guide*.

The IP address can change when the following conditions are met:

- You are using a public IP address for communication between the external master instance and the DB instance.
- The external master instance was stopped and restarted.

If these conditions are met, verify the IP address before adding it.

You might also need to configure your local network to permit connections from the IP address of your Amazon RDS DB instance. You do this so that your local network can communicate with your external MySQL or MariaDB instance. To find the IP address of the Amazon RDS DB instance, use the `host` command.

```
host <db_instance_endpoint>
```

The host name is the DNS name from the Amazon RDS DB instance endpoint.

6. Using the client of your choice, connect to the external instance and create a user to use for replication. Use this account solely for replication. and restrict it to your domain to improve security. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY '<password>';
```

7. For the external instance, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. For example, to grant the `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the '`repl_user`' user for your domain, issue the following command.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
 IDENTIFIED BY '<password>';
```

8. Make the Amazon RDS DB instance the replica. To do so, first connect to the Amazon RDS DB instance as the master user. Then identify the external MySQL or MariaDB database as the replication master by using the mysql.rds_set_external_master (p. 822) command. Use the master log file name and master log position that you determined in step 2. The following is an example.

```
CALL mysql.rds_set_external_master ('mymasterserver.mydomain.com', 3306, 'repl_user',
 '<password>', 'mysql-bin-changelog.000031', 107, 0);
```

Note
On Amazon RDS MySQL, you can choose to use delayed replication by running the mysql.rds_set_external_master_with_delay (p. 824) stored procedure instead. One reason to use delayed replication is to enable disaster recovery with the mysql.rds_start_replication_until (p. 832) stored procedure. Currently, delayed replication is not supported on Amazon RDS MariaDB.

9. On the Amazon RDS DB instance, issue the mysql.rds_start_replication (p. 832) command to start replication:

```
CALL mysql.rds_start_replication;
```

Configuring GTID-Based Replication with an External Master Instance

When you set up an external replication master and a replica on Amazon RDS, monitor failover events for the Amazon RDS DB instance that is your replica. If a failover occurs, then the DB instance that is your replica might be recreated on a new host with a different network address. For information on how to monitor failover events, see Using Amazon RDS Event Notification (p. 429).

> **Important**
> GTID-based replication is only supported on Amazon RDS MySQL version 5.7.23 and later MySQL 5.7 versions. GTID-based replication is not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

To configure GTID-based replication with an external master instance

1. Prepare for GTID-based replication:

   a. Make sure that the external MySQL or MariaDB database has GTID-based replication enabled. To do so, make sure that the external database has the following parameters set to the specified values:

      `gtid_mode` – `ON`

      `enforce_gtid_consistency` – `ON`

      For more information, see Replication with Global Transaction Identifiers in the MySQL documentation or Global Transaction ID in the MariaDB documentation.

   b. Make sure that the parameter group associated with the DB instance has the following parameter settings:

      - `gtid_mode` – `ON`, `ON_PERMISSIVE`, or `OFF_PERMISSIVE`
      - `enforce_gtid_consistency` – `ON`

      For more information about parameter groups, see Working with DB Parameter Groups (p. 202).

   c. If you changed the parameter group of the DB instance, reboot the DB instance. For more information, see Rebooting a DB Instance (p. 247).

2. Make the source MySQL or MariaDB instance read-only.

```
mysql> FLUSH TABLES WITH READ LOCK;
mysql> SET GLOBAL read_only = ON;
```

3. Copy the database from the external instance to the Amazon RDS DB instance using `mysqldump`. For very large databases, you might want to use the procedure in Importing Data to an Amazon RDS MySQL or MariaDB DB Instance with Reduced Downtime (p. 756).

   For Linux, macOS, or Unix:

```
mysqldump --databases <database_name> \
    --single-transaction \
    --compress \
    --order-by-primary \
    -u <local_user> \
    -p<local_password> | mysql \
        --host=hostname \
        --port=3306 \
        -u <RDS_user_name> \
        -p<RDS_password>
```

For Windows:

```
mysqldump --databases <database_name> ^
    --single-transaction ^
    --compress ^
    --order-by-primary ^
    -u <local_user> ^
    -p<local_password> | mysql ^
        --host=hostname ^
        --port=3306 ^
        -u <RDS_user_name> ^
        -p<RDS_password>
```

Note
Make sure that there is not a space between the `-p` option and the entered password.

To specify the host name, user name, port, and password to connect to your Amazon RDS DB instance, use the `--host`, `--user (-u)`, `--port` and `-p` options in the `mysql` command. The host name is the DNS name from the Amazon RDS DB instance endpoint, for example, `myinstance.123456789012.us-east-1.rds.amazonaws.com`. You can find the endpoint value in the instance details in the AWS Management Console.

4. Make the source MySQL or MariaDB instance writeable again.

```
mysql> SET GLOBAL read_only = OFF;
mysql> UNLOCK TABLES;
```

For more information on making backups for use with replication, see Backing Up a Master or Slave by Making It Read Only in the MySQL documentation.

5. In the AWS Management Console, add the IP address of the server that hosts the external database to the VPC security group for the Amazon RDS DB instance. For more information on modifying a VPC security group, see Security Groups for Your VPC in the *Amazon Virtual Private Cloud User Guide*.

The IP address can change when the following conditions are met:

- You are using a public IP address for communication between the external master instance and the DB instance.
- The external master instance was stopped and restarted.

If these conditions are met, verify the IP address before adding it.

You might also need to configure your local network to permit connections from the IP address of your Amazon RDS DB instance. You do this so that your local network can communicate with your external MySQL or MariaDB instance. To find the IP address of the Amazon RDS DB instance, use the `host` command.

```
host <db_instance_endpoint>
```

The host name is the DNS name from the Amazon RDS DB instance endpoint.

6. Using the client of your choice, connect to the external instance and create a user to use for replication. Use this account solely for replication. and restrict it to your domain to improve security. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY '<password>';
```

7. For the external instance, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. For example, to grant the `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the '`repl_user`' user for your domain, issue the following command.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
 IDENTIFIED BY '<password>';
```

8. Make the Amazon RDS DB instance the replica. To do so, first connect to the Amazon RDS DB instance as the master user. Then identify the external MySQL or MariaDB database as the replication master by using the mysql.rds_set_external_master_with_auto_position (p. 826) command. The following is an example.

```
CALL mysql.rds_set_external_master_with_auto_position ('mymasterserver.mydomain.com',
 3306, 'repl_user', '<password>', 0, 0);
```

   Note
   On Amazon RDS MySQL, you can choose to use delayed replication by running the mysql.rds_set_external_master_with_delay (p. 824) stored procedure instead.
   One reason to use delayed replication is to enable disaster recovery with the mysql.rds_start_replication_until_gtid (p. 833) stored procedure. Currently, delayed replication is not supported on Amazon RDS MariaDB.

9. On the Amazon RDS DB instance, issue the mysql.rds_start_replication (p. 832) command to start replication.

```
CALL mysql.rds_start_replication;
```

Exporting Data from a MySQL DB Instance by Using Replication

You can use replication to export data from a MySQL 5.6 or later DB instance to a MySQL instance running external to Amazon RDS. The MySQL instance external to Amazon RDS can be running either on-premises in your data center, or on an Amazon EC2 instance. The MySQL DB instance must be running version 5.6.13 or later. The MySQL instance external to Amazon RDS must be running the same version as the Amazon RDS instance, or a later version.

Replication to an instance of MySQL running external to Amazon RDS is only supported during the time it takes to export a database from a MySQL DB instance. The replication should be terminated when the data has been exported and applications can start accessing the external instance.

The following list shows the steps to take. Each step is discussed in more detail in later sections.

1. Prepare an instance of MySQL running external to Amazon RDS.
2. Configure the MySQL DB instance to be the replication source.
3. Use `mysqldump` to transfer the database from the Amazon RDS instance to the instance external to Amazon RDS.
4. Start replication to the instance running external to Amazon RDS.
5. After the export completes, stop replication.

Prepare an Instance of MySQL External to Amazon RDS

Install an instance of MySQL external to Amazon RDS.

Connect to the instance as the master user, and create the users required to support the administrators, applications, and services that access the instance.

Follow the directions in the MySQL documentation to prepare the instance of MySQL running external to Amazon RDS as a replica. For more information, see Setting the Replication Slave Configuration.

Configure an egress rule for the external instance to operate as a read replica during the export. The egress rule will allow the MySQL read replica to connect to the MySQL DB instance during replication. Specify an egress rule that allows TCP connections to the port and IP address of the source Amazon RDS MySQL DB instance.

If the read replica is running in an Amazon EC2 instance in an Amazon VPC, specify the egress rules in a VPC security group. If the read replica is running in an Amazon EC2 instance that is not in a VPC, specify the egress rule in an EC2-Classic security group. If the read replica is installed on-premises, specify the egress rule in a firewall.

If the read replica is running in a VPC, configure VPC ACL rules in addition to the security group egress rule. For more information about Amazon VPC network ACLs, see Network ACLs.

- ACL ingress rule allowing TCP traffic to ports 1024-65535 from the IP address of the source MySQL DB instance.
- ACL egress rule: allowing outbound TCP traffic to the port and IP address of the source MySQL DB instance.

We recommend setting the `max_allowed_packet` parameter to the maximum size to avoid replication errors.

Prepare the Replication Source

Prepare the MySQL DB instance as the replication source.

Ensure your client computer has enough disk space available to save the binary logs while setting up replication.

Create a replication account by following the directions in Creating a User For Replication.

Configure ingress rules on the system running the replication source MySQL DB instance that will allow the external MySQL read replica to connect during replication. Specify an ingress rule that allows TCP connections to the port used by the Amazon RDS instance from the IP address of the MySQL read replica running external to Amazon RDS.

If the Amazon RDS instance is running in a VPC, specify the ingress rules in a VPC security group. If the Amazon RDS instance is not running in an in a VPC, specify the ingress rules in a database security group.

If the Amazon RDS instance is running in a VPC, configure VPC ACL rules in addition to the security group ingress rule. For more information about Amazon VPC network ACLs, see Network ACLs.

- ACL ingress rule: allow TCP connections to the port used by the Amazon RDS instance from the IP address of the external MySQL read replica.
- ACL egress rule: allow TCP connections from ports 1024-65535 to the IP address of the external MySQL read replica.

Ensure that the backup retention period is set long enough that no binary logs are purged during the export. If any of the logs are purged before the export is complete, you must restart replication from the beginning. For more information about setting the backup retention period, see Working With Backups (p. 291).

Use the `mysql.rds_set_configuration` stored procedure to set the binary log retention period long enough that the binary logs are not purged during the export. For more information, see Accessing MySQL Binary Logs (p. 474).

To further ensure that the binary logs of the source instance are not purged, create an Amazon RDS read replica from the source instance. For more information, see Creating a Read Replica (p. 253). After the Amazon RDS read replica has been created, call the `mysql.rds_stop_replication` stored procedure to stop the replication process. The source instance will no longer purge its binary log files, so they will be available for the replication process.

We recommend setting both the `max_allowed_packet` parameter and the `slave_max_allowed_packet` parameter to the maximum size to avoid replication errors. The maximum size for both parameters is 1 GB. For information about setting parameters, see Modifying Parameters in a DB Parameter Group (p. 204).

Copy the Database

Run the MySQL `SHOW SLAVE STATUS` statement on the RDS read replica, and note the values for the following:

- `master_host`
- `master_port`
- `master_log_file`
- `exec_master_log_pos`

Use the `mysqldump` utility to create a snapshot, which copies the data from Amazon RDS to your local client computer. Then run another utility to load the data into the MySQL instance running external to RDS. Ensure your client computer has enough space to hold the `mysqldump` files from the databases to be replicated. This process can take several hours for very large databases. Follow the directions in Creating a Dump Snapshot Using mysqldump.

The following example shows how to run `mysqldump` on a client, and then pipe the dump into the `mysql` client utility, which loads the data into the external MySQL instance.

For Linux, macOS, or Unix:

```
mysqldump -h RDS instance endpoint \
    -u user \
    -p password \
    --port=3306 \
    --single-transaction \
    --routines \
    --triggers \
    --databases  database database2 \
    --compress  \
    --port 3306
```

For Windows:

```
mysqldump -h RDS instance endpoint ^
    -u user ^
    -p password ^
    --port=3306 ^
    --single-transaction ^
    --routines ^
    --triggers ^
    --databases  database database2 ^
    --compress  ^
    --port 3306
```

The following example shows how to run `mysqldump` on a client and write the dump to a file.

For Linux, macOS, or Unix:

```
mysqldump -h RDS instance endpoint \
    -u user \
    -p password \
    --port=3306 \
    --single-transaction \
    --routines \
    --triggers \
    --databases  database database2 > path/rds-dump.sql
```

For Windows:

```
mysqldump -h RDS instance endpoint ^
    -u user ^
    -p password ^
    --port=3306 ^
    --single-transaction ^
    --routines ^
    --triggers ^
    --databases  database database2 > path\rds-dump.sql
```

Complete the Export

After you have loaded the `mysqldump` files to create the databases on the MySQL instance running external to Amazon RDS, start replication from the source MySQL DB instance to export all source changes that have occurred after you stopped replication from the Amazon RDS read replica.

Use the MySQL `CHANGE MASTER` statement to configure the external MySQL instance. Specify the ID and password of the user granted REPLICATION SLAVE permissions. Specify the `master_host`, `master_port`, `relay_master_log_file` and `exec_master_log_pos` values you got from the Mysql `SHOW SLAVE STATUS` statement you ran on the RDS read replica. For more information, see Setting the Master Configuration on the Slave.

Use the MySQL `START SLAVE` command to initiate replication from the source MySQL DB instance and the MySQL replica.

Run the MySQL `SHOW SLAVE STATUS` command on the Amazon RDS instance to verify that it is operating as a read replica. For more information about interpreting the results, see SHOW SLAVE STATUS Syntax.

After replication on the MySQL instance has caught up with the Amazon RDS source, use the MySQL `STOP SLAVE` command to terminate replication from the source MySQL DB instance.

On the Amazon RDS read replica, call the `mysql.rds_start_replication` stored procedure. This will allow Amazon RDS to start purging the binary log files from the source MySQL DB instance.

Related Topics

- Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747)
- Backing Up and Restoring an Amazon RDS DB Instance (p. 290)

Options for MySQL DB Instances

This appendix describes options, or additional features, that are available for Amazon RDS instances running the MySQL DB engine. To enable these options, you can add them to a custom option group, and then associate the option group with your DB instance. For more information about working with option groups, see Working with Option Groups (p. 186).

Amazon RDS supports the following options for MySQL:

Option	Option ID	Engine Versions
MariaDB Audit Plugin Support (p. 795)	`MARIADB_AUDIT_PLUGIN`	All MySQL 5.6 versions MySQL 5.7.16 and later 5.7 versions
MySQL memcached Support (p. 798)	`MEMCACHED`	All MySQL 5.6, 5.7, and 8.0 versions

MariaDB Audit Plugin Support

Amazon RDS supports using the MariaDB Audit Plugin on MySQL database instances. The MariaDB Audit Plugin records database activity such as users logging on to the database, queries run against the database, and more. The record of database activity is stored in a log file.

Note
Currently, the MariaDB Audit Plugin is only supported for the following Amazon RDS MySQL versions:

- All 5.6 versions
- MySQL 5.7.16 and later 5.7 versions

Audit Plugin Option Settings

Amazon RDS supports the following settings for the MariaDB Audit Plugin option.

Option Setting	Valid Values	Default Value	Description
`SERVER_AUDIT_FILE_PATH`	`/rdsdbdata/log/audit/`	`/rdsdbdata/log/audit/`	The location of the log file. The log file contains the record of the activity specified in `SERVER_AUDIT_EVENTS`. For more information, see Viewing and Listing Database Log Files (p. 453) and MySQL Database Log Files (p. 468).
`SERVER_AUDIT_FILE_ROTATE_SIZE`	1–1000000000	1000000	The size in bytes that when reached, causes the file to rotate. For more information, see Log File Size (p. 472).
`SERVER_AUDIT_FILE_ROTATIONS`	0–100	9	The number of log rotations to save. For more information, see Log File Size (p. 472) and Downloading a Database Log File (p. 453).
`SERVER_AUDIT_EVENTS`	`CONNECT`, `QUERY`, `QUERY_DDL`, `QUERY_DML`, `QUERY_DCL`	`CONNECT`, `QUERY`	The types of activity to record in the log. Installing the MariaDB Audit Plugin is itself logged. • `CONNECT`: Log successful and unsuccessful connections to the database, and disconnections from the database. • `QUERY`: Log the text of all queries run against the database. • `QUERY_DDL`: Similar to the `QUERY` event, but returns only data definition language (DDL) queries (`CREATE`, `ALTER`, and so on). • `QUERY_DML`: Similar to the `QUERY` event, but returns only data manipulation language (DML) queries (`INSERT`, `UPDATE`, and so on, and also `SELECT`). • `QUERY_DCL`: Similar to the `QUERY` event, but returns only data control language (DCL) queries (`GRANT`, `REVOKE`, and so on). For MySQL, `TABLE` is not supported.

Option Setting	Valid Values	Default Value	Description
SERVER_AUDIT_INCL_USERS	Multiple comma-separated values	None	Include only activity from the specified users. By default, activity is recorded for all users. If a user is specified in both SERVER_AUDIT_EXCL_USERS and SERVER_AUDIT_INCL_USERS, then activity is recorded for the user.
SERVER_AUDIT_EXCL_USERS	Multiple comma-separated values	None	Exclude activity from the specified users. By default, activity is recorded for all users. If a user is specified in both SERVER_AUDIT_EXCL_USERS and SERVER_AUDIT_INCL_USERS, then activity is recorded for the user. The rdsadmin user queries the database every second to check the health of the database. Depending on your other settings, this activity can possibly cause the size of your log file to grow very large, very quickly. If you don't need to record this activity, add the rdsadmin user to the SERVER_AUDIT_EXCL_USERS list. **Note** CONNECT activity is always recorded for all users, even if the user is specified for this option setting.
SERVER_AUDIT_LOGGING	ON	ON	Logging is active. The only valid value is ON. Amazon RDS does not support deactivating logging. If you want to deactivate logging, remove the MariaDB Audit Plugin. For more information, see Removing the MariaDB Audit Plugin (p. 797).

Adding the MariaDB Audit Plugin

The general process for adding the MariaDB Audit Plugin to a DB instance is the following:

- Create a new option group, or copy or modify an existing option group
- Add the option to the option group
- Associate the option group with the DB instance

After you add the MariaDB Audit Plugin, you don't need to restart your DB instance. As soon as the option group is active, auditing begins immediately.

> **Important**
> Adding the MariaDB Audit Plugin to a DB instance might cause an outage. We recommend adding the MariaDB Audit Plugin during a maintenance window or during a time of low database workload.

To add the MariaDB Audit Plugin

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group. Choose **mysql** for **Engine**, and choose **5.6** or **5.7** for **Major engine version**. For more information, see Creating an Option Group (p. 187).

2. Add the **MARIADB_AUDIT_PLUGIN** option to the option group, and configure the option settings. For more information about adding options, see Adding an Option to an Option Group (p. 190). For more information about each setting, see Audit Plugin Option Settings (p. 795).
3. Apply the option group to a new or existing DB instance.
   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Viewing and Downloading the MariaDB Audit Plugin Log

After you enable the MariaDB Audit Plugin, you access the results in the log files the same way you access any other text-based log files. The audit log files are located at `/rdsdbdata/log/audit/`. For information about viewing the log file in the console, see Viewing and Listing Database Log Files (p. 453). For information about downloading the log file, see Downloading a Database Log File (p. 453).

Modifying MariaDB Audit Plugin Settings

After you enable the MariaDB Audit Plugin, you can modify the settings. For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see Audit Plugin Option Settings (p. 795).

Removing the MariaDB Audit Plugin

Amazon RDS doesn't support turning off logging in the MariaDB Audit Plugin. However, you can remove the plugin from a DB instance. When you remove the MariaDB Audit Plugin, the DB instance is restarted automatically to stop auditing.

To remove the MariaDB Audit Plugin from a DB instance, do one of the following:

- Remove the MariaDB Audit Plugin option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198)
- Modify the DB instance and specify a different option group that doesn't include the plugin. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

MySQL memcached Support

Amazon RDS supports using the `memcached` interface to InnoDB tables that was introduced in MySQL 5.6. The `memcached` API enables applications to use InnoDB tables in a manner similar to NoSQL key-value data stores.

The `memcached` interface is a simple, key-based cache. Applications use `memcached` to insert, manipulate, and retrieve key-value data pairs from the cache. MySQL 5.6 introduced a plugin that implements a daemon service that exposes data from InnoDB tables through the `memcached` protocol. For more information about the MySQL `memcached` plugin, see InnoDB Integration with memcached.

To enable memcached support for an Amazon RDS MySQL 5.6 or later instance

1. Determine the security group to use for controlling access to the `memcached` interface. If the set of applications already using the SQL interface are the same set that will access the `memcached` interface, you can use the existing VPC or DB security group used by the SQL interface. If a different set of applications will access the `memcached` interface, define a new VPC or DB security group. For more information about managing security groups, see Controlling Access with Security Groups (p. 1414)
2. Create a custom DB option group, selecting MySQL as the engine type and a 5.6 or later version. For more information about creating an option group, see Creating an Option Group (p. 187).
3. Add the `MEMCACHED` option to the option group. Specify the port that the `memcached` interface will use, and the security group to use in controlling access to the interface. For more information about adding options, see Adding an Option to an Option Group (p. 190).
4. Modify the option settings to configure the `memcached` parameters, if necessary. For more information about how to modify option settings, see Modifying an Option Setting (p. 195).
5. Apply the option group to an instance. Amazon RDS enables `memcached` support for that instance when the option group is applied:
   - You enable `memcached` support for a new instance by specifying the custom option group when you launch the instance. For more information about launching a MySQL instance, see Creating an Amazon RDS DB Instance (p. 136).
   - You enable `memcached` support for an existing instance by specifying the custom option group when you modify the instance. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).
6. Specify which columns in your MySQL tables can be accessed through the `memcached` interface. The `memcached` plug-in creates a catalog table named `containers` in a dedicated database named `innodb_memcache`. You insert a row into the `containers` table to map an InnoDB table for access through `memcached`. You specify a column in the InnoDB table that is used to store the `memcached` key values, and one or more columns that are used to store the data values associated with the key. You also specify a name that a `memcached` application uses to refer to that set of columns. For details on inserting rows in the `containers` table, see Internals of the InnoDB memcached Plugin. For an example of mapping an InnoDB table and accessing it through `memcached`, see Specifying the Table and Column Mappings for an InnoDB + memcached Application.
7. If the applications accessing the `memcached` interface are on different computers or EC2 instances than the applications using the SQL interface, add the connection information for those computers to the VPC or DB security group associated with the MySQL instance. For more information about managing security groups, see Controlling Access with Security Groups (p. 1414).

You turn off the `memcached` support for an instance by modifying the instance and specifying the default option group for your MySQL version. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

MySQL memcached Security Considerations

The memcached protocol does not support user authentication. For more information about MySQL memcached security considerations, see memcached Deployment and Using memcached as a MySQL Caching Layer.

You can take the following actions to help increase the security of the memcached interface:

- Specify a different port than the default of 11211 when adding the MEMCACHED option to the option group.
- Ensure that you associate the memcached interface with either a VPC or DB security group that limits access to known, trusted client addresses or EC2 instances. For more information about managing security groups, see Controlling Access with Security Groups (p. 1414).

MySQL memcached Connection Information

To access the memcached interface, an application must specify both the DNS name of the Amazon RDS instance and the memcached port number. For example, if an instance has a DNS name of my-cache-instance.cg034hpkmmjt.region.rds.amazonaws.com and the memcached interface is using port 11212, the connection information specified in PHP would be:

```
<?php

$cache = new Memcache;
$cache->connect('my-cache-instance.cg034hpkmmjt.region.rds.amazonaws.com',11212);
?>
```

To find the DNS name and memcached port of an Amazon RDS MySQL instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the top right corner of the AWS Management Console, select the region that contains the DB instance.
3. In the navigation pane, choose **Databases**.
4. Choose the MySQL DB instance name to display its details.
5. In the **Connect** section, note the value of the **Endpoint** field. The DNS name is the same as the endpoint. Also, note that the port in the **Connect** section is not used to access the memcached interface.
6. In the **Details** section, note the name listed in the **Option Group** field.
7. In the navigation pane, choose **Option groups**.
8. Choose the name of the option group used by the MySQL DB instance to show the option group details. In the **Options** section, note the value of the **Port** setting for the **MEMCACHED** option.

MySQL memcached Option Settings

Amazon RDS exposes the MySQL memcached parameters as option settings in the Amazon RDS MEMCACHED option.

MySQL memcached Parameters

- DAEMON_MEMCACHED_R_BATCH_SIZE – an integer that specifies how many memcached read operations (get) to perform before doing a COMMIT to start a new transaction. The allowed values are 1 to 4294967295; the default is 1. The option does not take effect until the instance is restarted.

- DAEMON_MEMCACHED_W_BATCH_SIZE – an integer that specifies how many memcached write operations, such as add, set, or incr, to perform before doing a COMMIT to start a new transaction. The allowed values are 1 to 4294967295; the default is 1. The option does not take effect until the instance is restarted.
- INNODB_API_BK_COMMIT_INTERVAL – an integer that specifies how often to auto-commit idle connections that use the InnoDB memcached interface. The allowed values are 1 to 1073741824; the default is 5. The option takes effect immediately, without requiring that you restart the instance.
- INNODB_API_DISABLE_ROWLOCK – a Boolean that disables (1 (true)) or enables (0 (false)) the use of row locks when using the InnoDB memcached interface. The default is 0 (false). The option does not take effect until the instance is restarted.
- INNODB_API_ENABLE_MDL – a Boolean that when set to 0 (false) locks the table used by the InnoDB memcached plugin, so that it cannot be dropped or altered by DDL through the SQL interface. The default is 0 (false). The option does not take effect until the instance is restarted.
- INNODB_API_TRX_LEVEL – an integer that specifies the transaction isolation level for queries processed by the memcached interface. The allowed values are 0 to 3. The default is 0. The option does not take effect until the instance is restarted.

Amazon RDS configures these MySQL memcached parameters, and they cannot be modified: DAEMON_MEMCACHED_LIB_NAME, DAEMON_MEMCACHED_LIB_PATH, and INNODB_API_ENABLE_BINLOG. The parameters that MySQL administrators set by using daemon_memcached_options are available as individual MEMCACHED option settings in Amazon RDS.

MySQL daemon_memcached_options Parameters

- BINDING_PROTOCOL – a string that specifies the binding protocol to use. The allowed values are auto, ascii, or binary. The default is auto, which means the server automatically negotiates the protocol with the client. The option does not take effect until the instance is restarted.
- BACKLOG_QUEUE_LIMIT – an integer that specifies how many network connections can be waiting to be processed by memcached. Increasing this limit may reduce errors received by a client that is not able to connect to the memcached instance, but does not improve the performance of the server. The allowed values are 1 to 2048; the default is 1024. The option does not take effect until the instance is restarted.
- CAS_DISABLED – a Boolean that enables (1 (true)) or disables (0 (false)) the use of compare and swap (CAS), which reduces the per-item size by 8 bytes. The default is 0 (false). The option does not take effect until the instance is restarted.
- CHUNK_SIZE – an integer that specifies the minimum chunk size, in bytes, to allocate for the smallest item's key, value, and flags. The allowed values are 1 to 48. The default is 48 and you can significantly improve memory efficiency with a lower value. The option does not take effect until the instance is restarted.
- CHUNK_SIZE_GROWTH_FACTOR – a float that controls the size of new chunks. The size of a new chunk is the size of the previous chunk times CHUNK_SIZE_GROWTH_FACTOR. The allowed values are 1 to 2; the default is 1.25. The option does not take effect until the instance is restarted.
- ERROR_ON_MEMORY_EXHAUSTED – a Boolean that when set to 1 (true) specifies that memcached will return an error rather than evicting items when there is no more memory to store items. If set to 0 (false), memcached will evict items if there is no more memory. The default is 0 (false). The option does not take effect until the instance is restarted.
- MAX_SIMULTANEOUS_CONNECTIONS – an integer that specifies the maximum number of concurrent connections. Setting this value to anything under 10 prevents MySQL from starting. The allowed values are 10 to 1024; the default is 1024. The option does not take effect until the instance is restarted.
- VERBOSITY – a string that specifies the level of information logged in the MySQL error log by the memcached service. The default is v. The option does not take effect until the instance is restarted. The allowed values are:

- `v` – Logs errors and warnings while executing the main event loop.
- `vv` – In addition to the information logged by v, also logs each client command and the response.
- `vvv` – In addition to the information logged by vv, also logs internal state transitions.

Amazon RDS configures these MySQL `DAEMON_MEMCACHED_OPTIONS` parameters, they cannot be modified: `DAEMON_PROCESS`, `LARGE_MEMORY_PAGES`, `MAXIMUM_CORE_FILE_LIMIT`, `MAX_ITEM_SIZE`, `LOCK_DOWN_PAGE_MEMORY`, `MASK`, `IDFILE`, `REQUESTS_PER_EVENT`, `SOCKET`, and `USER`.

Common DBA Tasks for MySQL DB Instances

This section describes the Amazon RDS-specific implementations of some common DBA tasks for DB instances running the MySQL database engine. In order to deliver a managed service experience, Amazon RDS does not provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges.

For information about working with MySQL log files on Amazon RDS, see MySQL Database Log Files (p. 468)

Topics

Killing a Session or Query

You can terminate user sessions or queries on DB instances by using the `rds_kill` and `rds_kill_query` commands. First connect to your MySQL database instance, then issue the appropriate command as shown following. For more information, see Connecting to a DB Instance Running the MySQL Database Engine (p. 722).

```
CALL mysql.rds_kill(thread-ID)
CALL mysql.rds_kill_query(thread-ID)
```

For example, to kill the session that is running on thread 99, you would type the following:

```
CALL mysql.rds_kill(99);
```

To kill the query that is running on thread 99, you would type the following:

```
CALL mysql.rds_kill_query(99);
```

Skipping the Current Replication Error

Amazon RDS provides a mechanism for you to skip an error on your read replicas if the error is causing your read replica to hang and the error doesn't affect the integrity of your data. First connect to your MySQL database instance, then issue the appropriate commands as shown following. For more information, see Connecting to a DB Instance Running the MySQL Database Engine (p. 722).

> **Note**
> You should first verify that the error can be safely skipped. In a MySQL utility, connect to the read replica and run the following MySQL command:
>
> ```
> SHOW SLAVE STATUS\G
> ```
>
> For information about the values returned, go to SHOW SLAVE STATUS Syntax in the MySQL documentation.

To skip the error, you can issue the following command:

```
CALL mysql.rds_skip_repl_error;
```

This command has no effect if you run it on the source DB instance, or on a read replica that has not encountered a replication error.

For more information, such as the versions of MySQL that support `mysql.rds_skip_repl_error`, see mysql.rds_skip_repl_error (p. 835).

Important

If you attempt to call *mysql.rds_skip_repl_error* and encounter the following error: `ERROR 1305 (42000): PROCEDURE mysql.rds_skip_repl_error does not exist`, then upgrade your MySQL DB instance to the latest minor version or one of the minimum minor versions listed in mysql.rds_skip_repl_error (p. 835).

Working with InnoDB Tablespaces to Improve Crash Recovery Times

Every table in MySQL consists of a table definition, data, and indexes. The MySQL storage engine InnoDB stores table data and indexes in a *tablespace*. InnoDB creates a global shared tablespace that contains a data dictionary and other relevant metadata, and it can contain table data and indexes. InnoDB can also create separate tablespaces for each table and partition. These separate tablespaces are stored in files with a .ibd extension and the header of each tablespace contains a number that uniquely identifies it.

Amazon RDS provides a parameter in a MySQL parameter group called `innodb_file_per_table`. This parameters controls whether InnoDB adds new table data and indexes to the shared tablespace (by setting the parameter value to 0) or to individual tablespaces (by setting the parameter value to 1). Amazon RDS sets the default value for `innodb_file_per_table` parameter to 1, which allows you to drop individual InnoDB tables and reclaim storage used by those tables for the DB instance. In most use cases, setting the `innodb_file_per_table` parameter to 1 is the recommended setting.

You should set the `innodb_file_per_table` parameter to 0 when you have a large number of tables, such as over 1000 tables when you use standard (magnetic) or general purpose SSD storage or over 10,000 tables when you use Provisioned IOPS storage. When you set this parameter to 0, individual tablespaces are not created and this can improve the time it takes for database crash recovery.

MySQL processes each metadata file, which includes tablespaces, during the crash recovery cycle. The time it takes MySQL to process the metadata information in the shared tablespace is negligible compared to the time it takes to process thousands of tablespace files when there are multiple tablespaces. Because the tablespace number is stored within the header of each file, the aggregate time to read all the tablespace files can take up to several hours. For example, a million InnoDB tablespaces on standard storage can take from five to eight hours to process during a crash recovery cycle. In some cases, InnoDB can determine that it needs additional cleanup after a crash recovery cycle so it will begin another crash recovery cycle, which will extend the recovery time. Keep in mind that a crash recovery cycle also entails rolling-back transactions, fixing broken pages, and other operations in addition to the processing of tablespace information.

Since the `innodb_file_per_table` parameter resides in a parameter group, you can change the parameter value by editing the parameter group used by your DB instance without having to reboot the DB instance. After the setting is changed, for example, from 1 (create individual tables) to 0 (use shared tablespace), new InnoDB tables will be added to the shared tablespace while existing tables continue to have individual tablespaces. To move an InnoDB table to the shared tablespace, you must use the `ALTER TABLE` command.

Migrating Multiple Tablespaces to the Shared Tablespace

You can move an InnoDB table's metadata from its own tablespace to the shared tablespace, which will rebuild the table metadata according to the `innodb_file_per_table` parameter setting. First connect to your MySQL database instance, then issue the appropriate commands as shown following. For more information, see Connecting to a DB Instance Running the MySQL Database Engine (p. 722).

```
ALTER TABLE table_name ENGINE = InnoDB, ALGORITHM=COPY;
```

For example, the following query returns an `ALTER TABLE` statement for every InnoDB table that is not in the shared tablespace.

```
SELECT CONCAT('ALTER TABLE `',
REPLACE(LEFT(NAME , INSTR((NAME), '/') - 1), '`', '``'), '`.`',
REPLACE(SUBSTR(NAME FROM INSTR(NAME, '/') + 1), '`', '``'), '` ENGINE=InnoDB,
 ALGORITHM=COPY;') AS Query
FROM INFORMATION_SCHEMA.INNODB_SYS_TABLES
WHERE SPACE <> 0 AND LEFT(NAME, INSTR((NAME), '/') - 1) NOT IN ('mysql','');
```

Note
This query is supported on MySQL 5.6 and later.

Rebuilding a MySQL table to move the table's metadata to the shared tablespace requires additional storage space temporarily to rebuild the table, so the DB instance must have storage space available. During rebuilding, the table is locked and inaccessible to queries. For small tables or tables not frequently accessed, this might not be an issue. For large tables or tables frequently accessed in a heavily concurrent environment, you can rebuild tables on a read replica.

You can create a read replica and migrate table metadata to the shared tablespace on the read replica. While the ALTER TABLE statement blocks access on the read replica, the source DB instance is not affected. The source DB instance will continue to generate its binary logs while the read replica lags during the table rebuilding process. Because the rebuilding requires additional storage space and the replay log file can become large, you should create a read replica with storage allocated that is larger than the source DB instance.

To create a read replica and rebuild InnoDB tables to use the shared tablespace, take the following steps:

1. Make sure that backup retention is enabled on the source DB instance so that binary logging is enabled.
2. Use the AWS Management Console or AWS CLI to create a read replica for the source DB instance. Because the creation of a read replica involves many of the same processes as crash recovery, the creation process can take some time if there is a large number of InnoDB tablespaces. Allocate more storage space on the read replica than is currently used on the source DB instance.
3. When the read replica has been created, create a parameter group with the parameter settings `read_only = 0` and `innodb_file_per_table = 0`. Then associate the parameter group with the read replica.
4. Issue ALTER TABLE <name> ENGINE = InnoDB for all tables that you want migrated on the replica.
5. When all of your ALTER TABLE statements have completed on the read replica, verify that the read replica is connected to the source DB instance and that the two instances are in sync.
6. Use the console or CLI to promote the read replica to be the instance. Make sure that the parameter group used for the new master has the `innodb_file_per_table` parameter set to 0. Change the name of the new master, and point any applications to the new master instance.

Managing the Global Status History

MySQL maintains many status variables that provide information about its operation. Their value can help you detect locking or memory issues on a DB instance . The values of these status variables are cumulative since last time the DB instance was started. You can reset most status variables to 0 by using the `FLUSH STATUS` command.

To allow for monitoring of these values over time, Amazon RDS provides a set of procedures that will snapshot the values of these status variables over time and write them to a table, along with any changes since the last snapshot. This infrastructure, called Global Status History (GoSH), is installed on all MySQL DB instances starting with versions 5.5.23. GoSH is disabled by default.

To enable GoSH, you first enable the event scheduler from a DB parameter group by setting the parameter event_scheduler to ON. For information about creating and modifying a DB parameter group, see Working with DB Parameter Groups (p. 202).

You can then use the procedures in the following table to enable and configure GoSH. First connect to your MySQL database instance, then issue the appropriate commands as shown following. For more information, see Connecting to a DB Instance Running the MySQL Database Engine (p. 722). For each procedure, type the following:

```
CALL procedure-name;
```

Where *procedure-name* is one of the procedures in the table.

Procedure	Description
`mysql.rds_enable_gsh_collector`	Enables GoSH to take default snapshots at intervals specified by `rds_set_gsh_collector`.
`mysql.rds_set_gsh_collector`	Specifies the interval, in minutes, between snapshots. Default value is 5.
`mysql.rds_disable_gsh_collector`	Disables snapshots.
`mysql.rds_collect_global_status_history`	Takes a snapshot on demand.
`mysql.rds_enable_gsh_rotation`	Enables rotation of the contents of the `mysql.rds_global_status_history` table to `mysql.rds_global_status_history_old` at intervals specified by `rds_set_gsh_rotation`.
`mysql.rds_set_gsh_rotation`	Specifies the interval, in days, between table rotations. Default value is 7.
`mysql.rds_disable_gsh_rotation`	Disables table rotation.
`mysql.rds_rotate_global_status_history`	Rotates the contents of the `mysql.rds_global_status_history` table to `mysql.rds_global_status_history_old` on demand.

When GoSH is running, you can query the tables that it writes to. For example, to query the hit ratio of the Innodb buffer pool, you would issue the following query:

```
select a.collection_end, a.collection_start, (( a.variable_Delta-b.variable_delta)/
a.variable_delta)*100 as "HitRatio"
    from mysql.rds_global_status_history as a join mysql.rds_global_status_history as b on
 a.collection_end = b.collection_end
    where a. variable_name = 'Innodb_buffer_pool_read_requests' and b.variable_name =
 'Innodb_buffer_pool_reads'
```

Using Kerberos Authentication for MySQL

You can use Kerberos authentication to authenticate users when they connect to your MySQL DB instance. The DB instance works with AWS Directory Service for Microsoft Active Directory (AWS Managed Microsoft AD) to enable Kerberos authentication. When users authenticate with a MySQL DB instance joined to the trusting domain, authentication requests are forwarded. Forwarded requests go to the domain directory that you create with AWS Directory Service.

Keeping all of your credentials in the same directory can save you time and effort. With this approach, you have a centralized place for storing and managing credentials for multiple DB instances. Using a directory can also improve your overall security profile.

To set up Kerberos authentication for a MySQL DB instance, complete the following general steps, described in more detail later:

1. Use AWS Managed Microsoft AD to create an AWS Managed Microsoft AD directory. You can use the AWS Management Console, the AWS CLI, or the AWS Directory Service API to create the directory. For details about doing so, see Create Your AWS Managed Microsoft AD Directory in the *AWS Directory Service Administration Guide*.
2. Create an AWS Identity and Access Management (IAM) role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`. The role allows Amazon RDS to make calls to your directory.

   For the role to allow access, the AWS Security Token Service (AWS STS) endpoint must be activated in the AWS Region for your AWS account. AWS STS endpoints are active by default in all AWS Regions, and you can use them without any further actions. For more information, see Activating and Deactivating AWS STS in an AWS Region in the *IAM User Guide*.
3. Create and configure users in the AWS Managed Microsoft AD directory using the Microsoft Active Directory tools. For more information about creating users in your Active Directory, see Manage Users and Groups in AWS Managed Microsoft AD in the *AWS Directory Service Administration Guide*.
4. Create or modify a MySQL DB instance. If you use either the CLI or RDS API in the create request, specify a domain identifier with the `Domain` parameter. Use the `d-*` identifier that was generated when you created your directory and the name of the role that you created.

   If you modify an existing MySQL DB instance to use Kerberos authentication, set the domain and IAM role parameters for the DB instance. Locate the DB instance in the same VPC as the domain directory.
5. Use the Amazon RDS master user credentials to connect to the MySQL DB instance. Create the user in MySQL using the `CREATE USER` clause `IDENTIFIED WITH 'auth_pam'`. Users that you create this way can log in to the MySQL DB instance using Kerberos authentication.

Setting Up Kerberos Authentication for MySQL DB instances

You use AWS Managed Microsoft AD to set up Kerberos authentication for a MySQL DB instance. To set up Kerberos authentication, you take the following steps.

Step 1: Create a Directory Using AWS Managed Microsoft AD

AWS Directory Service creates a fully managed Active Directory in the AWS Cloud. When you create an AWS Managed Microsoft AD directory, AWS Directory Service creates two domain controllers and Domain Name System (DNS) servers on your behalf. The directory servers are created in different subnets in a VPC. This redundancy helps make sure that your directory remains accessible even if a failure occurs.

When you create an AWS Managed Microsoft AD directory, AWS Directory Service performs the following tasks on your behalf:

- Sets up an Active Directory within the VPC.
- Creates a directory administrator account with the user name Admin and the specified password. You use this account to manage your directory.

  Note
  Be sure to save this password. AWS Directory Service doesn't store it. You can reset it, but you can't retrieve it.
- Creates a security group for the directory controllers.

When you launch an AWS Managed Microsoft AD, AWS creates an Organizational Unit (OU) that contains all of your directory's objects. This OU has the NetBIOS name that you typed when you created your directory and is located in the domain root. The domain root is owned and managed by AWS.

The Admin account that was created with your AWS Managed Microsoft AD directory has permissions for the most common administrative activities for your OU:

- Create, update, or delete users
- Add resources to your domain such as file or print servers, and then assign permissions for those resources to users in your OU
- Create additional OUs and containers
- Delegate authority
- Restore deleted objects from the Active Directory Recycle Bin
- Run AD and DNS Windows PowerShell modules on the Active Directory Web Service

The Admin account also has rights to perform the following domain-wide activities:

- Manage DNS configurations (add, remove, or update records, zones, and forwarders)
- View DNS event logs
- View security event logs

To create a directory with AWS Managed Microsoft AD

1. Sign in to the AWS Management Console and open the AWS Directory Service console at https://console.aws.amazon.com/directoryservicev2/.
2. In the navigation pane, choose **Directories** and choose **Set up Directory**.
3. Choose **AWS Managed Microsoft AD**. AWS Managed Microsoft AD is the only option that you can currently use with Amazon RDS.
4. Enter the following information:

   Directory DNS name

   The fully qualified name for the directory, such as **`corp.example.com`**.

   Directory NetBIOS name

   The short name for the directory, such as **`CORP`**.

   Directory description

   (Optional) A description for the directory.

   Admin password

   The password for the directory administrator. The directory creation process creates an administrator account with the user name Admin and this password.

The directory administrator password and can't include the word "admin." The password is case-sensitive and must be 8–64 characters in length. It must also contain at least one character from three of the following four categories:

- Lowercase letters (a–z)
- Uppercase letters (A–Z)
- Numbers (0–9)
- Non-alphanumeric characters (~!@#$%^&*_-+=`|\(){}[]:;"'<>,.?/)

Confirm password

The administrator password retyped.

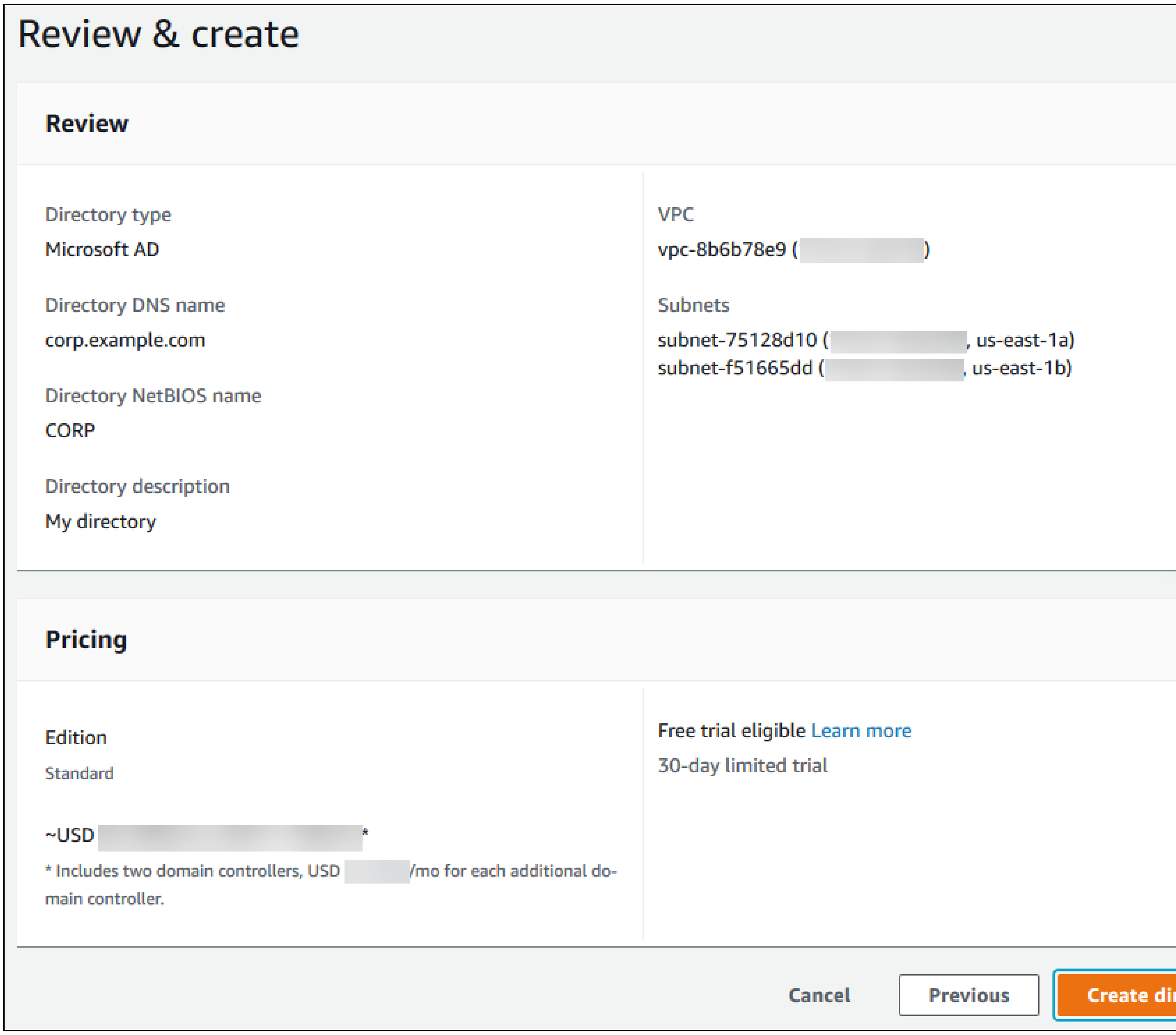
5. Choose **Next**.
6. Enter the following information in the **Networking** section and then choose **Next**:

   VPC

   The VPC for the directory. Create the MySQL DB instance in this same VPC.

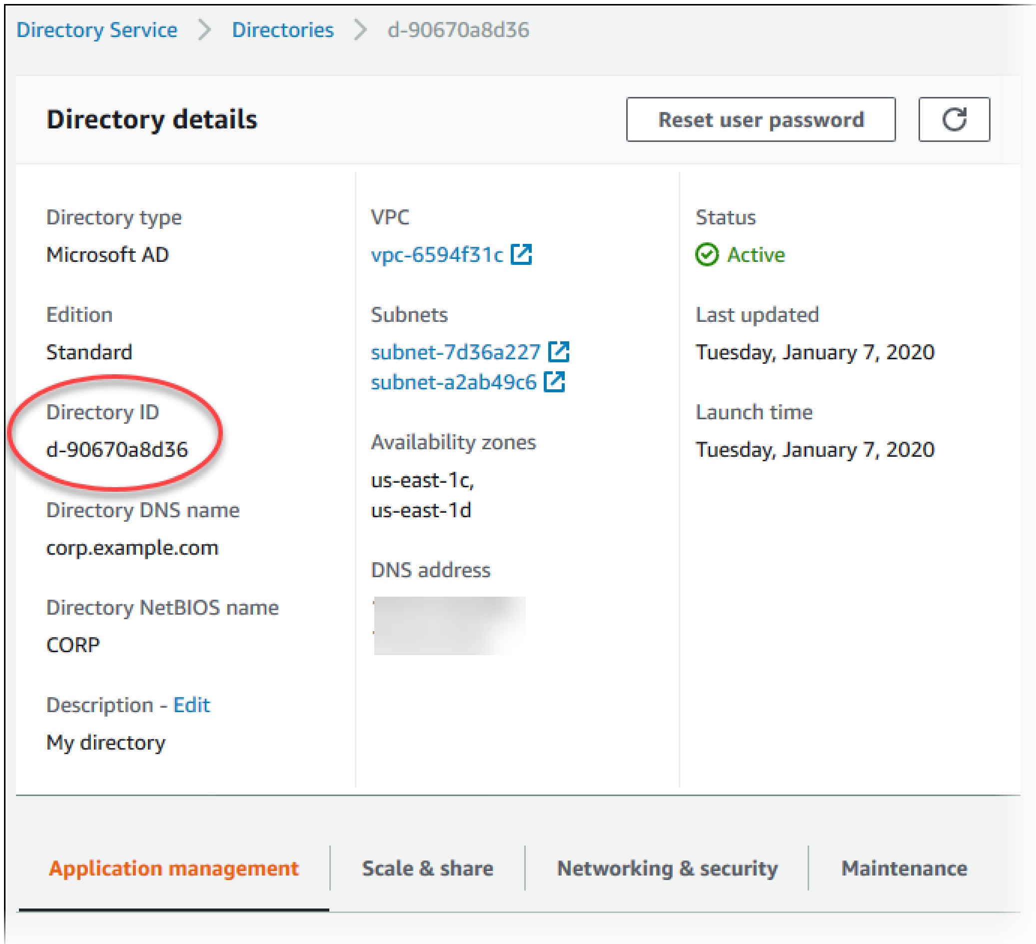
   Subnets

   Subnets for the directory servers. The two subnets must be in different Availability Zones.
7. Review the directory information and make any necessary changes. When the information is correct, choose **Create directory**.



It takes several minutes for the directory to be created. When it has been successfully created, the **Status** value changes to **Active**.

To see information about your directory, choose the directory name in the directory listing. Note the **Directory ID** value because you need this value when you create or modify your MySQL DB instance.



Step 2: Create the IAM Role for Use by Amazon RDS

For Amazon RDS to call AWS Directory Service for you, an IAM role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess` is required. This role allows Amazon RDS to make calls to the AWS Directory Service.

When a DB instance is created using the AWS Management Console and the console user has the `iam:CreateRole` permission, the console creates this role automatically. In this case, the role name is `rds-directoryservice-kerberos-access-role`. Otherwise, you must create the IAM role manually. When you create this IAM role, choose `Directory Service`, and attach the AWS managed policy `AmazonRDSDirectoryServiceAccess` to it.

For more information about creating IAM roles for a service, see Creating a Role to Delegate Permissions to an AWS Service in the *IAM User Guide*.

Note
The IAM role used for Windows Authentication for RDS for Microsoft SQL Server can't be used for RDS for MySQL.

Optionally, you can create policies with the required permissions instead of using the managed IAM policy `AmazonRDSDirectoryServiceAccess`. In this case, the IAM role must have the following IAM trust policy.

```
{
```

```
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": [
          "directoryservice.rds.amazonaws.com",
          "rds.amazonaws.com"
        ]
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

The role must also have the following IAM role policy.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "ds:DescribeDirectories",
        "ds:AuthorizeApplication",
        "ds:UnauthorizeApplication",
        "ds:GetAuthorizedApplicationDetails"
      ],
    "Effect": "Allow",
    "Resource": "*"
    }
  ]
}
```

Step 3: Create and Configure Users

You can create users with the Active Directory Users and Computers tool. This tool is part of the Active Directory Domain Services and Active Directory Lightweight Directory Services tools. Users represent individual people or entities that have access to your directory.

To create users in an AWS Directory Service directory, you must be connected to an Amazon EC2 instance based on Microsoft Windows. This instance must be a member of the AWS Directory Service directory and be logged in as a user that has privileges to create users. For more information, see Manage Users and Groups in AWS Managed Microsoft AD in the *AWS Directory Service Administration Guide*.

Step 4: Create or Modify a MySQL DB Instance

Create or modify a MySQL DB instance for use with your directory. You can use the console, CLI, or RDS API to associate a DB instance with a directory. You can do this in one of the following ways:

- Create a new MySQL DB instance using the console, the create-db-instance CLI command, or the CreateDBInstance RDS API operation.

  For instructions, see Creating an Amazon RDS DB Instance (p. 136).
- Modify an existing MySQL DB instance using the console, the modify-db-instance CLI command, or the ModifyDBInstance RDS API operation.

  For instructions, see Modifying an Amazon RDS DB Instance (p. 220).
- Restore a MySQL DB instance from a DB snapshot using the console, the restore-db-instance-from-db-snapshot CLI command, or the RestoreDBInstanceFromDBSnapshot RDS API operation.

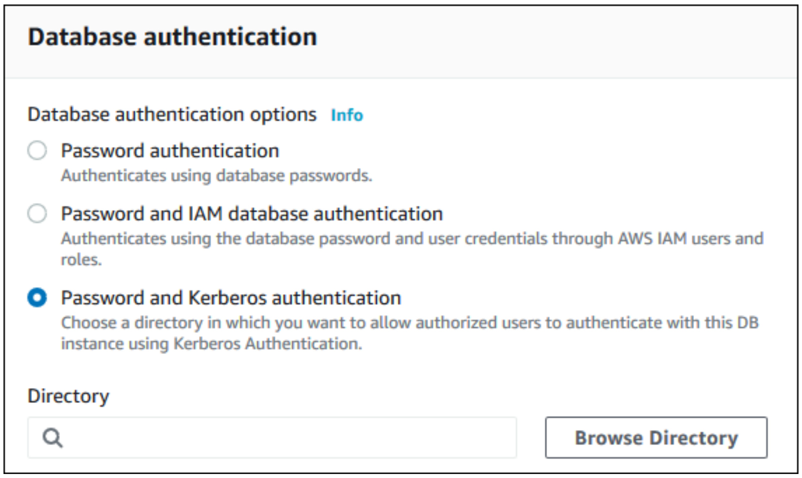
For instructions, see Restoring from a DB Snapshot (p. 303).

- Restore a MySQL DB instance to a point-in-time using the console, the restore-db-instance-to-point-in-time CLI command, or the RestoreDBInstanceToPointInTime RDS API operation.

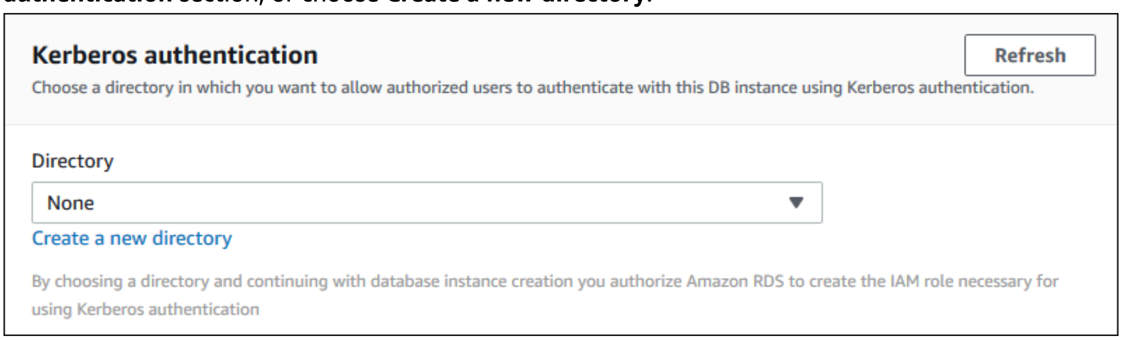
  For instructions, see Restoring a DB Instance to a Specified Time (p. 336).

Kerberos authentication is only supported for MySQL DB instances in a VPC. The DB instance can be in the same VPC as the directory, or in a different VPC. The DB instance must use a security group that allows egress within the directory's VPC so the DB instance can communicate with the directory.

When you use the console to create a DB instance, choose **Password and Kerberos authentication** in the **Database authentication** section. Choose **Browse Directory** and then select the directory, or choose **Create a new directory**.



When you use the console to modify or restore a DB instance, choose the directory in the **Kerberos authentication** section, or choose **Create a new directory**.



Use the CLI or RDS API to associate a DB instance with a directory. The following parameters are required for the DB instance to be able to use the domain directory you created:

- For the `--domain` parameter, use the domain identifier ("d-*" identifier) generated when you created the directory.
- For the `--domain-iam-role-name` parameter, use the role you created that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`.

For example, the following CLI command modifies a DB instance to use a directory.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --domain d-ID \
    --domain-iam-role-name role-name
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --domain d-ID ^
    --domain-iam-role-name role-name
```

Important
If you modify a DB instance to enable Kerberos authentication, reboot the DB instance after making the change.

Step 5: Create Kerberos Authentication MySQL Logins

Use the Amazon RDS master user credentials to connect to the MySQL DB instance as you do any other DB instance. The DB instance is joined to the AWS Managed Microsoft AD domain. Thus, you can provision MySQL logins and users from the Active Directory users and groups in your domain. Database permissions are managed through standard MySQL permissions that are granted to and revoked from these logins.

You can allow an Active Directory user to authenticate with MySQL. To do this, first use the Amazon RDS master user credentials to connect to the MySQL DB instance as with any other DB instance. After you're logged in, create an externally authenticated user in MySQL as shown following.

```
CREATE USER 'testuser'@'%' IDENTIFIED WITH 'auth_pam';
UPDATE mysql.user SET ssl_type = 'any' WHERE ssl_type = '' AND PLUGIN = 'auth_pam' and USER
 = 'testuser';`
FLUSH PRIVILEGES;
```

Replace *testuser* with the user name. Users (both humans and applications) from your domain can now connect to the DB instance from a domain joined client machine using Kerberos authentication.

Managing a DB Instance in a Domain

You can use the CLI or the RDS API to manage your DB instance and its relationship with your managed Active Directory. For example, you can associate an Active Directory for Kerberos authentication and disassociate an Active Directory to disable Kerberos authentication. You can also move a DB instance to be externally authenticated by one Active Directory to another.

For example, using the Amazon RDS API, you can do the following:

- To reattempt enabling Kerberos authentication for a failed membership, use the `ModifyDBInstance` API operation and specify the current membership's directory ID.
- To update the IAM role name for membership, use the `ModifyDBInstance` API operation and specify the current membership's directory ID and the new IAM role.
- To disable Kerberos authentication on a DB instance, use the `ModifyDBInstance` API operation and specify `none` as the domain parameter.

- To move a DB instance from one domain to another, use the `ModifyDBInstance` API operation and specify the domain identifier of the new domain as the domain parameter.
- To list membership for each DB instance, use the `DescribeDBInstances` API operation.

Understanding Domain Membership

After you create or modify your DB instance, it becomes a member of the domain. You can view the status of the domain membership for the DB instance by running the describe-db-instances CLI command. The status of the DB instance can be one of the following:

- `kerberos-enabled` – The DB instance has Kerberos authentication enabled.
- `enabling-kerberos` – AWS is in the process of enabling Kerberos authentication on this DB instance.
- `pending-enable-kerberos` – The enabling of Kerberos authentication is pending on this DB instance.
- `pending-maintenance-enable-kerberos` – AWS will attempt to enable Kerberos authentication on the DB instance during the next scheduled maintenance window.
- `pending-disable-kerberos` – The disabling of Kerberos authentication is pending on this DB instance.
- `pending-maintenance-disable-kerberos` – AWS will attempt to disable Kerberos authentication on the DB instance during the next scheduled maintenance window.
- `enable-kerberos-failed` – A configuration problem has prevented AWS from enabling Kerberos authentication on the DB instance. Check and fix your configuration before reissuing the DB instance modify command.
- `disabling-kerberos` – AWS is in the process of disabling Kerberos authentication on this DB instance.

A request to enable Kerberos authentication can fail because of a network connectivity issue or an incorrect IAM role. For example, suppose that you create a DB instance or modify an existing DB instance and the attempt to enable Kerberos authentication fails. If this happens, re-issue the modify command or modify the newly created DB instance to join the domain.

Connecting to MySQL with Kerberos Authentication

To connect to MySQL with Kerberos authentication, you must log in using the Kerberos authentication type.

To create a database user that you can connect to using Kerberos authentication, use an `IDENTIFIED WITH` clause on the `CREATE USER` statement. For instructions, see Step 5: Create Kerberos Authentication MySQL Logins (p. 813).

To connect to MySQL with Kerberos authentication, take the following steps:

1. At a command prompt, run the following command.

   ```
   kinit username
   ```

   Replace *`username`* with the user name and, at the prompt, enter the password stored in the Microsoft Active Directory for the user.
2. Connect to one of the endpoints associated with your MySQL DB instance. Follow the general procedures in Connecting to a DB Instance Running the MySQL Database Engine (p. 722). When you're prompted for the password, enter the Kerberos password associated with that user name.

Restoring a MySQL DB instance and Adding It to a Domain

You can restore a DB snapshot or complete a point-in-time restore for a MySQL DB instance and then add it to a domain. After the DB instance is restored, modify the DB instance using the process explained in Step 4: Create or Modify a MySQL DB Instance (p. 811) to add the DB instance to a domain.

Kerberos Authentication MySQL Limitations

The following limitations apply to Kerberos authentication for MySQL:

- A Managed Active Directory that has been shared with you isn't supported.
- Kerberos authentication is supported for the following Amazon RDS for MySQL versions:
  - Amazon RDS for MySQL version 8.0.13 and higher 8.0 versions
  - Amazon RDS for MySQL version 5.7.24 and higher 5.7 versions
- You must reboot the DB instance after enabling the feature.
- The domain name length can't be longer than 61 characters.
- You can't enable Kerberos authentication and IAM authentication at the same time. Choose one authentication method or the other for your MySQL DB instance.
- Don't modify the DB instance port after enabling the feature.
- Don't use Kerberos authentication with read replicas.
- To delete a DB instance with this feature enabled, first disable the feature. To do this, use the `modify-db-instance` CLI command for the DB instance and specify `none` for the `--domain` parameter.

  If you use the CLI or RDS API to delete a DB instance with this feature enabled, expect a delay.

Known Issues and Limitations for MySQL on Amazon RDS

Known issues and limitations for working with MySQL on Amazon RDS are as follows.

Topics

Inconsistent InnoDB Buffer Pool Size

For MySQL 5.7, there is currently a bug in the way that the InnoDB buffer pool size is managed. MySQL 5.7 might adjust the value of the `innodb_buffer_pool_size` parameter to a large value that can result in the InnoDB buffer pool growing too large and using up too much memory. This effect can cause the MySQL database engine to stop running or can prevent the MySQL database engine from starting. This issue is more common for DB instance classes that have less memory available.

To resolve this issue, set the value of the `innodb_buffer_pool_size` parameter to a multiple of the product of the `innodb_buffer_pool_instances` parameter value and the `innodb_buffer_pool_chunk_size` parameter value. For example, you might set the `innodb_buffer_pool_size` parameter value to a multiple of eight times the product of the `innodb_buffer_pool_instances` and `innodb_buffer_pool_chunk_size` parameter values, as shown in the following example.

```
innodb_buffer_pool_chunk_size = 536870912
innodb_buffer_pool_instances = 4
innodb_buffer_pool_size = (536870912 * 4) * 8 = 17179869184
```

For details on this MySQL 5.7 bug, go to https://bugs.mysql.com/bug.php?id=79379 in the MySQL documentation.

Index Merge Optimization Returns Wrong Results

Queries that use index merge optimization might return wrong results due to a bug in the MySQL query optimizer that was introduced in MySQL 5.5.37. When you issue a query against a table with multiple indexes the optimizer scans ranges of rows based on the multiple indexes, but does not merge the results together correctly. For more information on the query optimizer bug, go to http://bugs.mysql.com/bug.php?id=72745 and http://bugs.mysql.com/bug.php?id=68194 in the MySQL bug database.

For example, consider a query on a table with two indexes where the search arguments reference the indexed columns.

```
SELECT * FROM table1
WHERE indexed_col1 = 'value1' AND indexed_col2 = 'value2';
```

In this case, the search engine will search both indexes. However, due to the bug, the merged results are incorrect.

To resolve this issue, you can do one of the following:

- Set the `optimizer_switch` parameter to `index_merge=off` in the DB parameter group for your MySQL DB instance. For information on setting DB parameter group parameters, see Working with DB Parameter Groups (p. 202).
- Upgrade your MySQL DB instance to MySQL version 5.6, 5.7, or 8.0. For more information, see Upgrading a MySQL DB Snapshot (p. 739).
- If you cannot upgrade your instance or change the `optimizer_switch` parameter, you can work around the bug by explicitly identifying an index for the query, for example:

```
SELECT * FROM table1
USE INDEX covering_index
WHERE indexed_col1 = 'value1' AND indexed_col2 = 'value2';
```

For more information, go to Index Merge Optimization.

Log File Size

For MySQL, there is a size limit on BLOBs written to the redo log. To account for this limit, ensure that the `innodb_log_file_size` parameter for your MySQL DB instance is 10 times larger than the largest BLOB data size found in your tables, plus the length of other variable length fields (`VARCHAR`, `VARBINARY`, `TEXT`) in the same tables. For information on how to set parameter values, see Working with DB Parameter Groups (p. 202). For information on the redo log BLOB size limit, go to Changes in MySQL 5.6.20.

MySQL Parameter Exceptions for Amazon RDS DB Instances

Some MySQL parameters require special considerations when used with an Amazon RDS DB instance.

lower_case_table_names

Because Amazon RDS uses a case-sensitive file system, setting the value of the `lower_case_table_names` server parameter to 2 ("names stored as given but compared in lowercase") is not supported. The following are the supported values for Amazon RDS for MySQL DB instances:

- 0 ("names stored as given and comparisons are case-sensitive") is supported for all Amazon RDS for MySQL versions.
- 1 ("names stored in lowercase and comparisons are not case-sensitive") is supported for Amazon RDS for MySQL versions 5.5, 5.6, and 5.7.

> **Note**
> For MySQL 8.0 DB instances, setting `lower_case_table_names` to 1 isn't supported.

The `lower_case_table_names` parameter should be set as part of a custom DB parameter group before creating a DB instance. You should avoid changing the `lower_case_table_names` parameter for existing database instances because doing so could cause inconsistencies with point-in-time recovery backups and read replica DB instances.

Read replicas should always use the same `lower_case_table_names` parameter value as the master DB instance.

long_query_time

You can set the `long_query_time` parameter to a floating point value which allows you to log slow queries to the MySQL slow query log with microsecond resolution. You can set a value such as 0.1 seconds, which would be 100 milliseconds, to help when debugging slow transactions that take less than one second.

MySQL File Size Limits in Amazon RDS

For Amazon RDS MySQL DB instances, the maximum provisioned storage limit constrains the size of a table to a maximum size of 16 TB when using InnoDB file-per-table tablespaces. This limit also constrains the system tablespace to a maximum size of 16 TB. InnoDB file-per-table tablespaces (with tables each in their own tablespace) is set by default for Amazon RDS MySQL DB instances.

> **Note**
> Some existing DB instances have a lower limit. For example, MySQL DB instances created before April 2014 have a file and table size limit of 2 TB. This 2 TB file size limit also applies to DB instances or read replicas created from DB snapshots taken before April 2014, regardless of when the DB instance was created.

There are advantages and disadvantages to using InnoDB file-per-table tablespaces, depending on your application. To determine the best approach for your application, go to InnoDB File-Per-Table Mode in the MySQL documentation.

We don't recommend allowing tables to grow to the maximum file size. In general, a better practice is to partition data into smaller tables, which can improve performance and recovery times.

One option that you can use for breaking a large table up into smaller tables is partitioning. Partitioning distributes portions of your large table into separate files based on rules that you specify. For example, if you store transactions by date, you can create partitioning rules that distribute older transactions into separate files using partitioning. Then periodically, you can archive the historical transaction data that doesn't need to be readily available to your application. For more information, go to https://dev.mysql.com/doc/refman/5.6/en/partitioning.html in the MySQL documentation.

To determine the file size of a table

- Use the following SQL command to determine if any of your tables are too large and are candidates for partitioning.

```
SELECT TABLE_SCHEMA, TABLE_NAME,
round(((DATA_LENGTH + INDEX_LENGTH) / 1024 / 1024), 2) As "Approximate size (MB)"
FROM information_schema.TABLES
WHERE TABLE_SCHEMA NOT IN ('mysql', 'information_schema', 'performance_schema');
```

To enable InnoDB file-per-table tablespaces

- To enable InnoDB file-per-table tablespaces, set the *innodb_file_per_table* parameter to `1` in the parameter group for the DB instance.

To disable InnoDB file-per-table tablespaces

- To disable InnoDB file-per-table tablespaces, set the *innodb_file_per_table* parameter to `0` in the parameter group for the DB instance.

For information on updating a parameter group, see Working with DB Parameter Groups (p. 202).

When you have enabled or disabled InnoDB file-per-table tablespaces, you can issue an `ALTER TABLE` command to move a table from the global tablespace to its own tablespace, or from its own tablespace to the global tablespace as shown in the following example:

```
ALTER TABLE table_name ENGINE=InnoDB;
```

MySQL Keyring Plugin Not Supported

Currently, Amazon RDS for MySQL does not support the MySQL `keyring_aws` Amazon Web Services Keyring Plugin.

MySQL on Amazon RDS SQL Reference

This appendix describes system stored procedures that are available for Amazon RDS instances running the MySQL DB engine.

Overview

The following system stored procedures are supported for Amazon RDS DB instances running MySQL.

Replication

InnoDB cache warming

Managing additional configuration (for example, binlog file retention)

Terminating a session or query

Logging

Managing the global status history

SQL Reference Conventions

Following, you can find explanations for the conventions that are used to describe the syntax of the system stored procedures and tables described in the SQL reference section.

Character	Description
UPPERCASE	Words in uppercase are keywords.
[ ]	Square brackets indicate optional arguments.
{ }	Braces indicate that you are required to choose one of the arguments inside the braces.
|	Pipes separate arguments that you can choose.
italics	Words in italics indicate placeholders. You must insert the appropriate value in place of the word in italics.
...	An ellipsis indicates that you can repeat the preceding element.
'	Words in single quotes indicate that you must type the quotes.

mysql.rds_set_master_auto_position

Sets the replication mode to be based on either binary log file positions or on global transaction identifiers (GTIDs).

Syntax

```
CALL mysql.rds_set_master_auto_position (
auto_position_mode
);
```

Parameters

auto_position_mode

A value that indicates whether to use log file position replication or GTID-based replication:

- `0` – Use the replication method based on binary log file position. The default is `0`.
- `1` – Use the GTID-based replication method.

Usage Notes

The master user must run the `mysql.rds_set_master_auto_position` procedure.

For Amazon RDS MySQL 5.7, this procedure is supported for MySQL 5.7.23 and later MySQL 5.7 versions. This procedure is not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

mysql.rds_set_external_master

Configures a MySQL DB instance to be a read replica of an instance of MySQL running external to Amazon RDS.

> **Note**
> You can use the mysql.rds_set_external_master_with_delay (p. 824) stored procedure to configure an external master and delayed replication.

Syntax

```
CALL mysql.rds_set_external_master (
  host_name
  , host_port
  , replication_user_name
  , replication_user_password
  , mysql_binary_log_file_name
  , mysql_binary_log_file_location
  , ssl_encryption
);
```

Parameters

host_name

The host name or IP address of the MySQL instance running external to Amazon RDS to become the replication master.

host_port

The port used by the MySQL instance running external to Amazon RDS to be configured as the replication master. If your network configuration includes Secure Shell (SSH) port replication that converts the port number, specify the port number that is exposed by SSH.

replication_user_name

The ID of a user with REPLICATION CLIENT and REPLICATION SLAVE permissions on the MySQL instance running external to Amazon RDS. We recommend that you provide an account that is used solely for replication with the external instance.

replication_user_password

The password of the user ID specified in `replication_user_name`.

mysql_binary_log_file_name

The name of the binary log on the replication master that contains the replication information.

mysql_binary_log_file_location

The location in the `mysql_binary_log_file_name` binary log at which replication starts reading the replication information.

ssl_encryption

A value that specifies whether Secure Socket Layer (SSL) encryption is used on the replication connection. 1 specifies to use SSL encryption, 0 specifies to not use encryption. The default is 0.

Note
This parameter currently is only implemented for Amazon Aurora with MySQL compatibility. On MySQL DB instances, only the default is allowed.

Usage Notes

The master user must run the `mysql.rds_set_external_master` procedure. This procedure must be run on the MySQL DB instance to be configured as the read replica of a MySQL instance running external to Amazon RDS.

Before you run `mysql.rds_set_external_master`, you must configure the instance of MySQL running external to Amazon RDS to be a replication master. To connect to the MySQL instance running external to Amazon RDS, you must specify `replication_user_name` and `replication_user_password` values that indicate a replication user that has `REPLICATION CLIENT` and `REPLICATION SLAVE` permissions on the external instance of MySQL.

To configure an external instance of MySQL as a replication master

1. Using the MySQL client of your choice, connect to the external instance of MySQL and create a user account to be used for replication. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY 'password'
```

2. On the external instance of MySQL, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. The following example grants `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the 'repl_user' user for your domain.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
IDENTIFIED BY 'password'
```

To use encrypted replication, configure the master to use SSL connections. Also, import the certificate authority certificate, client certificate, and client key into the DB instance or DB cluster using the mysql.rds_import_binlog_ssl_material (p. 829) procedure.

Note
We recommend that you use read replicas to manage replication between two Amazon RDS DB instances when possible. When you do so, we recommend that you use only this and other replication-related stored procedures. These practices enable more complex replication topologies between Amazon RDS DB instances. We offer these stored procedures primarily to enable replication with MySQL instances running external to Amazon RDS. For information about managing replication between Amazon RDS DB instances, see Working with Read Replicas (p. 250).

After calling `mysql.rds_set_external_master` to configure an Amazon RDS DB instance as a read replica, you can call mysql.rds_start_replication (p. 832) on the read replica to start the replication process. You can call mysql.rds_reset_external_master (p. 828) to remove the read replica configuration.

When `mysql.rds_set_external_master` is called, Amazon RDS records the time, user, and an action of "set master" in the `mysql.rds_history` and `mysql.rds_replication_status` tables.

Examples

When run on a MySQL DB instance, the following example configures the DB instance to be a read replica of an instance of MySQL running external to Amazon RDS.

```
call mysql.rds_set_external_master(
  'Externaldb.some.com',
  3306,
  'repl_user',
  'password',
  'mysql-bin-changelog.0777',
  120,
  0);
```

mysql.rds_set_external_master_with_delay

Configures an Amazon RDS MySQL DB instance to be a read replica of an instance of MySQL running external to Amazon RDS and configures delayed replication.

Syntax

```
CALL mysql.rds_set_external_master_with_delay (
  host_name
  , host_port
  , replication_user_name
  , replication_user_password
  , mysql_binary_log_file_name
  , mysql_binary_log_file_location
  , ssl_encryption
  , delay
);
```

Parameters

host_name

The host name or IP address of the MySQL instance running external to Amazon RDS that will become the replication master.

host_port

The port used by the MySQL instance running external to Amazon RDS to be configured as the replication master. If your network configuration includes SSH port replication that converts the port number, specify the port number that is exposed by SSH.

replication_user_name

The ID of a user with REPLICATION CLIENT and REPLICATION SLAVE permissions on the MySQL instance running external to Amazon RDS. We recommend that you provide an account that is used solely for replication with the external instance.

replication_user_password

The password of the user ID specified in `replication_user_name`.

mysql_binary_log_file_name

The name of the binary log on the replication master contains the replication information.

mysql_binary_log_file_location

The location in the `mysql_binary_log_file_name` binary log at which replication will start reading the replication information.

ssl_encryption

This option is not currently implemented. The default is 0.

delay

The minimum number of seconds to delay replication from the master.

The limit for this parameter is one day (86400 seconds).

Usage Notes

The master user must run the `mysql.rds_set_external_master_with_delay` procedure. This procedure must be run on the MySQL DB instance to be configured as the read replica of a MySQL instance running external to Amazon RDS.

Before you run `mysql.rds_set_external_master_with_delay`, you must configure the instance of MySQL running external to Amazon RDS to be a replication master. To connect to the MySQL instance running external to Amazon RDS, you must specify values for `replication_user_name` and `replication_user_password`. These values must indicate a replication user that has `REPLICATION CLIENT` and `REPLICATION SLAVE` permissions on the external instance of MySQL.

To configure an external instance of MySQL as a replication master

1. Using the MySQL client of your choice, connect to the external instance of MySQL and create a user account to be used for replication. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY 'SomePassW0rd'
```

2. On the external instance of MySQL, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. The following example grants `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the `'repl_user'` user for your domain.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
IDENTIFIED BY 'SomePassW0rd'
```

For more information, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).

> **Note**
> We recommend that you use read replicas to manage replication between two Amazon RDS DB instances when possible. When you do so, we recommend that you use only this and other replication-related stored procedures. These practices enable more complex replication topologies between Amazon RDS DB instances. We offer these stored procedures primarily to enable replication with MySQL instances running external to Amazon RDS. For information about managing replication between Amazon RDS DB instances, see Working with Read Replicas (p. 250).

After calling `mysql.rds_set_external_master_with_delay` to configure an Amazon RDS DB instance as a read replica, you can call mysql.rds_start_replication (p. 832) on the read replica to start the replication process. You can call mysql.rds_reset_external_master (p. 828) to remove the read replica configuration.

When you call `mysql.rds_set_external_master_with_delay`, Amazon RDS records the time, the user, and an action of `"set master"` in the `mysql.rds_history` and `mysql.rds_replication_status` tables.

For disaster recovery, you can use this procedure with the mysql.rds_start_replication_until (p. 832) or mysql.rds_start_replication_until_gtid (p. 833) stored procedure. To roll forward changes to a delayed read replica to the time just before a disaster, you can run the mysql.rds_set_external_master_with_delay procedure. After the mysql.rds_start_replication_until procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

To use the mysql.rds_rds_start_replication_until_gtid procedure, GTID-based replication must be enabled. To skip a specific GTID-based transaction that is known to cause disaster, you can use the mysql.rds_skip_transaction_with_gtid (p. 835) stored procedure. For more information about working with GTID-based replication, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

The mysql.rds_set_external_master_with_delay procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6.40 and later 5.6 versions
- MySQL 5.7.22 and later 5.7 versions

Examples

When run on a MySQL DB instance, the following example configures the DB instance to be a read replica of an instance of MySQL running external to Amazon RDS. It sets the minimum replication delay to one hour (3,600 seconds) on the MySQL DB instance. A change from the MySQL master running external to Amazon RDS is not applied on the MySQL DB instance read replica for at least one hour.

```
call mysql.rds_set_external_master_with_delay(
  'Externaldb.some.com',
  3306,
  'repl_user',
  'SomePassW0rd',
  'mysql-bin-changelog.000777',
  120,
  0,
  3600);
```

mysql.rds_set_external_master_with_auto_position

Configures an Amazon RDS MySQL DB instance to be a read replica of an instance of MySQL running external to Amazon RDS. This procedure also configures delayed replication and replication based on global transaction identifiers (GTIDs).

Syntax

```
CALL mysql.rds_set_external_master_with_auto_position (
  host_name
  , host_port
  , replication_user_name
  , replication_user_password
  , ssl_encryption
  , delay
);
```

Parameters

host_name

The host name or IP address of the MySQL instance running external to Amazon RDS to become the replication master.

host_port

The port used by the MySQL instance running external to Amazon RDS to be configured as the replication master. If your network configuration includes Secure Shell (SSH) port replication that converts the port number, specify the port number that is exposed by SSH.

replication_user_name

The ID of a user with REPLICATION CLIENT and REPLICATION SLAVE permissions on the MySQL instance running external to Amazon RDS. We recommend that you provide an account that is used solely for replication with the external instance.

replication_user_password

The password of the user ID specified in `replication_user_name`.

ssl_encryption

This option is not currently implemented. The default is 0.

delay

The minimum number of seconds to delay replication from the master.

The limit for this parameter is one day (86,400 seconds).

Usage Notes

The master user must run the `mysql.rds_set_external_master_with_auto_position` procedure. This procedure must be run on the MySQL DB instance to be configured as the read replica of a MySQL instance running external to Amazon RDS.

For Amazon RDS MySQL 5.7, this procedure is supported for MySQL 5.7.23 and later MySQL 5.7 versions. This procedure is not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

Before you run `mysql.rds_set_external_master_with_auto_position`, you must configure the instance of MySQL running external to Amazon RDS to be a replication master. To connect to the MySQL instance running external to Amazon RDS, you must specify values for `replication_user_name` and `replication_user_password`. These values must indicate a replication user that has `REPLICATION CLIENT` and `REPLICATION SLAVE` permissions on the external instance of MySQL.

To configure an external instance of MySQL as a replication master

1. Using the MySQL client of your choice, connect to the external instance of MySQL and create a user account to be used for replication. The following is an example.

```
CREATE USER 'repl_user'@'mydomain.com' IDENTIFIED BY 'SomePassW0rd'
```

2. On the external instance of MySQL, grant `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges to your replication user. The following example grants `REPLICATION CLIENT` and `REPLICATION SLAVE` privileges on all databases for the `'repl_user'` user for your domain.

```
GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'mydomain.com'
IDENTIFIED BY 'SomePassW0rd'
```

For more information, see Replication with a MySQL or MariaDB Instance Running External to Amazon RDS (p. 783).

Note

We recommend that you use read replicas to manage replication between two Amazon RDS DB instances when possible. When you do so, we recommend that you use only this and other replication-related stored procedures. These practices enable more complex replication topologies between Amazon RDS DB instances. We offer these stored procedures primarily to enable replication with MySQL instances running external to Amazon RDS. For information about managing replication between Amazon RDS DB instances, see Working with Read Replicas (p. 250).

After calling `mysql.rds_set_external_master_with_auto_position` to configure an Amazon RDS DB instance as a read replica, you can call mysql.rds_start_replication (p. 832) on the read replica to start the replication process. You can call mysql.rds_reset_external_master (p. 828) to remove the read replica configuration.

When you call `mysql.rds_set_external_master_with_auto_position`, Amazon RDS records the time, the user, and an action of `"set master"` in the `mysql.rds_history` and `mysql.rds_replication_status` tables.

For disaster recovery, you can use this procedure with the mysql.rds_start_replication_until (p. 832) or mysql.rds_start_replication_until_gtid (p. 833) stored procedure. To roll forward changes to a delayed read replica to the time just before a disaster, you can run the `mysql.rds_set_external_master_with_auto_position` procedure. After the `mysql.rds_start_replication_until_gtid` procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

To use the `mysql.rds_rds_start_replication_until_gtid` procedure, GTID-based replication must be enabled. To skip a specific GTID-based transaction that is known to cause disaster, you can use the mysql.rds_skip_transaction_with_gtid (p. 835) stored procedure. For more information about working with GTID-based replication, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

Examples

When run on a MySQL DB instance, the following example configures the DB instance to be a read replica of an instance of MySQL running external to Amazon RDS. It sets the minimum replication delay to one hour (3,600 seconds) on the MySQL DB instance. A change from the MySQL master running external to Amazon RDS is not applied on the MySQL DB instance read replica for at least one hour.

```
call mysql.rds_set_external_master_with_auto_position(
  'Externaldb.some.com',
  3306,
  'repl_user',
  'SomePassW0rd',
  0,
  3600);
```

mysql.rds_reset_external_master

Reconfigures a MySQL DB instance to no longer be a read replica of an instance of MySQL running external to Amazon RDS.

Syntax

```
CALL mysql.rds_reset_external_master;
```

Usage Notes

The master user must run the `mysql.rds_reset_external_master` procedure. This procedure must be run on the MySQL DB instance to be removed as a read replica of a MySQL instance running external to Amazon RDS.

Note
We recommend that you use read replicas to manage replication between two Amazon RDS DB instances when possible. When you do so, we recommend that you use only this and other replication-related stored procedures. These practices enable more complex replication topologies between Amazon RDS DB instances. We offer these stored procedures primarily to enable replication with MySQL instances running external to Amazon RDS. For information about managing replication between Amazon RDS DB instances, see Working with Read Replicas (p. 250).

For more information about using replication to import data from an instance of MySQL running external to Amazon RDS, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).

mysql.rds_import_binlog_ssl_material

Imports the certificate authority certificate, client certificate, and client key into an Aurora MySQL DB cluster. The information is required for SSL communication and encrypted replication.

Note
Currently, this procedure is only supported for Aurora MySQL version 5.6.

Syntax

```
CALL mysql.rds_import_binlog_ssl_material (
  ssl_material
);
```

Parameters

ssl_material

JSON payload that contains the contents of the following .pem format files for a MySQL client:

- "ssl_ca":"*Certificate authority certificate*"
- "ssl_cert":"*Client certificate*"
- "ssl_key":"*Client key*"

Usage Notes

Prepare for encrypted replication before you run this procedure:

- If you don't have SSL enabled on the external MySQL master database and don't have a client key and client certificate prepared, enable SSL on the MySQL database server and generate the required client key and client certificate.
- If SSL is enabled on the external master, supply a client key and certificate for the Aurora MySQL DB cluster. If you don't have these, generate a new key and certificate for the Aurora MySQL DB cluster. To sign the client certificate, you must have the certificate authority key you used to configure SSL on the external MySQL master database.

For more information, see Creating SSL Certificates and Keys Using openssl in the MySQL documentation.

Important
After you prepare for encrypted replication, use an SSL connection to run this procedure. The client key must not be transferred across an insecure connection.

This procedure imports SSL information from an external MySQL database into an Aurora MySQL DB cluster. The SSL information is in .pem format files that contain the SSL information for the Aurora MySQL DB cluster. During encrypted replication, the Aurora MySQL DB cluster acts a client to the MySQL database server. The certificates and keys for the Aurora MySQL client are in files in .pem format.

You can copy the information from these files into the `ssl_material` parameter in the correct JSON payload. To support encrypted replication, import this SSL information into the Aurora MySQL DB cluster.

The JSON payload must be in the following format.

```
'{"ssl_ca":"-----BEGIN CERTIFICATE-----
ssl_ca_pem_body_code
-----END CERTIFICATE-----\n","ssl_cert":"-----BEGIN CERTIFICATE-----
ssl_cert_pem_body_code
-----END CERTIFICATE-----\n","ssl_key":"-----BEGIN RSA PRIVATE KEY-----
ssl_key_pem_body_code
-----END RSA PRIVATE KEY-----\n"}'
```

Examples

The following example imports SSL information into an Aurora MySQL DB cluster. In .pem format files, the body code typically is longer than the body code shown in the example.

```
call mysql.rds_import_binlog_ssl_material(
'{"ssl_ca":"-----BEGIN CERTIFICATE-----
AAAAB3NzaC1yc2EAAAADAQABAAABAQClKsfkNkuSevGj3eYhCe53pcjqP3maAhDFcvBS7O6V
hz2ItxCih+PnDSUaw+WNQn/mZphTk/a/gU8jEzoOWbkM4yxyb/wB96xbiFveSFJuOp/d6RJhJOI0iBXr
lsLnBItntckiJ7FbtxJMXLvvwJryDUilBMTjYtwB+QhYXUMOzce5Pjz5/i8SeJtjnV3iAoG/cQk+0FzZ
qaeJAAHco+CY/5WrUBkrHmFJr6HcXkvJdWPkYQS3xqC0+FmUZofz221CBt5IMucxXPkX4rWi+z7wB3Rb
BQoQzd8v7yeb7OzlPnWOyN0qFU0XA246RA8QFYiCNYwI3f05p6KLxEXAMPLE
-----END CERTIFICATE-----\n","ssl_cert":"-----BEGIN CERTIFICATE-----
AAAAB3NzaC1yc2EAAAADAQABAAABAQClKsfkNkuSevGj3eYhCe53pcjqP3maAhDFcvBS7O6V
hz2ItxCih+PnDSUaw+WNQn/mZphTk/a/gU8jEzoOWbkM4yxyb/wB96xbiFveSFJuOp/d6RJhJOI0iBXr
lsLnBItntckiJ7FbtxJMXLvvwJryDUilBMTjYtwB+QhYXUMOzce5Pjz5/i8SeJtjnV3iAoG/cQk+0FzZ
qaeJAAHco+CY/5WrUBkrHmFJr6HcXkvJdWPkYQS3xqC0+FmUZofz221CBt5IMucxXPkX4rWi+z7wB3Rb
BQoQzd8v7yeb7OzlPnWOyN0qFU0XA246RA8QFYiCNYwI3f05p6KLxEXAMPLE
-----END CERTIFICATE-----\n","ssl_key":"-----BEGIN RSA PRIVATE KEY-----
AAAAB3NzaC1yc2EAAAADAQABAAABAQClKsfkNkuSevGj3eYhCe53pcjqP3maAhDFcvBS7O6V
hz2ItxCih+PnDSUaw+WNQn/mZphTk/a/gU8jEzoOWbkM4yxyb/wB96xbiFveSFJuOp/d6RJhJOI0iBXr
lsLnBItntckiJ7FbtxJMXLvvwJryDUilBMTjYtwB+QhYXUMOzce5Pjz5/i8SeJtjnV3iAoG/cQk+0FzZ
qaeJAAHco+CY/5WrUBkrHmFJr6HcXkvJdWPkYQS3xqC0+FmUZofz221CBt5IMucxXPkX4rWi+z7wB3Rb
BQoQzd8v7yeb7OzlPnWOyN0qFU0XA246RA8QFYiCNYwI3f05p6KLxEXAMPLE
-----END RSA PRIVATE KEY-----\n"}');
```

Note
For information about using Amazon Aurora, see the *Amazon Aurora User Guide*.

mysql.rds_remove_binlog_ssl_material

Removes the certificate authority certificate, client certificate, and client key for SSL communication and encrypted replication. This information is imported by using mysql.rds_import_binlog_ssl_material (p. 829).

Note
Currently, this procedure is only supported for Aurora MySQL version 5.6.

Syntax

```
CALL mysql.rds_remove_binlog_ssl_material;
```

mysql.rds_set_source_delay

Sets the minimum number of seconds to delay replication from the master to the current read replica. Use this procedure when you are connected to a read replica to delay replication from its master.

Syntax

```
CALL mysql.rds_set_source_delay(
delay
);
```

Parameters

delay

The minimum number of seconds to delay replication from the master.

The limit for this parameter is one day (86400 seconds).

Usage Notes

The master user must run the `mysql.rds_set_source_delay` procedure.

For disaster recovery, you can use this procedure with the mysql.rds_start_replication_until (p. 832) stored procedure or the mysql.rds_start_replication_until_gtid (p. 833) stored procedure. To roll forward changes to a delayed read replica to the time just before a disaster, you can run the `mysql.rds_set_source_delay` procedure. After the `mysql.rds_start_replication_until` or `mysql.rds_start_replication_until_gtid` procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

To use the `mysql.rds_rds_start_replication_until_gtid` procedure, GTID-based replication must be enabled. To skip a specific GTID-based transaction that is known to cause disaster, you can use the mysql.rds_skip_transaction_with_gtid (p. 835) stored procedure. For more information on GTID-based replication, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

The `mysql.rds_set_source_delay` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6.40 and later 5.6 versions
- MySQL 5.7.22 and later 5.7 versions

Examples

To delay replication from the master to the current read replica for at least one hour (3,600 seconds), you can call `mysql.rds_set_source_delay` with the following parameter:

```
CALL mysql.rds_set_source_delay(3600);
```

mysql.rds_start_replication

Initiates replication from a MySQL DB instance.

Note
You can use the mysql.rds_start_replication_until (p. 832) or mysql.rds_start_replication_until_gtid (p. 833) stored procedure to initiate replication from an Amazon RDS MySQL DB instance and stop replication at the specified binary log file location.

Syntax

```
CALL mysql.rds_start_replication;
```

Usage Notes

The master user must run the `mysql.rds_start_replication` procedure.

If you are configuring replication to import data from an instance of MySQL running external to Amazon RDS, you call `mysql.rds_start_replication` on the read replica to start the replication process after you have called mysql.rds_set_external_master (p. 822) to build the replication configuration. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).

If you are configuring replication to export data to an instance of MySQL external to Amazon RDS, you call `mysql.rds_start_replication` and `mysql.rds_stop_replication` on the read replica to control some replication actions, such as purging binary logs. For more information, see Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

You can also call `mysql.rds_start_replication` on the read replica to restart any replication process that you previously stopped by calling mysql.rds_stop_replication (p. 834). For more information, see Working with Read Replicas (p. 250).

mysql.rds_start_replication_until

Initiates replication from an Amazon RDS MySQL DB instance and stops replication at the specified binary log file location.

Syntax

```
CALL mysql.rds_start_replication_until (
replication_log_file
  , replication_stop_point
);
```

Parameters

replication_log_file

The name of the binary log on the replication master contains the replication information.

replication_stop_point

The location in the `replication_log_file` binary log at which replication will stop.

Usage Notes

The master user must run the `mysql.rds_start_replication_until` procedure.

You can use this procedure with delayed replication for disaster recovery. If you have delayed replication configured, you can use this procedure to roll forward changes to a delayed read replica to the time just before a disaster. After this procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

You can configure delayed replication using the following stored procedures:

- mysql.rds_set_configuration (p. 839)
- mysql.rds_set_external_master_with_delay (p. 824)
- mysql.rds_set_source_delay (p. 831)

The file name specified for the `replication_log_file` parameter must match the master binlog file name.

When the `replication_stop_point` parameter specifies a stop location that is in the past, replication is stopped immediately.

The `mysql.rds_start_replication_until` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6.40 and later 5.6 versions
- MySQL 5.7.22 and later 5.7 versions

Examples

The following example initiates replication and replicates changes until it reaches location `120` in the `mysql-bin-changelog.000777` binary log file.

```
call mysql.rds_start_replication_until(
  'mysql-bin-changelog.000777',
  120);
```

mysql.rds_start_replication_until_gtid

Initiates replication from an Amazon RDS MySQL DB instance and stops replication immediately after the specified global transaction identifier (GTID).

Syntax

```
CALL mysql.rds_start_replication_until_gtid (
gtid
);
```

Parameters

gtid

The GTID after which replication is to stop.

Usage Notes

The master user must run the `mysql.rds_start_replication_until_gtid` procedure.

For Amazon RDS MySQL 5.7, this procedure is supported for MySQL 5.7.23 and later MySQL 5.7 versions. This procedure is not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

You can use this procedure with delayed replication for disaster recovery. If you have delayed replication configured, you can use this procedure to roll forward changes to a delayed read replica to the time just before a disaster. After this procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

You can configure delayed replication using the following stored procedures:

- mysql.rds_set_configuration (p. 839)
- mysql.rds_set_external_master_with_auto_position (p. 826)
- mysql.rds_set_source_delay (p. 831)

When the `gtid` parameter specifies a transaction that has already been executed by the replica, replication is stopped immediately.

Examples

The following example initiates replication and replicates changes until it reaches GTID `3E11FA47-71CA-11E1-9E33-C80AA9429562:23`.

```
call mysql.rds_start_replication_until_gtid(
  '3E11FA47-71CA-11E1-9E33-C80AA9429562:23');
```

mysql.rds_stop_replication

Terminates replication from a MySQL DB instance.

Syntax

```
CALL mysql.rds_stop_replication;
```

Usage Notes

The master user must run the `mysql.rds_stop_replication` procedure.

If you are configuring replication to import data from an instance of MySQL running external to Amazon RDS, you call `mysql.rds_stop_replication` on the read replica to stop the replication process after the import has completed. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).

If you are configuring replication to export data to an instance of MySQL external to Amazon RDS, you call `mysql.rds_start_replication` and `mysql.rds_stop_replication` on the read replica to control some replication actions, such as purging binary logs. For more information, see Exporting Data from a MySQL DB Instance by Using Replication (p. 790).

You can also use `mysql.rds_stop_replication` to stop replication between two Amazon RDS DB instances. You typically stop replication to perform a long running operation on the read replica, such as creating a large index on the read replica. You can restart any replication process that you stopped by calling mysql.rds_start_replication (p. 832) on the read replica. For more information, see Working with Read Replicas (p. 250).

mysql.rds_skip_transaction_with_gtid

Skips replication of a transaction with the specified global transaction identifier (GTID) on a MySQL DB instance.

You can use this procedure for disaster recovery when a specific GTID transaction is known to cause a problem. Use this stored procedure to skip the problematic transaction. Examples of problematic transactions include transactions that disable replication, delete important data, or cause the DB instance to become unavailable.

Syntax

```
CALL mysql.rds_skip_transaction_with_gtid (
gtid_to_skip
);
```

Parameters

gtid_to_skip

The GTID of the replication transaction to skip.

Usage Notes

The master user must run the `mysql.rds_skip_transaction_with_gtid` procedure.

For Amazon RDS MySQL 5.7, this procedure is supported for MySQL 5.7.23 and later MySQL 5.7 versions. This procedure is not supported for Amazon RDS MySQL 5.5, 5.6, or 8.0.

mysql.rds_skip_repl_error

Skips and deletes a replication error on a MySQL DB instance.

Syntax

```
CALL mysql.rds_skip_repl_error;
```

Usage Notes

The master user must run the `mysql.rds_skip_repl_error` procedure.

To determine if there are errors, run the MySQL `show slave status\G` command. If a replication error isn't critical, you can run `mysql.rds_skip_repl_error` to skip the error. If there are multiple errors, `mysql.rds_skip_repl_error` deletes the first error, then warns that others are present. You can then use `show slave status\G` to determine the correct course of action for the next error. For information about the values returned, see SHOW SLAVE STATUS Syntax in the MySQL documentation.

For more information about addressing replication errors with Amazon RDS, see Troubleshooting a MySQL Read Replica Problem (p. 777).

Important
If you try to call `mysql.rds_skip_repl_error`, you might encounter the following error: `ERROR 1305 (42000): PROCEDURE mysql.rds_skip_repl_error does not exist.`

If you do, upgrade your MySQL DB instance to the latest minor version or one of the minimum minor versions listed in this topic.

Slave Down or Disabled Error

When you call the `mysql.rds_skip_repl_error` command, you might receive the following error message: `Slave is down or disabled.`

This error message appears because replication has stopped and could not be restarted.

If you need to skip a large number of errors, the replication lag can increase beyond the default retention period for binary log (binlog) files. In this case, you might encounter a fatal error due to binlog files being purged before they have been replayed on the read replica. This purge causes replication to stop, and you can no longer call the `mysql.rds_skip_repl_error` command to skip replication errors.

You can mitigate this issue by increasing the number of hours that binlog files are retained on your replication master. After you have increased the binlog retention time, you can restart replication and call the `mysql.rds_skip_repl_error` command as needed.

To set the binlog retention time, use the mysql.rds_set_configuration (p. 839) procedure and specify a configuration parameter of `'binlog retention hours'` along with the number of hours to retain binlog files on the DB cluster. The following example sets the retention period for binlog files to 48 hours.

```
CALL mysql.rds_set_configuration('binlog retention hours', 48);
```

mysql.rds_next_master_log

Changes the replication master log position to the start of the next binary log on the master. Use this procedure only if you are receiving replication I/O error 1236 on a read replica.

Syntax

```
CALL mysql.rds_next_master_log(
curr_master_log
);
```

Parameters

curr_master_log

The index of the current master log file. For example, if the current file is named `mysql-bin-changelog.012345`, then the index is 12345. To determine the current master log file name, run the `SHOW SLAVE STATUS` command and view the `Master_Log_File` field.

Usage Notes

The master user must run the `mysql.rds_next_master_log` procedure.

Warning
Call `mysql.rds_next_master_log` only if replication fails after a failover of a Multi-AZ DB instance that is the replication source, and the `Last_IO_Errno` field of `SHOW SLAVE STATUS` reports I/O error 1236.
Calling `mysql.rds_next_master_log` may result in data loss in the read replica if transactions in the source instance were not written to the binary log on disk before the failover

event occurred. You can reduce the chance of this happening by configuring the source instance parameters sync_binlog = 1 and innodb_support_xa = 1, although this may reduce performance. For more information, see Working with Read Replicas (p. 250).

Examples

Assume replication fails on an Amazon RDS read replica. Running `SHOW SLAVE STATUS\G` on the read replica returns the following result:

```
*************************** 1. row ***************************
               Slave_IO_State:
                  Master_Host: myhost.XXXXXXXXXXXXXXX.rr-rrrr-1.rds.amazonaws.com
                  Master_User: MasterUser
                  Master_Port: 3306
                Connect_Retry: 10
              Master_Log_File: mysql-bin-changelog.012345
          Read_Master_Log_Pos: 1219393
               Relay_Log_File: relaylog.012340
                Relay_Log_Pos: 30223388
        Relay_Master_Log_File: mysql-bin-changelog.012345
             Slave_IO_Running: No
            Slave_SQL_Running: Yes
              Replicate_Do_DB:
          Replicate_Ignore_DB:
           Replicate_Do_Table:
       Replicate_Ignore_Table:
      Replicate_Wild_Do_Table:
  Replicate_Wild_Ignore_Table:
                   Last_Errno: 0
                   Last_Error:
                 Skip_Counter: 0
          Exec_Master_Log_Pos: 30223232
              Relay_Log_Space: 5248928866
              Until_Condition: None
               Until_Log_File:
                Until_Log_Pos: 0
           Master_SSL_Allowed: No
           Master_SSL_CA_File:
           Master_SSL_CA_Path:
              Master_SSL_Cert:
            Master_SSL_Cipher:
               Master_SSL_Key:
        Seconds_Behind_Master: NULL
Master_SSL_Verify_Server_Cert: No
                Last_IO_Errno: 1236
                Last_IO_Error: Got fatal error 1236 from master when reading data from
 binary log: 'Client requested master to start replication from impossible position; the
 first event 'mysql-bin-changelog.013406' at 1219393, the last event read from '/rdsdbdata/
log/binlog/mysql-bin-changelog.012345' at 4, the last byte read from '/rdsdbdata/log/
binlog/mysql-bin-changelog.012345' at 4.'
               Last_SQL_Errno: 0
               Last_SQL_Error:
  Replicate_Ignore_Server_Ids:
             Master_Server_Id: 67285976
```

The `Last_IO_Errno` field shows that the instance is receiving I/O error 1236. The `Master_Log_File` field shows that the file name is `mysql-bin-changelog.012345`, which means that the log file index is `12345`. To resolve the error, you can call `mysql.rds_next_master_log` with the following parameter:

```
CALL mysql.rds_next_master_log(12345);
```

mysql.rds_innodb_buffer_pool_dump_now

Dumps the current state of the buffer pool to disk. For more information, see InnoDB Cache Warming (p. 719).

Syntax

```
CALL mysql.rds_innodb_buffer_pool_dump_now();
```

Usage Notes

The master user must run the `mysql.rds_innodb_buffer_pool_dump_now` procedure.

The `mysql.rds_innodb_buffer_pool_dump_now` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6
- MySQL 5.7
- MySQL 8.0

mysql.rds_innodb_buffer_pool_load_now

Loads the saved state of the buffer pool from disk. For more information, see InnoDB Cache Warming (p. 719).

Syntax

```
CALL mysql.rds_innodb_buffer_pool_load_now();
```

Usage Notes

The master user must run the `mysql.rds_innodb_buffer_pool_load_now` procedure.

The `mysql.rds_innodb_buffer_pool_load_now` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6
- MySQL 5.7
- MySQL 8.0

mysql.rds_innodb_buffer_pool_load_abort

Cancels a load of the saved buffer pool state while in progress. For more information, see InnoDB Cache Warming (p. 719).

Syntax

```
CALL mysql.rds_innodb_buffer_pool_load_abort();
```

Usage Notes

The master user must run the `mysql.rds_innodb_buffer_pool_load_abort` procedure.

The `mysql.rds_innodb_buffer_pool_load_abort` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6
- MySQL 5.7
- MySQL 8.0

mysql.rds_set_configuration

Specifies the number of hours to retain binary logs or the number of seconds to delay replication.

Syntax

```
CALL mysql.rds_set_configuration(name,value);
```

Parameters

name

The name of the configuration parameter to set.

value

The value of the configuration parameter.

Usage Notes

The `mysql.rds_set_configuration` stored procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6
- MySQL 5.7
- MySQL 8.0

The `mysql.rds_set_configuration` procedure supports the following configuration parameters:

- binlog retention hours (p. 839)
- target delay (p. 840)

binlog retention hours

The `binlog retention hours` parameter is used to specify the number of hours to retain binary log files. Amazon RDS normally purges a binary log as soon as possible, but the binary log might still be required for replication with a MySQL database external to Amazon RDS. The default value of `binlog retention hours` is NULL (do not retain binary logs).

To specify the number of hours for Amazon RDS to retain binary logs on a DB instance, use the `mysql.rds_set_configuration` stored procedure and specify a period with enough time for replication to occur, as shown in the following example.

```
call mysql.rds_set_configuration('binlog retention hours', 24);
```

For MySQL DB instances, the maximum `binlog retention hours` value is 168 (7 days).

After you set the retention period, monitor storage usage for the DB instance to make sure that the retained binary logs don't take up too much storage.

target delay

Use the `target delay` parameter to specify the number of seconds to delay replication from the master to the read replica. The specified delay applies to new replicas created from the current DB instance. Amazon RDS normally replicates changes as soon as possible, but some environments might want to delay replication. For example, when replication is delayed, you can roll forward a delayed read replica to the time just before a disaster. If a table is dropped accidentally, you can use delayed replication to recover it quickly. The default value of `target delay` is `0` (don't delay replication).

For disaster recovery, you can use this configuration parameter with the mysql.rds_start_replication_until (p. 832) stored procedure or the mysql.rds_start_replication_until_gtid (p. 833) stored procedure. To roll forward changes to a delayed read replica to the time just before a disaster, you can run the `mysql.rds_set_configuration` procedure with this parameter set. After the `mysql.rds_start_replication_until` or `mysql.rds_start_replication_until_gtid` procedure stops replication, you can promote the read replica to be the new master DB instance by using the instructions in Promoting a Read Replica to Be a Standalone DB Instance (p. 255).

To use the `mysql.rds_rds_start_replication_until_gtid` procedure, GTID-based replication must be enabled. To skip a specific GTID-based transaction that is known to cause disaster, you can use the mysql.rds_skip_transaction_with_gtid (p. 835) stored procedure. For more information about working with GTID-based replication, see Using GTID-Based Replication for Amazon RDS MySQL (p. 779).

To specify the number of seconds for Amazon RDS to delay replication to a read replica, use the `mysql.rds_set_configuration` stored procedure and specify the number of seconds to delay replication. The following example specifies that replication is delayed by at least one hour (3,600 seconds).

```
call mysql.rds_set_configuration('target delay', 3600);
```

The limit for the `target delay` parameter is one day (86400 seconds).

> **Note**
> The `target delay` parameter is only supported for Amazon RDS MySQL.
> The `target delay` parameter is not supported for Amazon RDS MySQL version 8.0.

mysql.rds_show_configuration

The number of hours that binary logs are retained.

Syntax

```
CALL mysql.rds_show_configuration;
```

Usage Notes

To verify the number of hours that Amazon RDS retains binary logs, use the `mysql.rds_show_configuration` stored procedure.

The `mysql.rds_show_configuration` procedure is available in these versions of Amazon RDS MySQL:

- MySQL 5.6

- MySQL 5.7
- MySQL 8.0

Examples

The following example displays the retention period:

```
call mysql.rds_show_configuration;
                name                         value     description
                binlog retention hours       24        binlog retention hours specifies the
 duration in hours before binary logs are automatically deleted.
```

mysql.rds_kill

Terminates a connection to the MySQL server.

Syntax

```
CALL mysql.rds_kill(processID);
```

Parameters

processID

The identity of the connection thread to be terminated.

Usage Notes

Each connection to the MySQL server runs in a separate thread. To terminate a connection, use the `mysql.rds_kill` procedure and pass in the thread ID of that connection. To obtain the thread ID, use the MySQL SHOW PROCESSLIST command.

Examples

The following example terminates a connection with a thread ID of 4243:

```
call mysql.rds_kill(4243);
```

mysql.rds_kill_query

Terminates a query running against the MySQL server.

Syntax

```
CALL mysql.rds_kill_query(queryID);
```

Parameters

queryID

The identity of the query to be terminated.

Usage Notes

To terminate a query running against the MySQL server, use the `mysql_rds_kill_query` procedure and pass in the ID of that query. To obtain the query ID, use the MySQL INFORMATION_SCHEMA PROCESSLIST command. The connection to the MySQL server is retained.

Examples

The following example terminates a query with a thread ID of 230040:

```
call mysql.rds_kill_query(230040);
```

mysql.rds_rotate_general_log

Rotates the `mysql.general_log` table to a backup table. For more information, see MySQL Database Log Files (p. 468).

Syntax

```
CALL mysql.rds_rotate_general_log;
```

Usage Notes

You can rotate the `mysql.general_log` table to a backup table by calling the `mysql.rds_rotate_general_log` procedure. When log tables are rotated, the current log table is copied to a backup log table and the entries in the current log table are removed. If a backup log table already exists, then it is deleted before the current log table is copied to the backup. You can query the backup log table if needed. The backup log table for the `mysql.general_log` table is named `mysql.general_log_backup`.

mysql.rds_rotate_slow_log

Rotates the `mysql.slow_log` table to a backup table. For more information, see MySQL Database Log Files (p. 468).

Syntax

```
CALL mysql.rds_rotate_slow_log;
```

Usage Notes

You can rotate the `mysql.slow_log` table to a backup table by calling the `mysql.rds_rotate_slow_log` procedure. When log tables are rotated, the current log table is copied to a backup log table and the entries in the current log table are removed. If a backup log table already exists, then it is deleted before the current log table is copied to the backup.

You can query the backup log table if needed. The backup log table for the `mysql.slow_log` table is named `mysql.slow_log_backup`.

mysql.rds_enable_gsh_collector

Enables the Global Status History (GoSH) to take default snapshots at intervals specified by `rds_set_gsh_collector`. For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_enable_gsh_collector;
```

mysql.rds_set_gsh_collector

Specifies the interval, in minutes, between snapshots taken by the Global Status History (GoSH). Default value is For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_set_gsh_collector(intervalPeriod);
```

Parameters

intervalPeriod

The interval, in minutes, between snapshots. Default value is

mysql.rds_disable_gsh_collector

Disables snapshots taken by the Global Status History (GoSH). For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_disable_gsh_collector;
```

mysql.rds_collect_global_status_history

Takes a snapshot on demand for the Global Status History (GoSH). For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_collect_global_status_history;
```

mysql.rds_enable_gsh_rotation

Enables rotation of the contents of the `mysql.global_status_history` table to `mysql.global_status_history_old` at intervals specified by `rds_set_gsh_rotation`. For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_enable_gsh_rotation;
```

mysql.rds_set_gsh_rotation

Specifies the interval, in days, between rotations of the `mysql.global_status_history` table. Default value is 7. For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_set_gsh_rotation(intervalPeriod);
```

Parameters

intervalPeriod

The interval, in days, between table rotations. Default value is 7.

mysql.rds_disable_gsh_rotation

Disables rotation of the `mysql.global_status_history` table. For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_disable_gsh_rotation;
```

mysql.rds_rotate_global_status_history

Rotates the contents of the `mysql.global_status_history` table to `mysql.global_status_history_old` on demand. For more information, see Managing the Global Status History (p. 804).

Syntax

```
CALL mysql.rds_rotate_global_status_history;
```

Oracle on Amazon RDS

Amazon RDS supports DB instances that run the following versions and editions of Oracle Database:

- Oracle 19c, Version 19.0.0.0
- Oracle 18c, Version 18.0.0.0
- Oracle 12c, Version 12.2.0.1
- Oracle 12c, Version 12.1.0.2

Note
Amazon RDS also currently supports Oracle 11g, Version 11.2.0.4 (Deprecation of Oracle 11.2.0.4 (p. 867)). This version is on a deprecation path because Oracle will no longer provides patches for 11.2.0.4 after the end-of-support date.

You can create DB instances and DB snapshots, point-in-time restores, and automated or manual backups. DB instances running Oracle can be used inside a VPC. You can also enable various options to add additional features to your Oracle DB instance. Amazon RDS supports Multi-AZ deployments for Oracle as a high-availability, failover solution.

To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges. Amazon RDS supports access to databases on a DB instance using any standard SQL client application such as Oracle SQL Plus. Amazon RDS doesn't enable direct host access to a DB instance by using Telnet or Secure Shell (SSH).

When you create a DB instance, the master account that you use to create the instance gets DBA user privileges (with some limitations). Use this account for any administrative tasks such as creating additional user accounts in the database. The SYS user, SYSTEM user, and other administrative accounts can't be used.

Before creating a DB instance, complete the steps in the Setting Up for Amazon RDS (p. 58) section of this guide.

Common Management Tasks for Oracle on Amazon RDS

The following are the common management tasks you perform with an Amazon RDS Oracle DB instance, with links to relevant documentation for each task.

Task Area	Relevant Documentation
Instance Classes, Storage, and PIOPS If you are creating a DB instance for production purposes, you should understand how instance classes, storage types, and Provisioned IOPS work in Amazon RDS.	DB Instance Class Support for Oracle (p. 850) Amazon RDS Storage Types (p. 29)
Multi-AZ Deployments A production DB instance should use Multi-AZ deployments. Multi-AZ deployments provide increased availability, data durability, and fault tolerance for DB instances.	High Availability (Multi-AZ) for Amazon RDS (p. 41)

Task Area	Relevant Documentation
Amazon Virtual Private Cloud (VPC) If your AWS account has a default VPC, then your DB instance is automatically created inside the default VPC. If your account doesn't have a default VPC, and you want the DB instance in a VPC, create the VPC and subnet groups before you create the DB instance.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Working with a DB Instance in a VPC (p. 1442)
Security Groups By default, DB instances are created with a firewall that prevents access to them. You therefore must create a security group with the correct IP addresses and network configuration to access the DB instance. The security group you create depends on what Amazon EC2 platform your DB instance is on, and whether you will access your DB instance from an Amazon EC2 instance. In general, if your DB instance is on the EC2-Classic platform, you need to create a DB security group. Also, generally, if your DB instance is on the EC2-VPC platform, you need to create a VPC security group.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Controlling Access with Security Groups (p. 1414)
Parameter Groups If your DB instance is going to require specific database parameters, you should create a parameter group before you create the DB instance.	Working with DB Parameter Groups (p. 202)
Option Groups If your DB instance is going to require specific database options, you should create an option group before you create the DB instance.	Options for Oracle DB Instances (p. 914)
Connecting to Your DB Instance After creating a security group and associating it to a DB instance, you can connect to the DB instance using any standard SQL client application such as Oracle SQL Plus.	Connecting to a DB Instance Running the Oracle Database Engine (p. 874)
Backup and Restore You can configure your DB instance to take automated backups, or take manual snapshots, and then restore instances from the backups or snapshots.	Backing Up and Restoring an Amazon RDS DB Instance (p. 290)
Monitoring You can monitor an Oracle DB instance by using CloudWatch Amazon RDS metrics, events, and enhanced monitoring.	Viewing DB Instance Metrics (p. 356) Viewing Amazon RDS Events (p. 448)
Log Files You can access the log files for your Oracle DB instance.	Amazon RDS Database Log Files (p. 453)

There are also advanced tasks and optional features for working with Oracle DB instances. For more information, see the following documentation:

- For information on common DBA tasks for Oracle on Amazon RDS, see Common DBA Tasks for Oracle DB Instances (p. 996).
- For information on Oracle GoldenGate support, see Using Oracle GoldenGate with Amazon RDS (p. 1072).
- For information on Siebel Customer Relationship Management (CRM) support, see Installing a Siebel Database on Oracle on Amazon RDS (p. 1089).

Oracle Licensing

There are two licensing options available for Amazon RDS for Oracle: License Included and Bring Your Own License (BYOL). After you create an Oracle DB instance on Amazon RDS, you can change the licensing model by modifying the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

License Included

In the License Included model, you don't need to purchase Oracle licenses separately. AWS holds the license for the Oracle database software. In this model, if you have an AWS Support account with case support, you contact AWS Support for both Amazon RDS and Oracle Database service requests.

The License Included model is supported on Amazon RDS for the following Oracle database editions:

- Oracle Database Standard Edition One (SE1)
- Oracle Database Standard Edition Two (SE2)

> **Note**
> The Oracle Database SE1 License Included model isn't supported in the following opt-in AWS Regions:
>
> - Africa (Cape Town)
> - Asia Pacific (Hong Kong)
> - Europe (Milan)
> - Middle East (Bahrain)

Bring Your Own License (BYOL)

In the Bring Your Own License model, you can use your existing Oracle Database licenses to run Oracle deployments on Amazon RDS. You must have the appropriate Oracle Database license (with Software Update License and Support) for the DB instance class and Oracle Database edition you wish to run. You must also follow Oracle's policies for licensing Oracle Database software in the cloud computing environment. For more information on Oracle's licensing policy for Amazon EC2, see Licensing Oracle Software in the Cloud Computing Environment.

In this model, you continue to use your active Oracle support account, and you contact Oracle directly for Oracle Database service requests. If you have an AWS Support account with case support, you can contact AWS Support for Amazon RDS issues. Amazon Web Services and Oracle have a multi-vendor support process for cases that require assistance from both organizations.

The Bring Your Own License model is supported on Amazon RDS for the following Oracle database editions:

- Oracle Database Enterprise Edition (EE)
- Oracle Database Standard Edition (SE)
- Oracle Database Standard Edition One (SE1)
- Oracle Database Standard Edition Two (SE2)

Integrating with AWS License Manager

If you use the Bring Your Own License model, AWS License Manager integration with Amazon RDS for Oracle makes it easier to monitor your Oracle license usage within your organization. License Manager supports tracking of RDS for Oracle engine editions and licensing packs based on virtual cores (vCPUs). You can also use License Manager with AWS Organizations to manage all of your organizational accounts centrally.

> **Note**
> RDS for Oracle integration with License Manager isn't supported in the Asia Pacific (Osaka-Local) Region.

The following table shows the product information filters for RDS for Oracle.

Filter	Name	Description
Engine Edition	`oracle-ee`	Oracle Database Enterprise Edition (EE)
	`oracle-se`	Oracle Database Standard Edition (SE)
	`oracle-se1`	Oracle Database Standard Edition One (SE1)
	`oracle-se2`	Oracle Database Standard Edition Two (SE2)
License Pack	`data guard`	See Working with Oracle Read Replicas for Amazon RDS (p. 908) (Oracle Active Data Guard)
	`olap`	See Oracle OLAP (p. 966)
	`ols`	See Oracle Label Security (p. 954)
	`diagnostic pack sqlt`	See Oracle SQLT (p. 979)
	`tuning pack sqlt`	See Oracle SQLT (p. 979)

You can create a license configuration to track license usage of your Oracle DB instances. After the license configuration is created, RDS for Oracle resources matching the product information filter are associated automatically with the license configuration. Discovery of Oracle DB instances can take up to 24 hours.

Console

To create a license configuration to track the license usage of your Oracle DB instances

1. Go to https://console.aws.amazon.com/license-manager/.
2. Create a license configuration.

   For instructions, see Create a License Configuration in the *AWS License Manager User Guide*.

   Add a rule for an **RDS Product Information Filter** in the **Product Information** panel.

   For more information, see ProductInformation in the *AWS License Manager API Reference*.

AWS CLI

To create a license configuration to track the license usage of your Oracle DB instances by using the AWS CLI, call the create-license-configuration command. You can use the `--cli-input-json` or `--cli-input-yaml` parameters to] pass the parameters to the command.

Example

The following code creates a license configuration for Oracle Enterprise Edition.

```
aws license-manager create-license-configuration –cli-input-json file://rds-oracle-ee.json
```

The following is the sample `rds-oracle-ee.json` file used in the example.

```
{
    "Name": "rds-oracle-ee",
    "Description": "RDS Oracle Enterprise Edition",
    "LicenseCountingType": "vCPU",
    "LicenseCountHardLimit": false,
    "ProductInformationList": [
        {
            "ResourceType": "RDS",
            "ProductInformationFilterList": [
                {
                    "ProductInformationFilterName": "Engine Edition",
                    "ProductInformationFilterValue": ["oracle-ee"],
                    "ProductInformationFilterComparator": "EQUALS"
                }
            ]
        }
    ]
}
```

For more information about product information, see Automated Discovery of Resource Inventory in the *AWS License Manager User Guide*.

For more information about the `--cli-input` parameter, see Generating AWS CLI Skeleton and Input Parameters from a JSON or YAML Input File in the *AWS CLI User Guide*.

Licensing Oracle Multi-AZ Deployments

Amazon RDS supports Multi-AZ deployments for Oracle as a high-availability, failover solution. We recommend Multi-AZ for production workloads. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

If you use the Bring Your Own License model, you must have a license for both the primary DB instance and the standby DB instance in a Multi-AZ deployment.

Migrating Between Oracle Editions

For the BYOL model, you can migrate from any Standard Edition (SE, SE1, or SE2) to Enterprise Edition (EE), assuming you have an unused Oracle license appropriate for the edition and class of DB instance you plan to run. You can't migrate from Enterprise Edition to other editions.

To change the edition and retain your data

1. Create a snapshot of the DB instance.

   For more information, see Creating a DB Snapshot (p. 301).
2. Restore the snapshot to a new DB instance, and select the Oracle database edition you want to use.

   For more information, see Restoring from a DB Snapshot (p. 303).
3. (Optional) Delete the old DB instance, unless you want to keep it running and have the appropriate Oracle Database licenses for it.

   For more information, see Deleting a DB Instance (p. 286).

DB Instance Class Support for Oracle

The computation and memory capacity of a DB instance is determined by its DB instance class. The DB instance class you need depends on your processing power and memory requirements. For more information, see DB Instance Classes (p. 7).

The following are the DB instance classes supported for Oracle.

Oracle Edition	19c, 18c, and 12c Version 12.2.0.1 Support	12c Version 12.1.0.2 Support	11g Version 11.2.0.4 Support
Enterprise Edition (EE) Bring Your Own License (BYOL)	db.m5.large–db.m5.24xlarge db.m4.large–db.m4.16xlarge db.z1d.large–db.z1d.12xlarge db.x1e.xlarge–db.x1e.32xlarge db.x1.16xlarge–db.x1.32xlarge db.r5.large–db.r5.24xlarge db.r4.large–db.r4.16xlarge db.t3.small–db.t3.2xlarge	db.m5.large–db.m5.24xlarge db.m4.large–db.m4.16xlarge db.z1d.large–db.z1d.12xlarge db.x1e.xlarge–db.x1e.32xlarge db.x1.16xlarge–db.x1.32xlarge db.r5.large–db.r5.24xlarge db.r4.large–db.r4.16xlarge db.t3.micro–db.t3.2xlarge	db.m5.large–db.m5.24xlarge db.m4.large–db.m4.16xlarge db.z1d.large–db.z1d.12xlarge db.x1e.xlarge–db.x1e.32xlarge db.x1.16xlarge–db.x1.32xlarge db.r5.large–db.r5.24xlarge db.r4.large–db.r4.16xlarge db.t3.micro–db.t3.2xlarge
Standard Edition 2 (SE2) Bring Your Own License (BYOL)	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.z1d.large–db.z1d.3xlarge db.x1e.xlarge–db.x1e.4xlarge db.r5.large–db.r5.4xlarge db.r4.large–db.r4.4xlarge	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.z1d.large–db.z1d.3xlarge db.x1e.xlarge–db.x1e.4xlarge db.r5.large–db.r5.4xlarge db.r4.large–db.r4.4xlarge	—

Oracle Edition	19c, 18c, and 12c Version 12.2.0.1 Support	12c Version 12.1.0.2 Support	11g Version 11.2.0.4 Support
	db.t3.small–db.t3.2xlarge	db.t3.micro–db.t3.2xlarge	
Standard Edition 2 (SE2) License Included	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.r5.large–db.r5.4xlarge db.r4.large–db.r4.4xlarge db.t3.small–db.t3.2xlarge	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.r5.large–db.r5.4xlarge db.r4.large–db.r4.4xlarge db.t3.micro–db.t3.2xlarge	—
Standard Edition 1 (SE1) Bring Your Own License (BYOL)	—	—	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.z1d.large–db.z1d.3xlarge db.x1e.xlarge–db.x1e.4xlarge db.r5.large–db.r5.4xlarge db.r4.large–db.r4.4xlarge db.t3.micro–db.t3.2xlarge
Standard Edition 1 (SE1) License Included	—	—	db.m5.large–db.m5.4xlarge db.m4.large–db.m4.4xlarge db.r5.large–db.r5.4xlarge db.t3.micro–db.t3.2xlarge
Standard Edition (SE) Bring Your Own License (BYOL)	—	—	db.m5.large–db.m5.8xlarge db.m4.large–db.m4.4xlarge db.z1d.large–db.z1d.6xlarge db.x1e.xlarge–db.x1e.8xlarge db.r5.large–db.r5.8xlarge db.r4.large–db.r4.8xlarge db.t3.micro–db.t3.2xlarge

Note

We encourage all bring-your-own-license customers to consult their licensing agreement to assess the impact of Amazon RDS for Oracle deprecations. For more information on the compute capacity of DB instance classes supported by Amazon RDS for Oracle, see DB Instance Classes (p. 7) and Configuring the Processor for a DB Instance Class (p. 17).

Deprecated db.t2 DB Instance Classes for Oracle

The db.t2 DB instance classes are deprecated for Amazon RDS for Oracle. The db.t2 DB instance classes have been replaced by the better performing db.t3 DB instance classes that are generally available at a lower cost. Starting on January 15, 2020, Amazon RDS for Oracle will automatically scale db.t2 DB instances to comparable db.t3 DB instance classes.

If you have DB instances that use db.t2 DB instance classes, Amazon RDS will modify each one automatically to use a comparable DB instance class that is not deprecated. You can change the DB instance class for a DB instance yourself by modifying the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

If you have DB snapshots of DB instances that were using db.t2 DB instance classes, you can choose a DB instance class that is not deprecated when you restore the DB snapshots. For more information, see Restoring from a DB Snapshot (p. 303).

> **Note**
> The db.t3 DB instance classes have hyper-threading enabled by default. When DB instances running the db.t2 DB instance class are migrated, the number of vCPUs is set automatically to the default number of the comparable db.t3 DB instance class. To learn more about the vCPU management features available on Amazon RDS for Oracle, and the default settings for each db.t3 DB instance class, see Configuring the Processor for a DB Instance Class (p. 17).

Deprecated db.m3 and db.r3 DB Instance Classes for Oracle

The db.m3 and db.r3 DB instance classes are deprecated for Amazon RDS for Oracle. These DB instance classes have been replaced by better performing DB instance classes that are generally available at a lower cost. Starting on September 30, 2019, Amazon RDS for Oracle will automatically scale DB instances to DB instance classes that are not deprecated.

If you have DB instances that use db.m3 and db.r3 DB instance classes, Amazon RDS will modify each one automatically to use a comparable DB instance class that is not deprecated. You can change the DB instance class for a DB instance yourself by modifying the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

If you have DB snapshots of DB instances that were using db.m3 or db.r3 DB instance classes, you can choose a DB instance class that is not deprecated when you restore the DB snapshots. For more information, see Restoring from a DB Snapshot (p. 303).

Deprecated db.m1 and db.m2 DB Instance Classes for Oracle

The db.m1 and db.m2 DB instance classes are deprecated for Amazon RDS for Oracle. These DB instance classes have been replaced by better performing DB instance classes that are generally available at a lower cost. Starting on September 12, 2018, Amazon RDS for Oracle will automatically scale DB instances to DB instance classes that are not deprecated.

If you have DB instances that use db.m1 and db.m2 DB instance classes, Amazon RDS will modify each one automatically to use a comparable DB instance class that is not deprecated. You can change the DB instance class for a DB instance yourself by modifying the DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

If you have DB snapshots of DB instances that were using db.m1 or db.m2 DB instance classes, you can choose a DB instance class that is not deprecated when you restore the DB snapshots. For more information, see Restoring from a DB Snapshot (p. 303).

Oracle Security

The Oracle database engine uses role-based security. A role is a collection of privileges that can be granted to or revoked from a user. A predefined role, named *DBA*, normally allows all administrative privileges on an Oracle database engine. The following privileges are not available for the DBA role on an Amazon RDS DB instance using the Oracle engine:

- Alter database
- Alter system
- Create any directory
- Drop any directory
- Grant any privilege
- Grant any role

When you create a DB instance, the master account that you use to create the instance gets DBA user privileges (with some limitations). Use this account for any administrative tasks such as creating additional user accounts in the database. The SYS user, SYSTEM user, and other administrative accounts can't be used.

Amazon RDS Oracle supports SSL/TLS encrypted connections and also the Oracle Native Network Encryption (NNE) option to encrypt connections between your application and your Oracle DB instance. For more information about using SSL with Oracle on Amazon RDS, see Using SSL with an Oracle DB Instance (p. 853). For more information about the Oracle Native Network Encryption option, see Oracle Native Network Encryption (p. 963).

Using SSL with an Oracle DB Instance

Secure Sockets Layer (SSL) is an industry standard protocol used for securing network connections between client and server. After SSL version 3.0, the name was changed to Transport Layer Security (TLS), but it is still often referred to as SSL and we refer to the protocol as SSL. Amazon RDS supports SSL encryption for Oracle DB instances. Using SSL, you can encrypt a connection between your application client and your Oracle DB instance. SSL support is available in all AWS regions for Oracle.

You enable SSL encryption for an Oracle DB instance by adding the Oracle SSL option to the option group associated with the DB instance. Amazon RDS uses a second port, as required by Oracle, for SSL connections. Doing this allows both clear text and SSL-encrypted communication to occur at the same time between a DB instance and an Oracle client. For example, you can use the port with clear text communication to communicate with other resources inside a VPC while using the port with SSL-encrypted communication to communicate with resources outside the VPC.

For more information, see Oracle Secure Sockets Layer (p. 967).

> **Note**
> You can't use both SSL and Oracle native network encryption (NNE) on the same DB instance. Before you can use SSL encryption, you must disable any other connection encryption.

Oracle 19c with Amazon RDS

Amazon RDS supports Oracle version 19c, which includes Oracle Enterprise Edition and Oracle Standard Edition Two.

Oracle 19c version 19.0.0.0 includes many new features and updates from the previous version. In this section, you can find the features and changes important to using Oracle 19c version 19.0.0.0 on

Amazon RDS. For a complete list of the changes, see the Oracle Database 19c documentation. For a complete list of features supported by each Oracle 19c edition, see Permitted Features, Options, and Management Packs by Oracle Database Offering in the Oracle documentation.

Amazon RDS Parameter Changes for Oracle 19c Version 19.0.0.0

Oracle 19c version 19.0.0.0 includes several new parameters and parameters with new ranges and new default values.

The following table shows the new Amazon RDS parameters for Oracle 19c version 19.0.0.0.

Name	Values	Modifi	Description
lob_signature_enable	TRUE, FALSE (default)	Y	Enables or disables the LOB locator signature feature.
max_datapump_parallel_per_job	1 to 1024, or AUTO	Y	Specifies the maximum number of parallel processes allowed for each Oracle Data Pump job.

The `compatible` parameter has a new maximum value for Oracle 19c version 19.0.0.0 on Amazon RDS. The following table shows the new default value.

Parameter Name	Oracle 19c Version 19.0.0.0 Maximum Value	Oracle 18c Version 18.0.0.0 Maximum Value
compatible	19.0.0	18.0.0

The following parameters were removed in Oracle 19c Version 19.0.0.0:

- exafusion_enabled
- max_connections
- o7_dictionary_access

Oracle 18c with Amazon RDS

Amazon RDS supports Oracle version 18c, which includes Oracle Enterprise Edition and Oracle Standard Edition Two.

Oracle 18c version 18.0.0.0 includes many new features and updates from the previous version. In this section, you can find the features and changes important to using Oracle 18c version 18.0.0.0 on Amazon RDS. For a complete list of the changes, see the Oracle Database 18c. For a complete list of features supported by each Oracle 18c edition, see Permitted Features, Options, and Management Packs by Oracle Database Offering in the Oracle documentation.

Amazon RDS Parameter Changes for Oracle 18c Version 18.0.0.0

Oracle 18c version 18.0.0.0 includes several new parameters and parameters with new ranges and new default values.

The following table shows the new Amazon RDS parameters for Oracle 18c version 18.0.0.0.

Name	Values	Modifiable	Description
adg_account_info_tracking	LOCAL (default), GLOBAL	N	Controls login attempts of users on Active Data Guard Standby databases. It extends the control of user account security information.
inmemory_optimized_arithmetic	ENABLE, DISABLE (default)	Y	Encodes the `NUMBER` data type in in-memory tables compressed with `QUERY LOW` as a fixed-width native integer scaled by a common exponent.
optimizer_ignore_hints	TRUE, FALSE (default)	Y	Specifies whether embedded hints are ignored.
optimizer_ignore_parallel_hints	TRUE, FALSE (default)	Y	Specifies that embedded parallel hints are ignored.
parallel_min_degree	1 (default) and higher or CPU	Y	Controls the minimum degree of parallelism computed by automatic degree of parallelism.

The `compatible` parameter has a new default value for Oracle 18c version 18.0.0.0 on Amazon RDS. The following table shows the new default value.

Parameter Name	Oracle 18c Version 18.0.0.0 Default Value	Oracle 12c Version 12.2.0.1 Default Value
compatible	18.0.0	12.2.0

The following parameters were removed in Oracle 18c Version 18.0.0.0:

- standby_archive_dest
- utl_file_dir

Oracle 12c with Amazon RDS

Amazon RDS supports Oracle version 12c, which includes Oracle Enterprise Edition and Oracle Standard Edition Two. Oracle version 12c includes two major versions:

- Oracle 12c Version 12.2.0.1 with Amazon RDS (p. 855)
- Oracle 12c Version 12.1.0.2 with Amazon RDS (p. 858)

Oracle 12c Version 12.2.0.1 with Amazon RDS

Oracle 12c version 12.2.0.1 includes many new features and updates from the previous version. In this section, you can find the features and changes important to using Oracle 12c version 12.2.0.1 on Amazon RDS. For a complete list of the changes, see the Oracle 12c version 12.2 documentation. For a complete list of features supported by each Oracle 12c edition, see Permitted Features, Options, and Management Packs by Oracle Database Offering in the Oracle documentation.

Amazon RDS Parameter Changes for Oracle 12c Version 12.2.0.1

Oracle 12c version 12.2.0.1 includes 20 new parameters in addition to several parameters with new ranges and new default values.

The following table shows the new Amazon RDS parameters for Oracle 12c version 12.2.0.1.

Name	Values	Modifiable	Description
allow_global_dblinks	TRUE, FALSE (default)	Y	Specifies whether LDAP lookup for database links is allowed for the database.
approx_for_aggregation	TRUE, FALSE (default)	Y	Replaces exact query processing for aggregation queries with approximate query processing.
approx_for_count_distinct	TRUE, FALSE (default)	Y	Automatically replaces `COUNT (DISTINCT expr)` queries with `APPROX_COUNT_DISTINCT` queries.
approx_for_percentile	NONE (default), PERCENTILE_CONT, PERCENTILE_CONT DETERMINISTIC, PERCENTILE_DISC, PERCENTILE_DISC DETERMINISTIC, ALL, ALL DETERMINISTIC	Y	Converts exact percentile functions to their approximate percentile function counterparts.
cursor_invalidation	DEFERRED, IMMEDIATE (default)	Y	Controls whether deferred cursor invalidation or immediate cursor invalidation is used for DDL statements by default.
data_guard_sync_latency	0 (default) to the number of seconds specified by the NET_TIMEOUT attribute for the LOG_ARCHIVE_DEST_n parameter	Y	Controls how many seconds the Log Writer (LGWR) process waits beyond the response of the first in a series of Oracle Data Guard SYNC redo transport mode connections.
data_transfer_cache_size	0 – 512M, rounded up to the next granule size	Y	Sets the size of the data transfer cache (in bytes) used to receive data blocks (typically from a primary database in an Oracle Data Guard environment) for consumption by an instance during execution of an RMAN RECOVER ... NONLOGGED BLOCK command.
inmemory_adg_enabled	TRUE (default), FALSE	Y	Indicates whether in-memory for Active Data Guard is enabled in addition to the in-memory cache size.

Name	Values	Modifi	Description
inmemory_expressions_usage	STATIC_ONLY, DYNAMIC_ONLY,ENABLE (default), DISABLE	Y	Controls which In-Memory Expressions (IM expressions) are populated into the In-Memory Column Store (IM column store) and are available for queries.
inmemory_virtual_columns	ENABLE, MANUAL (default), DISABLE	Y	Controls which In-Memory Expressions (IM expressions) are populated into the In-Memory Column Store (IM column store) and are available for queries.
instance_abort_delay_time	0 (default) and higher	Y	Specifies how much time to delay an internal initiated instance abort (in seconds), such as when a fatal process dies or an unrecoverable instance error occurs.
instance_mode	READ-WRITE (default), READ-ONLY, READ-MOSTLY	N	Indicates whether the instance is read-write, read-only, or read-mostly.
long_module_action	TRUE (default), FALSE	Y	Enables the use of longer lengths for modules and actions.
max_idle_time	0 (default) to the maximum integer. The value of 0 indicates that there is no limit.	Y	Specifies the maximum number of minutes that a session can be idle. After that point, the session is automatically terminated.
optimizer_adaptive_plans	TRUE (default), FALSE	Y	Controls adaptive plans. Adaptive plans are execution plans built with alternative choices that are decided at run time based on statistics collected as the query executes.
optimizer_adaptive_statistics	TRUE, FALSE (default)	Y	Controls adaptive statistics. Some query shapes are too complex to rely on base table statistics alone, so the optimizer augments these statistics with adaptive statistics.
outbound_dblink_protocols	ALL (default), NONE, TCP, TCPS, IPC	N	Specifies the network protocols allowed for communicating for outbound database links in the database.
resource_manage_goldengate	TRUE, FALSE (default)	Y	Determines whether Oracle GoldenGate apply processes in the database are resource managed.
standby_db_preserve_states	NONE (default), SESSION, ALL	N	Controls whether user sessions and other internal states of the instance are retained when a readable physical standby database is converted to a primary database.

Name	Values	Modifi	Description
uniform_log_timestamp_format	TRUE (default), FALSE	Y	Specifies that a uniform timestamp format be used in Oracle Database trace (.trc) files and log files (such as the alert log).

The `compatible` parameter has a new default value for Oracle 12c version 12.2.0.1 on Amazon RDS. The following table shows the new default value.

Parameter Name	Oracle 12c Version 12.2.0.1 Default Value	Oracle 12c Version 12.1.0.2 Default Value
compatible	12.2.0	12.0.0

The `optimizer_features_enable` parameter has a new value range for Oracle 12c version 12.2.0.1 on Amazon RDS. For the old and new value ranges, see the following table.

Parameter Name	12c Version 12.2.0.1 Range	12c Version 12.1.0.2 Range
optimizer_features_enable	8.0.0 to 12.2.0.1	8.0.0 to 12.1.0.2

The following parameters were removed in Oracle 12c Version 12.2.0.1:

- global_context_pool_size
- max_enabled_roles
- optimizer_adaptive_features
- parallel_automatic_tuning
- parallel_degree_level
- use_indirect_data_buffers

The following parameter is not supported in Oracle 12c Version 12.2.0.1:

- sec_case_sensitive_logon

Amazon RDS Security Changes for Oracle 12c Version 12.2.0.1

In Oracle 12c version 12.2.0.1, direct grant of the privilege `ADMINISTER DATABASE TRIGGER` is required for the owners of database-level triggers. During a major version upgrade to Oracle 12c version 12.2.0.1, Amazon RDS grants this privilege to any user that owns a trigger so that the trigger owner has the required privileges. For more information, see the My Oracle Support document 2275535.1.

Oracle 12c Version 12.1.0.2 with Amazon RDS

Oracle 12c version 12.1.0.2 brings over 500 new features and updates from the previous version. In this section, you can find the features and changes important to using Oracle 12c version 12.1.0.2 on Amazon RDS. For a complete list of the changes, see the Oracle 12c version 12.1 documentation. For a complete list of features supported by each Oracle 12c edition, see Permitted Features, Options, and Management Packs by Oracle Database Edition in the Oracle documentation.

Oracle 12c version 12.1.0.2 includes 16 new parameters that impact your Amazon RDS DB instance, and also 18 new system privileges, several no longer supported packages, and several new option group settings. For more information on these changes, see the following sections.

Amazon RDS Parameter Changes for Oracle 12c Version 12.1.0.2

Oracle 12c version 12.1.0.2 includes 16 new parameters in addition to several parameters with new ranges and new default values.

The following table shows the new Amazon RDS parameters for Oracle 12c version 12.1.0.2.

Name	Values	Modifi	Description
connection_brokers	CONNECTION_BROKERS = broker_description[,...]	N	Specifies connection broker types, the number of connection brokers of each type, and the maximum number of connections per broker.
db_index_compression_inheritance	TABLESPACE, TABL, ALL, NONE	Y	Displays the options that are set for table or tablespace level compression inheritance.
db_big_table_cache_percent_target	0-90	Y	Specifies the cache section target size for automatic big table caching, as a percentage of the buffer cache.
heat_map	ON, OFF	Y	Enables the database to track read and write access of all segments and modification of database blocks that are due to data manipulation language (DML) and data definition language (DDL) statements.
inmemory_clause_default	INMEMORY, NO INMEMORY	Y	INMEMORY_CLAUSE_DEFAULT enables you to specify a default In-Memory Column Store (IM column store) clause for new tables and materialized views.
inmemory_clause_default_memcompress	NO MEMCOMPRESS, MEMCOMPRESS FOR DML, MEMCOMPRESS FOR QUERY, MEMCOMPRESS FOR QUERY LOW, MEMCOMPRESS FOR QUERY HIGH, MEMCOMPRESS FOR CAPACITY, MEMCOMPRESS FOR CAPACITY LOW, MEMCOMPRESS FOR CAPACITY HIGH	Y	See INMEMORY_CLAUSE_DEFAULT.
inmemory_clause_default_priority	PRIORITY LOW, PRIORITY MEDIUM, PRIORITY HIGH,	Y	See INMEMORY_CLAUSE_DEFAULT.

Name	Values	Modifi	Description
	PRIORITY CRITICAL, PRIORITY NONE		
inmemory_force	DEFAULT, OFF	Y	INMEMORY_FORCE allows you to specify whether tables and materialized view that are specified as INMEMORY are populated into the In-Memory Column Store (IM column store) or not.
inmemory_max_populate_servers	Null	N	INMEMORY_MAX_POPULATE_SERVERS specifies the maximum number of background populate servers to use for In-Memory Column Store (IM column store) population, so that these servers don't overload the rest of the system.
inmemory_query	ENABLE (default), DISABLE	Y	INMEMORY_QUERY is used to enable or disable in-memory queries for the entire database at the session or system level.
inmemory_size	0, 104857600-274877906944	Y	INMEMORY_SIZE sets the size of the In-Memory Column Store (IM column store) on a database instance.
inmemory_trickle_repopulate_servers_percent	0 to 50	Y	INMEMORY_TRICKLE_REPOPULATE_SERVERS_PERC limits the maximum number of background populate servers used for In-Memory Column Store (IM column store) repopulation. This limit is applied because trickle repopulation is designed to use only a small percentage of the populate servers.
max_string_size	STANDARD (default), EXTENDED	N	Controls the maximum size of VARCHAR2, NVARCHAR2, and RAW. For more information, see Using Extended Data Types (p. 872).
optimizer_adaptive_features	TRUE (default), FALSE	Y	Enables or disables all of the adaptive optimizer features.
optimizer_adaptive_reporting_only	TRUE, FALSE (default)	Y	Controls reporting-only mode for adaptive optimizations.
pdb_file_name_convert	There is no default value.	N	Maps names of existing files to new file names.
pga_aggregate_limit	1-max of memory	Y	Specifies a limit on the aggregate PGA memory consumed by the instance.
processor_group_name	There is no default value.	N	Instructs the database instance to run itself within the specified operating system processor group.

Name	Values	Modifi	Description
spatial_vector_acceleration	TRUE, FALSE	N	Enables or disables the spatial vector acceleration, part of spatial option.
temp_undo_enabled	TRUE, FALSE (default)	Y	Determines whether transactions within a particular session can have a temporary undo log.
threaded_execution	TRUE, FALSE	N	Enables the multithreaded Oracle model, but prevents OS authentication.
unified_audit_sga_queue_size	1 MB - 30 MB	Y	Specifies the size of the system global area (SGA) queue for unified auditing.
use_dedicated_broker	TRUE, FALSE	N	Determines how dedicated servers are spawned.

Several parameters have new value ranges for Oracle 12c version 12.1.0.2 on Amazon RDS. For the old and new value ranges, see the following table.

Parameter Name	12c Version 12.1.0.2 Range	11g Range
audit_trail	os | db [, extended] | xml [, extended]	os | db [, extended] | xml [, extended] | true | false
compatible	For DB instances upgraded from Oracle 11g, automatically set to 12.0.0 on Amazon RDS unless a lower value is explicitly provided during the upgrade (as low as 11.2.0) For new Oracle 12c version 12.1.0.2 DB instances, starts with 12.0.0 on Amazon RDS	Starts with 11.2.0 on Amazon RDS
db_securefile	PERMITTED | PREFERRED | ALWAYS | IGNORE | FORCE	PERMITTED | ALWAYS | IGNORE | FORCE
db_writer_processes	1-100	1-36
optimizer_features_enable	8.0.0 to 12.1.0.2	8.0.0 to 11.2.0.4
parallel_degree_policy	MANUAL,LIMITED,AUTO,ADAPTIVE	MANUAL,LIMITED,AUTO
parallel_min_server	0 to parallel_max_servers	CPU_COUNT * PARALLEL_THREADS_PER_CPU * 2 to parallel_max_servers

One parameter has a new default value for Oracle 12c on Amazon RDS. The following table shows the new default value.

Parameter Name	Oracle 12c Default Value	Oracle 11g Default Value
job_queue_processes	50	1000

Amazon RDS System Privileges for Oracle 12c Version 12.1.0.2

Several new system privileges have been granted to the system account for Oracle 12c version 12.1.0.2. These new system privileges include the following:

- ALTER ANY CUBE BUILD PROCESS
- ALTER ANY MEASURE FOLDER
- ALTER ANY SQL TRANSLATION PROFILE
- CREATE ANY SQL TRANSLATION PROFILE
- CREATE SQL TRANSLATION PROFILE
- DROP ANY SQL TRANSLATION PROFILE
- EM EXPRESS CONNECT
- EXEMPT DDL REDACTION POLICY
- EXEMPT DML REDACTION POLICY
- EXEMPT REDACTION POLICY
- LOGMINING
- REDEFINE ANY TABLE
- SELECT ANY CUBE BUILD PROCESS
- SELECT ANY MEASURE FOLDER
- USE ANY SQL TRANSLATION PROFILE

Amazon RDS Options for Oracle 12c Version 12.1.0.2

Several Oracle options changed between Oracle 11g and Oracle 12c version 12.1.0.2, though most of the options remain the same between the two versions. The Oracle 12c version 12.1.0.2 changes include the following:

- Oracle Enterprise Manager Database Express 12c replaced Oracle Enterprise Manager 11g Database Control. For more information, see Oracle Enterprise Manager Database Express (p. 936).
- The option XMLDB is installed by default in Oracle 12c version 12.1.0.2. You no longer need to install this option yourself.

Amazon RDS PL/SQL Packages for Oracle 12c Version 12.1.0.2

Oracle 12c version 12.1.0.2 includes a number of new built-in PL/SQL packages. The packages included with Amazon RDS Oracle 12c version 12.1.0.2 include the following.

Package Name	Description
CTX_ANL	The CTX_ANL package is used with AUTO_LEXER and provides procedures for adding and dropping a custom dictionary from the lexer.
DBMS_APP_CONT	The DBMS_APP_CONT package provides an interface to determine if the in-flight transaction on a now unavailable session committed or not, and if the last call on that session completed or not.
DBMS_AUTO_REPORT	The DBMS_AUTO_REPORT package provides an interface to view SQL Monitoring and Real-time Automatic Database Diagnostic Monitor (ADDM) data that has been captured into Automatic Workload Repository (AWR).

Package Name	Description
DBMS_GOLDENGATE_AUTH	The DBMS_GOLDENGATE_AUTH package provides subprograms for granting privileges to and revoking privileges from GoldenGate administrators.
DBMS_HEAT_MAP	The DBMS_HEAT_MAP package provides an interface to externalize heatmaps at various levels of storage including block, extent, segment, object, and tablespace.
DBMS_ILM	The DBMS_ILM package provides an interface for implementing Information Lifecycle Management (ILM) strategies using Automatic Data Optimization (ADO) policies.
DBMS_ILM_ADMIN	The DBMS_ILM_ADMIN package provides an interface to customize Automatic Data Optimization (ADO) policy execution.
DBMS_PART	The DBMS_PART package provides an interface for maintenance and management operations on partitioned objects.
DBMS_PRIVILEGE_CAPTURE	The DBMS_PRIVILEGE_CAPTURE package provides an interface to database privilege analysis.
DBMS_QOPATCH	The DBMS_QOPATCH package provides an interface to view the installed database patches.
DBMS_REDACT	The DBMS_REDACT package provides an interface to Oracle Data Redaction, which enables you to mask (redact) data that is returned from queries issued by low-privileged users or an application.
DBMS_SPD	The DBMS_SPD package provides subprograms for managing SQL plan directives (SPD).
DBMS_SQL_TRANSLATOR	The DBMS_SQL_TRANSLATOR package provides an interface for creating, configuring, and using SQL translation profiles.
DBMS_SQL_MONITOR	The DBMS_SQL_MONITOR package provides information about real-time SQL Monitoring and real-time Database Operation Monitoring.
DBMS_SYNC_REFRESH	The DBMS_SYNC_REFRESH package provides an interface to perform a synchronous refresh of materialized views.
DBMS_TSDP_MANAGE	The DBMS_TSDP_MANAGE package provides an interface to import and manage sensitive columns and sensitive column types in the database. DBMS_TSDP_MANAGE is used with the DBMS_TSDP_PROTECT package for transparent sensitive data protection (TSDP) policies. DBMS_TSDP_MANAGE is available with the Enterprise Edition only.
DBMS_TSDP_PROTECT	The DBMS_TSDP_PROTECT package provides an interface to configure transparent sensitive data protection (TSDP) policies in conjunction with the DBMS_TSDP_MANAGE package. DBMS_TSDP_PROTECT is available with the Enterprise Edition only.
DBMS_XDB_CONFIG	The DBMS_XDB_CONFIG package provides an interface for configuring Oracle XML DB and its repository.

Package Name	Description
DBMS_XDB_CONSTANTS	The DBMS_XDB_CONSTANTS package provides an interface to commonly used constants. Oracle recommends using constants instead of dynamic strings to avoid typographical errors.
DBMS_XDB_REPOS	The DBMS_XDB_REPOS package provides an interface to operate on the Oracle XML database Repository.
DBMS_XMLSCHEMA_ANNOTATE	The DBMS_XMLSCHEMA_ANNOTATE package provides an interface to manage and configure the structured storage model, mainly through the use of pre-registration schema annotations.
DBMS_XMLSTORAGE_MANAGE	The DBMS_XMLSTORAGE_MANAGE package provides an interface to manage and modify XML storage after schema registration has been completed.
DBMS_XSTREAM_ADM	The DBMS_XSTREAM_ADM package provides interfaces for streaming database changes between an Oracle database and other systems. XStream enables applications to stream out or stream in database changes.
DBMS_XSTREAM_AUTH	The DBMS_XSTREAM_AUTH package provides subprograms for granting privileges to and revoking privileges from XStream administrators.
UTL_CALL_STACK	The UTL_CALL_STACK package provides an interface to provide information about currently executing subprograms.

Oracle 12c Version 12.1.0.2 Packages Not Supported

Several Oracle 11g PL/SQL packages are not supported in Oracle 12c version 12.1.0.2. These packages include the following:

- DBMS_AUTO_TASK_IMMEDIATE
- DBMS_CDC_PUBLISH
- DBMS_CDC_SUBSCRIBE
- DBMS_EXPFIL
- DBMS_OBFUSCATION_TOOLKIT
- DBMS_RLMGR
- SDO_NET_MEM

Oracle Database Feature Support

Oracle Database supports a wide variety of features and capabilities, most of which are supported in Amazon RDS Oracle. Some features might have limited support or restricted privileges. Some features are only available in Enterprise Edition, and some require additional licenses. For more information about Oracle Database features for specific Oracle Database versions, see the *Oracle Database Licensing Information User Manual* for the version you're using.

> **Note**
> These lists are not exhaustive.

Amazon RDS Oracle supports the following Oracle Database features:

- Advanced Compression
- Application Express (APEX)

  For more information, see Oracle Application Express (p. 927).
- Automatic Memory Management
- Automatic Undo Management
- Automatic Workload Repository (AWR)

  For more information, see Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015).
- Active Data Guard with Maximum Performance in the same AWS Region or across AWS Regions

  For more information, see Working with Oracle Read Replicas for Amazon RDS (p. 908).
- Continuous Query Notification (version 12.1.0.2.v7 and later)

  For more information, see Using Continuous Query Notification (CQN) in the Oracle documentation.
- Data Redaction
- Database Change Notification (version 11.2.0.4.v11 and later 11g versions)

  For more information, see Database Change Notification in the Oracle documentation.

  Note
  This feature changes to Continuous Query Notification in version 12.1 and later.
- Database In-Memory (version 12.1 and later)
- Distributed Queries and Transactions
- Edition-Based Redefinition

  For more information, see Setting the Default Edition for a DB Instance (p. 1019).
- Enterprise Manager Database Control (11g) and EM Express (12c)

  For more information, see Oracle Enterprise Manager (p. 935).
- Fine-Grained Auditing
- Flashback Table, Flashback Query, Flashback Transaction Query
- Import/export (legacy and Data Pump) and SQL*Loader

  For more information, see Importing Data into Oracle on Amazon RDS (p. 896).
- Java Virtual Machine (JVM)

  For more information, see Oracle Java Virtual Machine (p. 951).
- Label Security (version 12.1 and later)

  For more information, see Oracle Label Security (p. 954).
- Locator

  For more information, see Oracle Locator (p. 957).
- Materialized Views
- Multimedia

  For more information, see Oracle Multimedia (p. 960).
- Network encryption

  For more information, see Oracle Native Network Encryption (p. 963) and Oracle Secure Sockets Layer (p. 967).
- Partitioning

- Spatial and Graph

  For more information, see Oracle Spatial (p. 976).
- Star Query Optimization
- Streams and Advanced Queuing
- Summary Management – Materialized View Query Rewrite
- Text (File and URL data store types are not supported)
- Total Recall
- Transparent Data Encryption (TDE)

  For more information, see Oracle Transparent Data Encryption (p. 990).
- Unified Auditing, Mixed Mode (version 12.2 and later)

  For more information, see Mixed Mode Auditing in the Oracle documentation.
- XML DB (without the XML DB Protocol Server)

  For more information, see Oracle XML DB (p. 994).
- Virtual Private Database

Amazon RDS Oracle doesn't support the following Oracle Database features:

- Automatic Storage Management (ASM)
- Database Vault
- Flashback Database
- Multitenant
- Oracle Enterprise Manager Cloud Control Management Repository
- Real Application Clusters (Oracle RAC)
- Real Application Testing
- Unified Auditing, Pure Mode

Oracle Database Parameter Support

In Amazon RDS, you manage parameters using parameter groups. For more information, see Working with DB Parameter Groups (p. 202). To view the supported parameters for a specific Oracle edition and version, you can run the AWS CLI `describe-engine-default-parameters` command.

For example, to view the supported parameters for Oracle Enterprise Edition version 12.2, run the following command.

```
aws rds describe-engine-default-parameters --db-parameter-group-family oracle-ee-12.2
```

Oracle Engine Version Management

With DB engine version management, you can control when and how the database engine software running your DB instances is patched and upgraded. With this feature, you get the flexibility to maintain compatibility with database engine patch versions. You can also test new patch versions to ensure they work effectively with your application before deploying them in production. In addition, you can perform version upgrades on your own terms and timelines.

Note
Amazon RDS periodically aggregates official Oracle database patches using an Amazon RDS-specific DB engine version. To see a list of which Oracle patches are contained in an Amazon RDS Oracle-specific engine version, go to Oracle Database Engine Release Notes (p. 1092).

Currently, you perform all Oracle database upgrades manually. For more information about upgrading an Oracle DB instance, see Upgrading the Oracle DB Engine (p. 888).

Deprecation of Oracle 11.2.0.4

Oracle Corporation intends to deprecate support for Oracle Database version 11.2.0.4 on December 31, 2020. On October 31, 2020, Amazon RDS plans to deprecate support for Oracle version 11.2.0.4 SE1 using the License Included model. On December 31, 2020, Amazon RDS plans to deprecate support for 11.2.0.4 on all editions that use the Bring Your Own License model (BYOL).

Amazon RDS plans to deprecate support for Oracle version 11.2.0.4 by the following schedule, which includes upgrade recommendations.

Action or Recommendation	11.2.0.4 on SE1 with License Included	11.2.0.4 on EE, SE, and SE1 with BYOL
We recommend that you upgrade 11.2.0.4 DB instances manually to the version of your choice.	Now–October 31, 2020	Now–December 31, 2020
We recommend that you upgrade 11.2.0.4 snapshots manually to the version of your choice.	August 1–January 31, 2021	October 1, 2020–March 31, 2021
You can no longer create new instances with Amazon RDS for Oracle with the listed version.	August 1, 2020	October 1, 2020
Amazon RDS for Oracle starts automatic upgrades of your DB instances to version 19c.	November 1, 2020	January 1, 2021
Amazon RDS for Oracle starts automatic upgrades to version 19c for any DB instances restored from snapshots.	November 1, 2020–January 31, 2021	January 1–March 31, 2021

Using Huge Pages with an Oracle DB Instance

Amazon RDS for Oracle supports Linux kernel huge pages for increased database scalability. The use of huge pages results in smaller page tables and less CPU time spent on memory management, increasing the performance of large database instances. For more information, see Overview of HugePages in the Oracle documentation.

You can use huge pages with the following versions and editions of Oracle:

- 19.0.0.0, all editions
- 18.0.0.0, all editions
- 12.2.0.1, all editions
- 12.1.0.2, all editions

- 11.2.0.4, all editions

The `use_large_pages` parameter controls whether huge pages are enabled for a DB instance. The possible settings for this parameter are `ONLY`, `FALSE`, and `{DBInstanceClassHugePagesDefault}`. The `use_large_pages` parameter is set to `{DBInstanceClassHugePagesDefault}` in the default DB parameter group for Oracle.

To control whether huge pages are enabled for a DB instance automatically, you can use the `DBInstanceClassHugePagesDefault` formula variable in parameter groups. The value is determined as follows:

- For the DB instance classes mentioned in the table following, `DBInstanceClassHugePagesDefault` always evaluates to `FALSE` by default, and `use_large_pages` evaluates to `FALSE`. You can enable huge pages manually for these DB instance classes if the DB instance class has at least 14 GiB of memory.
- For DB instance classes not mentioned in the table following, if the DB instance class has less than 14 GiB of memory, `DBInstanceClassHugePagesDefault` always evaluates to `FALSE`. Also, `use_large_pages` evaluates to `FALSE`.
- For DB instance classes not mentioned in the table following, if the instance class has at least 14 GiB of memory and less than 100 GiB of memory, `DBInstanceClassHugePagesDefault` evaluates to `TRUE` by default. Also, `use_large_pages` evaluates to `ONLY`. You can disable huge pages manually by setting `use_large_pages` to `FALSE`.
- For DB instance classes not mentioned in the table following, if the instance class has at least 100 GiB of memory, `DBInstanceClassHugePagesDefault` always evaluates to `TRUE`. Also, `use_large_pages` evaluates to `ONLY` and huge pages can't be disabled.

Huge pages are not enabled by default for the following DB instance classes.

DB Instance Class Family	DB Instance Classes with Huge Pages Not Enabled by Default
db.m5	db.m5.large
db.m4	db.m4.large, db.m4.xlarge, db.m4.2xlarge, db.m4.4xlarge, db.m4.10xlarge
db.m3	db.m3.medium, db.m3.large, db.m3.xlarge, db.m3.2xlarge
db.r3	db.r3.large, db.r3.xlarge, db.r3.2xlarge, db.r3.4xlarge, db.r3.8xlarge
db.t3	db.t3.micro, db.t3.small, db.t3.medium, db.t3.large
db.t2	db.t2.micro, db.t2.small, db.t2.medium, db.t2.large

For more information about DB instance classes, see Hardware Specifications for All Available DB Instance Classes (p. 9).

To enable huge pages for new or existing DB instances manually, set the `use_large_pages` parameter to `ONLY`. You can't use huge pages with Oracle Automatic Memory Management (AMM). If you set the parameter `use_large_pages` to `ONLY`, then you must also set both `memory_target` and `memory_max_target` to `0`. For more information about setting DB parameters for your DB instance, see Working with DB Parameter Groups (p. 202).

You can also set the `sga_target`, `sga_max_size`, and `pga_aggregate_target` parameters. When you set system global area (SGA) and program global area (PGA) memory parameters, add the values together. Subtract this total from your available instance memory (`DBInstanceClassMemory`) to determine the free memory beyond the huge pages allocation. You must leave free memory of at least 2 GiB, or 10 percent of the total available instance memory, whichever is smaller.

After you configure your parameters, you must reboot your DB instance for the changes to take effect. For more information, see Rebooting a DB Instance (p. 247).

Note

The Oracle DB instance defers changes to SGA-related initialization parameters until you reboot the instance without failover. In the Amazon RDS console, choose **Reboot** but *do not* choose **Reboot with failover**. In the AWS CLI, call the `reboot-db-instance` command with the `--no-force-failover` parameter. The DB instance does not process the SGA-related parameters during failover or during other maintenance operations that cause the instance to restart.

The following is a sample parameter configuration for huge pages that enables huge pages manually. You should set the values to meet your needs.

```
memory_target            = 0
memory_max_target        = 0
pga_aggregate_target     = {DBInstanceClassMemory*1/8}
sga_target               = {DBInstanceClassMemory*3/4}
sga_max_size             = {DBInstanceClassMemory*3/4}
use_large_pages          = ONLY
```

Assume the following parameters values are set in a parameter group.

```
memory_target            = IF({DBInstanceClassHugePagesDefault}, 0,
 {DBInstanceClassMemory*3/4})
memory_max_target        = IF({DBInstanceClassHugePagesDefault}, 0,
 {DBInstanceClassMemory*3/4})
pga_aggregate_target     = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*1/8}, 0)
sga_target               = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*3/4}, 0)
sga_max_size             = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*3/4}, 0)
use_large_pages          = {DBInstanceClassHugePagesDefault}
```

The parameter group is used by a db.r4 DB instance class with less than 100 GiB of memory and a db.r3 instance with more than 100 GiB memory. With these parameter settings and `use_large_pages` set to `{DBInstanceClassHugePagesDefault}`, huge pages are enabled on the db.r4 instance, but disabled on the db.r3 instance.

Consider another example with following parameters values set in a parameter group.

```
memory_target           = IF({DBInstanceClassHugePagesDefault}, 0,
 {DBInstanceClassMemory*3/4})
memory_max_target       = IF({DBInstanceClassHugePagesDefault}, 0,
 {DBInstanceClassMemory*3/4})
pga_aggregate_target    = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*1/8}, 0)
sga_target              = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*3/4}, 0)
sga_max_size            = IF({DBInstanceClassHugePagesDefault},
 {DBInstanceClassMemory*3/4}, 0)
use_large_pages         = FALSE
```

The parameter group is used by a db.r4 DB instance class and a db.r5 DB instance class, both with less than 100 GiB of memory. The parameter group is also used by a db.r3 instance with more than 100 GiB memory. With these parameter settings, huge pages are disabled on the db.r4 instance, the db.r5 instance, and the db.r3 instance.

> **Note**
> If this parameter group is used by a db.r4 DB instance class or db.r5 DB instance class with at least 100 GiB of memory, the `FALSE` setting for `use_large_pages` is overridden and set to `ONLY`. In this case, a customer notification regarding the override is sent.

After huge pages are active on your DB instance, you can view huge pages information by enabling enhanced monitoring. For more information, see Enhanced Monitoring (p. 362).

Using utl_http, utl_tcp, and utl_smtp with an Oracle DB Instance

Amazon RDS supports outbound network access on your DB instances running Oracle. You can use `utl_http`, `utl_tcp`, and `utl_smtp` to connect from your DB instance to the network.

Note the following about working with outbound network access:

- To use `utl_http` on DB instances running Oracle 11g, you must install the XMLDB option. For more information, see Oracle XML DB (p. 994).
- Outbound network access with `utl_http`, `utl_tcp`, and `utl_smtp` is supported only for Oracle DB instances in a VPC. To determine whether or not your DB instance is in a VPC, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434). To move a DB instance not in a VPC into a VPC, see Moving a DB Instance Not in a VPC into a VPC (p. 1447).
- To use SMTP with the UTL_MAIL option, see Oracle UTL_MAIL (p. 992).
- The Domain Name Server (DNS) name of the remote host can be any of the following:
  - Publicly resolvable.
  - The endpoint of an Amazon RDS DB instance.
  - Resolvable through a custom DNS server. For more information, see Setting Up a Custom DNS Server (p. 1010).
  - The private DNS name of an Amazon EC2 instance in the same VPC or a peered VPC. In this case, make sure that the name is resolvable through a custom DNS server. Alternatively, to use the DNS provided by Amazon, you can enable the `enableDnsSupport` attribute in the VPC settings and enable DNS resolution support for the VPC peering connection. For more information, see DNS Support in Your VPC and Modifying Your VPC Peering Connection.

To connect securely to remote SSL/TLS resources, you can create and upload customized Oracle wallets. By using the Amazon S3 integration with Amazon RDS for Oracle feature, you can download a wallet from Amazon S3 into Oracle DB instances. For information about Amazon S3 integration for Oracle, see Amazon S3 Integration (p. 915).

The following example creates a wallet for accessing https://status.aws.amazon.com/robots.txt over `utl_http`.

1. Obtain the certificate for `Amazon Root CA 1` from the Amazon Trust Services Repository.
2. Create a new wallet and add the following certificate:

```
orapki wallet create -wallet . -auto_login_only
orapki wallet add -wallet . -trusted_cert -cert AmazonRootCA1.pem.pem -
```

```
auto_login_only orapki wallet display -wallet .
```

3. Upload the wallet to your Amazon S3 bucket.
4. Complete the prerequisites for Amazon S3 integration with Oracle, and add the `S3_INTEGRATION` option to your Oracle DB instance. Ensure that the IAM role for the option has access to the Amazon S3 bucket you are using.

   For more information, see Amazon S3 Integration (p. 915).
5. Connect to the DB instance, and create a directory in the database to hold the wallet. The following example creates a directory called `SSL_WALLET`:

```
exec rdsadmin.rdsadmin_util.create_directory('SSL_WALLET');
```

6. Download the wallet from your Amazon S3 bucket to the Oracle DB instance.

   The following example downloads a wallet to the DB instance directory `SSL_WALLET`:

```
SELECT rdsadmin.rdsadmin_s3_tasks.download_from_s3(
      p_bucket_name    =>  'bucket_name',
      p_s3_prefix      =>  'wallet_name',
      p_directory_name =>  'SSL_WALLET')
   AS TASK_ID FROM DUAL;
```

   Replace *`bucket_name`* with the name of the bucket you are using, and replace *`wallet_name`* with the name of the wallet.
7. Set this wallet for `utl_http` transactions by running the following procedure:

```
DECLARE
 l_wallet_path all_directories.directory_path%type;
BEGIN
 select directory_path into l_wallet_path from all_directories
 where upper(directory_name)='SSL_WALLET';

  utl_http.set_wallet('file:/' || l_wallet_path);
END;
```

8. Access the URL from above over SSL/TLS.

```
SELECT utl_http.request('https://status.aws.amazon.com/robots.txt') AS ROBOTS_TXT FROM
 DUAL;

ROBOTS_TXT
--------------------------------------------------------------------------------
User-agent: *
Allow: /
```

Note

The specific certificates that are required for your wallet vary by service. For AWS services, the certificates can typically be found in the Amazon Trust Services Repository.

You can use a similar setup to send emails through UTL_SMTP over SSL/TLS (including Amazon Simple Email Service).

You can establish database links between Oracle DB instances over an SSL/TLS endpoint if the Oracle SSL option is configured for each instance. No further configuration is required. For more information, see Oracle Secure Sockets Layer (p. 967).

Using OEM, APEX, TDE, and Other Options

Most Amazon RDS DB engines support option groups that allow you to select additional features for your DB instance. Oracle DB instances support several options, including Oracle Enterprise Manager (OEM), Transparent Data Encryption (TDE), Application Express (APEX), and Native Network Encryption. For a complete list of supported Oracle options, see Options for Oracle DB Instances (p. 914). For more information about working with option groups, see Working with Option Groups (p. 186).

Using Extended Data Types

Amazon RDS Oracle version 12c supports extended data types. With extended data types, the maximum size is 32,767 bytes for the VARCHAR2, NVARCHAR2, and RAW data types. To use extended data types, set the `MAX_STRING_SIZE` parameter to `EXTENDED`. For more information, see Extended Data Types in the Oracle documentation.

If you don't want to use extended data types, keep the `MAX_STRING_SIZE` parameter set to `STANDARD` (the default). When this parameter is set to `STANDARD`, the size limits are 4,000 bytes for the VARCHAR2 and NVARCHAR2 data types, and 2,000 bytes for the RAW data type.

You can enable extended data types on a new or existing DB instance. For new DB instances, DB instance creation time is typically longer when you enable extended data types. For existing DB instances, the DB instance is unavailable during the conversion process.

The following are considerations for a DB instance with extended data types enabled:

- When you enable extended data types for a DB instance, you can't change the DB instance back to use the standard size for data types. After a DB instance is converted to use extended data types, if you set the `MAX_STRING_SIZE` parameter back to `STANDARD` it results in the `incompatible-parameters` status.
- When you restore a DB instance that uses extended data types, you must specify a parameter group with the `MAX_STRING_SIZE` parameter set to `EXTENDED`. During restore, if you specify the default parameter group or any other parameter group with `MAX_STRING_SIZE` set to `STANDARD` it results in the `incompatible-parameters` status.
- We recommend that you don't enable extended data types for Oracle DB instances running on the t2.micro DB instance class.

When the DB instance status is `incompatible-parameters` because of the `MAX_STRING_SIZE` setting, the DB instance remains unavailable until you set the `MAX_STRING_SIZE` parameter to `EXTENDED` and reboot the DB instance.

Enabling Extended Data Types for a New DB Instance

To enable extended data types for a new DB instance

1. Set the `MAX_STRING_SIZE` parameter to `EXTENDED` in a parameter group.

To set the parameter, you can either create a new parameter group or modify an existing parameter group.

For more information, see Working with DB Parameter Groups (p. 202).

2. Create a new Amazon RDS Oracle DB instance, and associate the parameter group with `MAX_STRING_SIZE` set to `EXTENDED` with the DB instance.

   For more information, see Creating an Amazon RDS DB Instance (p. 136).

Enabling Extended Data Types for an Existing DB Instance

When you modify a DB instance to enable extended data types, the data in the database is converted to use the extended sizes. The DB instance is unavailable during the conversion. The amount of time it takes to convert the data depends on the DB instance class used by the DB instance and the size of the database.

> **Note**
> After you enable extended data types, you can't perform a point-in-time restore to a time during the conversion. You can restore to the time immediately before the conversion or after the conversion.

To enable extended data types for an existing DB instance

1. Take a snapshot of the database.

   If there are invalid objects in the database, Amazon RDS tries to recompile them. The conversion to extended data types can fail if Amazon RDS can't recompile an invalid object. The snapshot enables you to restore the database if there is a problem with the conversion. Always check for invalid objects before conversion and fix or drop those invalid objects. For production databases, we recommend testing the conversion process on a copy of your DB instance first.

   For more information, see Creating a DB Snapshot (p. 301).
2. Set the `MAX_STRING_SIZE` parameter to `EXTENDED` in a parameter group.

   To set the parameter, you can either create a new parameter group or modify an existing parameter group.

   For more information, see Working with DB Parameter Groups (p. 202).
3. Modify the DB instance to associate it with the parameter group with `MAX_STRING_SIZE` set to `EXTENDED`.

   For more information, see Modifying an Amazon RDS DB Instance (p. 220).
4. Reboot the DB instance for the parameter change to take effect.

   For more information, see Rebooting a DB Instance (p. 247).

Public Synonyms

You can create public synonyms referencing objects in your own schemas. Don't create or modify public synonyms for Oracle-maintained schemas, including `SYS`, `SYSTEM`, and `RDSADMIN`. Doing so might result in invalidation of core database components and affect the availability of your DB instance.

Connecting to a DB Instance Running the Oracle Database Engine

After Amazon RDS provisions your Oracle DB instance, you can use any standard SQL client application to connect to the DB instance. In this topic, you connect to a DB instance that is running the Oracle database engine by using Oracle SQL Developer or SQL*Plus.

For an example that walks you through the process of creating and connecting to a sample DB instance, see Creating an Oracle DB Instance and Connecting to a Database on an Oracle DB Instance (p. 85).

Finding the Endpoint of Your DB Instance

Each Amazon RDS DB instance has an endpoint, and each endpoint has the DNS name and port number for the DB instance. To connect to your DB instance using a SQL client application, you need the DNS name and port number for your DB instance.

You can find the endpoint for a DB instance using the Amazon RDS console or the AWS CLI.

> **Note**
> If you are using Kerberos authentication, see Connecting to Oracle with Kerberos Authentication (p. 1064).

Console

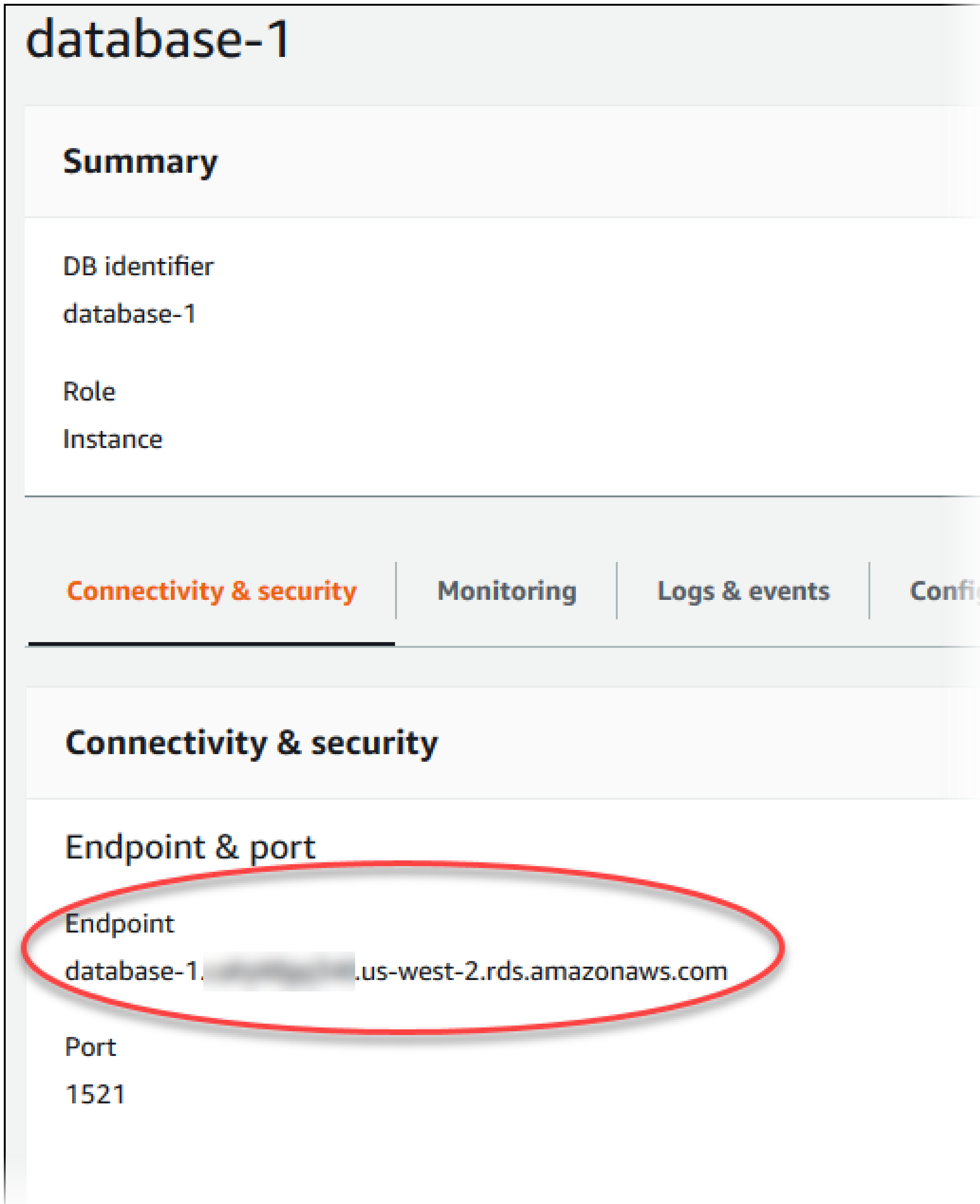
To find the endpoint using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the upper-right corner of the console, choose the AWS Region of your DB instance.
3. Find the DNS name and port number for your DB Instance.

   a. Choose **Databases** to display a list of your DB instances.

   b. Choose the Oracle DB instance name to display the instance details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



AWS CLI

To find the endpoint of an Oracle DB instance by using the AWS CLI, call the describe-db-instances command.

Example To find the endpoint using the AWS CLI

```
aws rds describe-db-instances
```

Search for `Endpoint` in the output to find the DNS name and port number for your DB instance. The `Address` line in the output contains the DNS name. The following is an example of the JSON endpoint output.

```
"Endpoint": {
    "HostedZoneId": "Z1PVIF0B656C1W",
    "Port": 3306,
    "Address": "myinstance.123456789012.us-west-2.rds.amazonaws.com"
},
```

Note
The output might contain information for multiple DB instances.

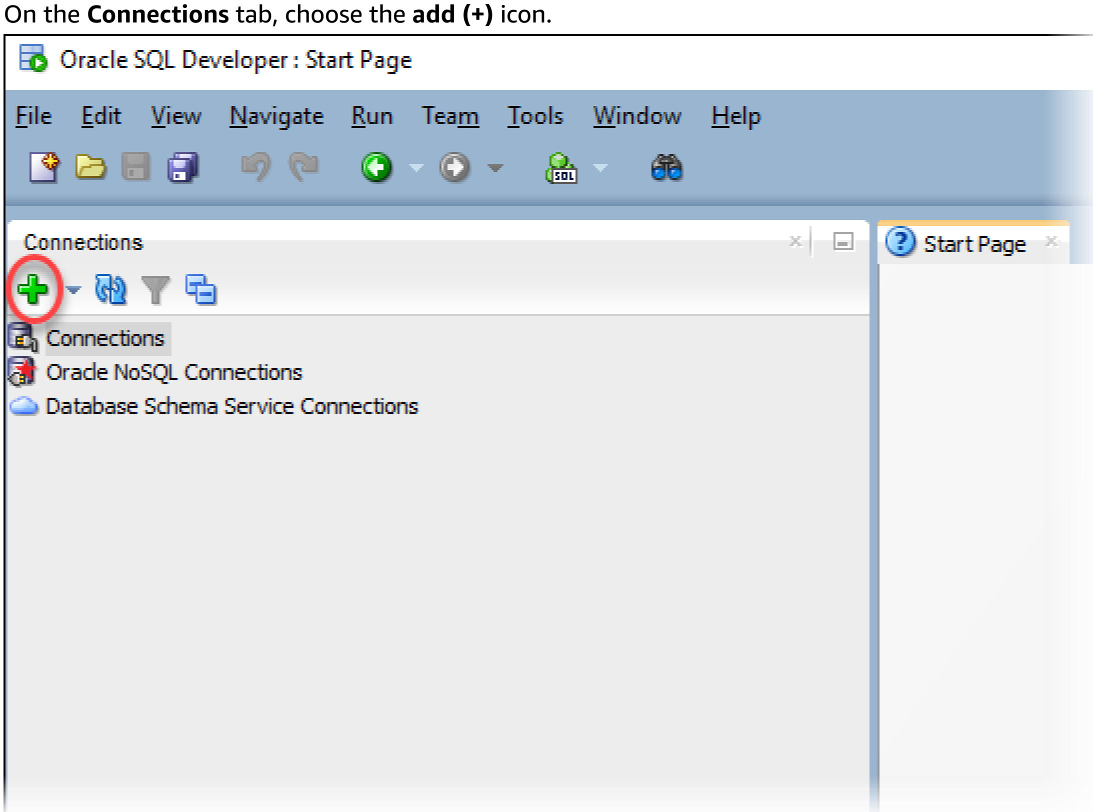
Connecting to Your DB Instance Using Oracle SQL Developer

In this procedure, you connect to your DB instance by using Oracle SQL Developer. To download a standalone version of this utility, see the Oracle SQL Developer Downloads page.

To connect to your DB instance, you need its DNS name and port number. For information about finding the DNS name and port number for a DB instance, see Finding the Endpoint of Your DB Instance (p. 874).

To connect to a DB instance using SQL Developer

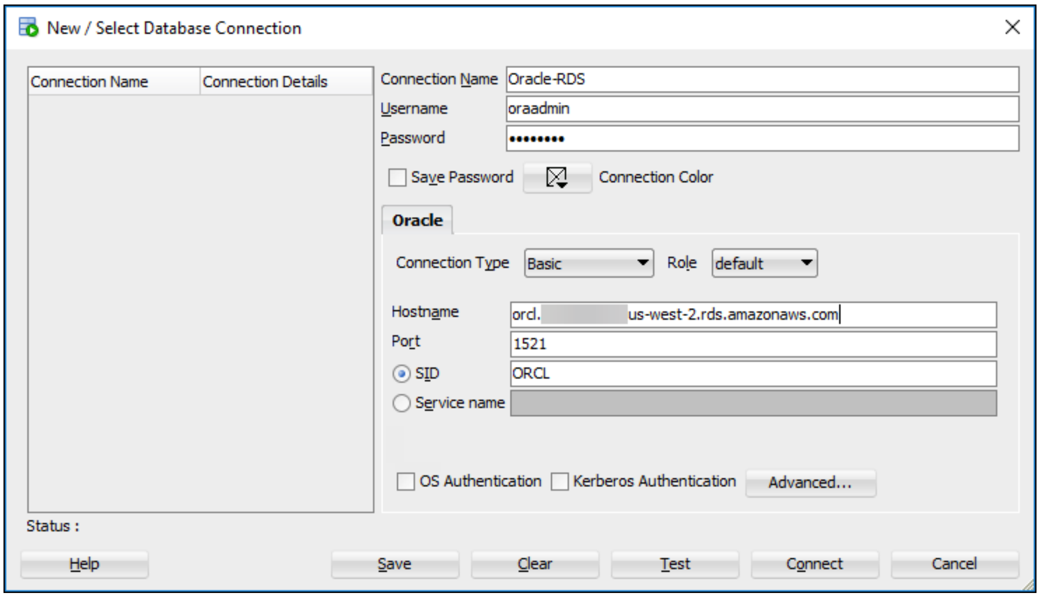
1. Start Oracle SQL Developer.
2. On the **Connections** tab, choose the **add (+)** icon.



3. In the **New/Select Database Connection** dialog box, provide the information for your DB instance:

   - For **Connection Name**, enter a name that describes the connection, such as `Oracle-RDS`.
   - For **Username**, enter the name of the database administrator for the DB instance.
   - For **Password**, enter the password for the database administrator.
   - For **Hostname**, enter the DNS name of the DB instance.
   - For **Port**, enter the port number.
   - For **SID**, enter the Oracle database SID.

   The completed dialog box should look similar to the following.

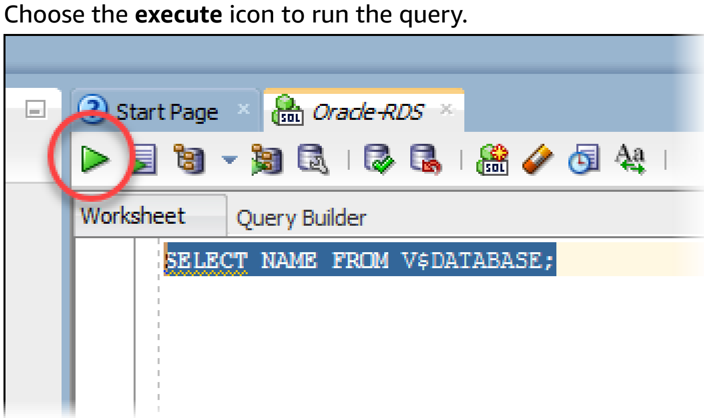


4. Choose **Connect**.
5. You can now start creating your own databases and running queries against your DB instance and databases as usual. To run a test query against your DB instance, do the following:

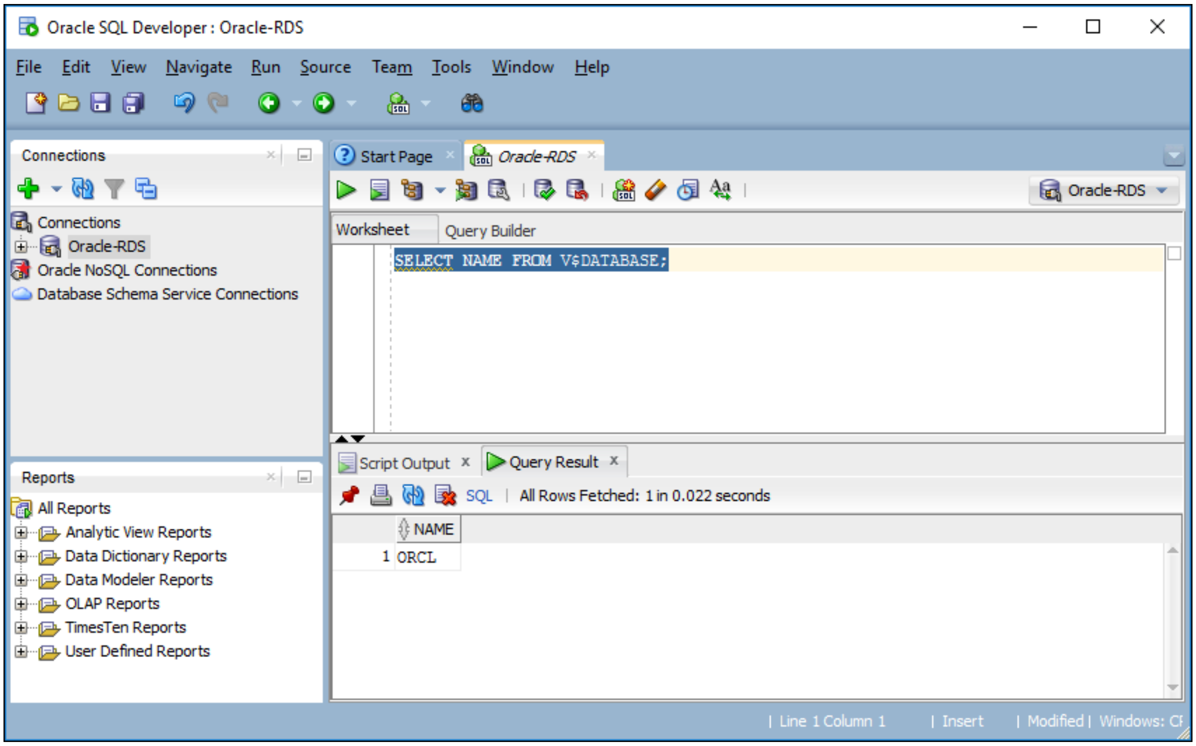
   a. In the **Worksheet** tab for your connection, enter the following SQL query.

```
SELECT NAME FROM V$DATABASE;
```

   b. Choose the **execute** icon to run the query.



SQL Developer returns the database name.



Connecting to Your DB Instance Using SQL*Plus

You can use a utility like SQL*Plus to connect to an Amazon RDS DB instance running Oracle. To download a standalone version of SQL*Plus, see SQL*Plus User's Guide and Reference.

To connect to your DB instance, you need its DNS name and port number. For information about finding the DNS name and port number for a DB instance, see Finding the Endpoint of Your DB Instance (p. 874).

Example To connect to an Oracle DB instance using SQL*Plus

In the following examples, substitute the user name of your DB instance administrator. Also, substitute the DNS name for your DB instance, and then include the port number and the Oracle SID. The SID value is the name of the DB instance's database that you specified when you created the DB instance, and not the name of the DB instance.

For Linux, macOS, or Unix:

```
sqlplus 'user_name@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=dns_name)(PORT=port))
(CONNECT_DATA=(SID=database_name)))'
```

For Windows:

```
sqlplus user_name@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=dns_name)(PORT=port))
(CONNECT_DATA=(SID=database_name)))
```

You should see output similar to the following.

```
SQL*Plus: Release 12.1.0.2.0 Production on Mon Aug 21 09:42:20 2017
```

After you enter the password for the user, the SQL prompt appears.

```
SQL>
```

Note

The shorter format connection string (Easy connect or EZCONNECT), such as `sqlplus USER/PASSWORD@LONGER-THAN-63-CHARS-RDS-ENDPOINT-HERE:1521/DATABASE_IDENTIFIER`, might encounter a maximum character limit and should not be used to connect.

Security Group Considerations

For you to connect to your DB instance, it must be associated with a security group that contains the IP addresses and network configuration that you use to access the DB instance. You might have associated your DB instance with an appropriate security group when you created it. If you assigned a default, nonconfigured security group when you created the DB instance, the DB instance firewall prevents connections.

If you need to create a new security group to enable access, the type of security group that you create depends on which Amazon EC2 platform your DB instance is on. To determine your platform, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434). In general, if your DB instance is on the *EC2-Classic* platform, you create a DB security group; if your DB instance is on the *VPC* platform, you create a VPC security group. For information about creating a new security group, see Controlling Access with Security Groups (p. 1414).

After you create the new security group, you modify your DB instance to associate it with the security group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

You can enhance security by using SSL to encrypt connections to your DB instance. For more information, see Oracle Secure Sockets Layer (p. 967).

Dedicated and Shared Server Processes

Server processes handle user connections to an Oracle DB instance. By default, the Oracle DB instance uses dedicated server processes. With dedicated server processes, each server process services only one user process. You can optionally configure shared server processes. With shared server processes, each server process can service multiple user processes.

You might consider using shared server processes when a high number of user sessions are using too much memory on the server. You might also consider shared server processes when sessions connect and disconnect very often, resulting in performance issues. There are also disadvantages to using shared server processes. For example, they can strain CPU resources, and they are more complicated to configure and administer.

For more information about dedicated and shared server processes, see About Dedicated and Shared Server Processes in the Oracle documentation. For more information about configuring shared server processes on an Amazon RDS Oracle DB instance, see How do I configure Amazon RDS for Oracle Database to work with shared servers? in the Knowledge Center.

Troubleshooting Connections to Your Oracle DB Instance

The following are issues you might encounter when you try to connect to your Oracle DB instance.

Issue	Troubleshooting Suggestions
Unable to connect to your DB instance.	For a newly created DB instance, the DB instance has a status of **creating** until it is ready to use. When the state changes to **available**, you can connect to the DB instance. Depending on the DB instance class and the amount of storage, it can take up to 20 minutes before the new DB instance is available.
Unable to connect to your DB instance.	If you can't send or receive communications over the port that you specified when you created the DB instance, you can't connect to the DB instance. Check with your network administrator to verify that the port you specified for your DB instance allows inbound and outbound communication.
Unable to connect to your DB instance.	The access rules enforced by your local firewall and the IP addresses you authorized to access your DB instance in the security group for the DB instance might not match. The problem is most likely the inbound or outbound rules on your firewall. You can add or edit an inbound rule in the security group. For **Source**, choose **My IP**. This allows access to the DB instance from the IP address detected in your browser. For more information, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433). For more information about security groups, see Controlling Access with Security Groups (p. 1414). To walk through the process of setting up rules for your security group, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).
Connect failed because target host or object does not exist – Oracle, Error: ORA-12545	Make sure that you specified the server name and port number correctly. For **Server name**, enter the DNS name from the console. For information about finding the DNS name and port number for a DB instance, see Finding the Endpoint of Your DB Instance (p. 874).
Invalid username/password; logon denied – Oracle, Error: ORA-01017	You were able to reach the DB instance, but the connection was refused. This is usually caused by providing an incorrect user name or password. Verify the user name and password, and then retry.

For more information on connection issues, see Can't Connect to Amazon RDS DB Instance (p. 1458).

Updating Applications to Connect to Oracle DB Instances Using New SSL/TLS Certificates

As of September 19, 2019, Amazon RDS has published new Certificate Authority (CA) certificates for connecting to your RDS DB instances using Secure Socket Layer or Transport Layer Security (SSL/TLS). Following, you can find information about updating your applications to use the new certificates.

This topic can help you to determine whether any client applications use SSL/TLS to connect to your DB instances.

Important
When you change the certificate for an Amazon RDS for Oracle DB instance, only the database listener is restarted. The DB instance isn't restarted. Existing database connections are unaffected, but new connections will encounter errors for a brief period while the listener is restarted.

Note
For client applications that use SSL/TLS to connect to your DB instances, you must update your client application trust stores to include the new CA certificates.

After you update your CA certificates in the client application trust stores, you can rotate the certificates on your DB instances. We strongly recommend testing these procedures in a development or staging environment before implementing them in your production environments.

For more information about certificate rotation, see Rotating Your SSL/TLS Certificate (p. 1363). For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For information about using SSL/TLS with Oracle DB instances, see Oracle Secure Sockets Layer (p. 967).

Topics

Determining Whether Any Applications Are Connecting to Your Oracle DB Instance Using SSL

If your Oracle DB instance uses an option group with the `SSL` option added, you might be using SSL. Check this by following the instructions in Listing the Options and Option Settings for an Option Group (p. 194). For information about the `SSL` option, see Oracle Secure Sockets Layer (p. 967).

Check the listener log to determine whether there are SSL connections. The following is sample output in a listener log.

```
date time * (CONNECT_DATA=(CID=(PROGRAM=program)
(HOST=host)(USER=user))(SID=sid)) *
(ADDRESS=(PROTOCOL=tcps)(HOST=host)(PORT=port)) * establish * ORCL * 0
```

When `PROTOCOL` has the value `tcps` for an entry, it shows an SSL connection. However, when `HOST` is `127.0.0.1`, you can ignore the entry. Connections from `127.0.0.1` are a local management agent on the DB instance. These connections aren't external SSL connections. Therefore, you have applications connecting using SSL if you see listener log entries where `PROTOCOL` is `tcps` and `HOST` is *not* `127.0.0.1`.

To check the listener log, you can publish the log to Amazon CloudWatch Logs. For more information, see Publishing Oracle Logs to Amazon CloudWatch Logs (p. 478).

Updating Your Application Trust Store

You can update the trust store for applications that use SQL*Plus or JDBC for SSL/TLS connections.

Updating Your Application Trust Store for SQL*Plus

You can update the trust store for applications that use SQL*Plus for SSL/TLS connections.

> **Note**
> When you update the trust store, you can retain older certificates in addition to adding the new certificates.

To update the trust store for SQL*Plus applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in the `ssl_wallet` directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Run the following command to update the Oracle wallet.

   ```
   prompt>orapki wallet add -wallet $ORACLE_HOME/ssl_wallet -trusted_cert -cert
         $ORACLE_HOME/ssl_wallet/rds-ca-2019-root.pem -auto_login_only
   ```

   Replace the file name with the one that you downloaded.
3. Run the following command to confirm that the wallet was updated successfully.

   ```
   prompt>orapki wallet display -wallet $ORACLE_HOME/ssl_wallet
   ```

   Your output should contain the following.

   ```
   Trusted Certificates:
   Subject: CN=Amazon RDS Root 2019 CA,OU=Amazon RDS,O=Amazon Web Services\,
    Inc.,L=Seattle,ST=Washington,C=US
   ```

Updating Your Application Trust Store for JDBC

You can update the trust store for applications that use JDBC for SSL/TLS connections.

To update the trust store for JDBC applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in the ssl_wallet directory.

For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

2. Convert the certificate to .der format using the following command.

```
openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
```

Replace the file name with the one that you downloaded.

3. Import the certificate into the key store using the following command.

```
keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
```

4. Confirm that the key store was updated successfully.

```
keytool -list -v -keystore clientkeystore.jks
```

Enter the key store password when you are prompted for it.

Your output should contain the following.

```
rds-root,date, trustedCertEntry,
Certificate fingerprint (SHA1):
 D4:0D:DB:29:E3:75:0D:FF:A6:71:C3:14:0B:BF:5F:47:8D:1C:80:96
# This fingerprint should match the output from the below command
openssl x509 -fingerprint -in rds-ca-2019-root.pem -noout
```

Example Java Code for Establishing SSL Connections

The following code example shows how to set up the SSL connection using JDBC.

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.SQLException;
import java.util.Properties;

public class OracleSslConnectionTest {
    private static final String DB_SERVER_NAME = "<dns-name-provided-by-amazon-rds>";
    private static final Integer SSL_PORT = "<ssl-option-port-configured-in-option-group>";
    private static final String DB_SID = "<oracle-sid>";
    private static final String DB_USER = "<user name>";
    private static final String DB_PASSWORD = "<password>";
    // This key store has only the prod root ca.
    private static final String KEY_STORE_FILE_PATH = "<file-path-to-keystore>";
    private static final String KEY_STORE_PASS = "<keystore-password>";

    public static void main(String[] args) throws SQLException {
```

```
        final Properties properties = new Properties();
        final String connectionString = String.format(
                "jdbc:oracle:thin:@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCPS)(HOST=%s)(PORT=%d))
(CONNECT_DATA=(SID=%s)))",
                DB_SERVER_NAME, SSL_PORT, DB_SID);
        properties.put("user", DB_USER);
        properties.put("password", DB_PASSWORD);
        properties.put("oracle.jdbc.J2EE13Compliant", "true");
        properties.put("javax.net.ssl.trustStore", KEY_STORE_FILE_PATH);
        properties.put("javax.net.ssl.trustStoreType", "JKS");
        properties.put("javax.net.ssl.trustStorePassword", KEY_STORE_PASS);
        final Connection connection = DriverManager.getConnection(connectionString,
 properties);
        // If no exception, that means handshake has passed, and an SSL connection can be
 opened
    }
}
```

Important
After you have determined that your database connections use SSL/TLS and have updated your application trust store, you can update your database to use the rds-ca-2019 certificates. For instructions, see step 3 in Updating Your CA Certificate by Modifying Your DB Instance (p. 1363).

Modifying Oracle sqlnet.ora Parameters

The sqlnet.ora file includes parameters that configure Oracle Net features on Oracle database servers and clients. Using the parameters in the sqlnet.ora file, you can modify properties for connections in and out of the database.

For more information about why you might set sqlnet.ora parameters, see Configuring Profile Parameters in the Oracle documentation.

Setting sqlnet.ora Parameters

Amazon RDS Oracle parameter groups include a subset of sqlnet.ora parameters. You set them in the same way that you set other Oracle parameters. The `sqlnetora.` prefix identifies which parameters are sqlnet.ora parameters. For example, in an Oracle parameter group in Amazon RDS, the `default_sdu_size` sqlnet.ora parameter is `sqlnetora.default_sdu_size`.

For information about managing parameter groups and setting parameter values, see Working with DB Parameter Groups (p. 202).

Supported sqlnet.ora Parameters

Amazon RDS supports the following sqlnet.ora parameters. Changes to dynamic sqlnet.ora parameters take effect immediately.

Parameter	Valid Values	Static/ Dynamic	Description
`sqlnetora.default_sdu_size`	Oracle 11g – `512` to `65535` Oracle 12c – `512` to `2097152`	Dynamic	The session data unit (SDU) size, in bytes. The SDU is the amount of data that is put in a buffer and sent across the network at one time.
`sqlnetora.diag_adr_enabled`	`ON`, `OFF`	Dynamic	A value that enables or disables Automatic Diagnostic Repository (ADR) tracing. `ON` specifies that ADR file tracing is used. `OFF` specifies that non-ADR file tracing is used.
`sqlnetora.recv_buf_size`	`8192` to `268435456`	Dynamic	The buffer space limit for receive operations of sessions, supported by the TCP/IP, TCP/IP with SSL, and SDP protocols.
`sqlnetora.send_buf_size`	`8192` to `268435456`	Dynamic	The buffer space limit for send operations of sessions, supported by the TCP/IP, TCP/IP with SSL, and SDP protocols.
`sqlnetora.sqlnet.allowed_logon_version_client`	`8`, `10`, `11`, `12`	Dynamic	Minimum authentication protocol version allowed for clients, and servers acting as clients, to establish a connection to Oracle DB instances.
`sqlnetora.sqlnet.allowed_logon_version_server`	`8`, `9`, `10`, `11`, `12`, `12a`	Dynamic	Minimum authentication protocol version allowed to establish a connection to Oracle DB instances.

Parameter	Valid Values	Static/ Dynamic	Description
sqlnetora.sqlnet.expire_time	0 to 1440	Dynamic	Time interval, in minutes, to send a check to verify that client-server connections are active.
sqlnetora.sqlnet.inbound_connect_timeout	0 or 10 to 7200	Dynamic	Time, in seconds, for a client to connect with the database server and provide the necessary authentication information.
sqlnetora.sqlnet.outbound_connect_timeout	0 or 10 to 7200	Dynamic	Time, in seconds, for a client to establish an Oracle Net connection to the DB instance.
sqlnetora.sqlnet.recv_timeout	0 or 10 to 7200	Dynamic	Time, in seconds, for a database server to wait for client data after establishing a connection.
sqlnetora.sqlnet.send_timeout	0 or 10 to 7200	Dynamic	Time, in seconds, for a database server to complete a send operation to clients after establishing a connection.
sqlnetora.tcp.connect_timeout	0 or 10 to 7200	Dynamic	Time, in seconds, for a client to establish a TCP connection to the database server.
sqlnetora.trace_level_server	0, 4, 10, 16, OFF, USER, ADMIN, SUPPORT	Dynamic	For non-ADR tracing, turns server tracing on at a specified level or turns it off.

The default value for each supported sqlnet.ora parameter is the Oracle default for the release. For information about default values for Oracle 12c, see Parameters for the sqlnet.ora File in the 12c Oracle documentation. For information about default values for Oracle 11g, see Parameters for the sqlnet.ora File in the 11g Oracle documentation.

Viewing sqlnet.ora Parameters

You can view sqlnet.ora parameters and their settings using the AWS Management Console, the AWS CLI, or a SQL client.

Viewing sqlnet.ora Parameters Using the Console

For information about viewing parameters in a parameter group, see Working with DB Parameter Groups (p. 202).

In Oracle parameter groups, the `sqlnetora.` prefix identifies which parameters are sqlnet.ora parameters.

Viewing sqlnet.ora Parameters Using the AWS CLI

To view the sqlnet.ora parameters that were configured in an Oracle parameter group, use the AWS CLI describe-db-parameters command.

To view the all of the sqlnet.ora parameters for an Oracle DB instance, call the AWS CLI download-db-log-file-portion command. Specify the DB instance identifier, the log file name, and the type of output.

Example

The following code lists all of the sqlnet.ora parameters for `mydbinstance`.

For Linux, macOS, or Unix:

```
aws rds download-db-log-file-portion \
--db-instance-identifier mydbinstance \
--log-file-name trace/sqlnet-parameters \
--output text
```

For Windows:

```
aws rds download-db-log-file-portion ^
--db-instance-identifier mydbinstance ^
--log-file-name trace/sqlnet-parameters ^
--output text
```

Viewing sqlnet.ora Parameters Using a SQL Client

After you connect to the Oracle DB instance in a SQL client, the following query lists the sqlnet.ora parameters.

```
SELECT * FROM TABLE
   (rdsadmin.rds_file_util.read_text_file(
        p_directory => 'BDUMP',
        p_filename  => 'sqlnet-parameters'));
```

For information about connecting to an Oracle DB instance in a SQL client, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).

Upgrading the Oracle DB Engine

When Amazon RDS supports a new version of Oracle, you can upgrade your DB instances to the new version. Amazon RDS supports the following upgrades to an Oracle DB instance:

- Major Version Upgrades
- Minor Version Upgrades

In general, a major engine version upgrade can introduce changes that are not compatible with existing applications. In contrast, a minor version upgrade includes only changes that are backward-compatible with existing applications.

You must modify the DB instance manually to perform a major version upgrade. Minor version upgrades occur automatically if you enable auto minor version upgrades on your DB instance. In all other cases, you must modify the DB instance manually to perform a minor version upgrade.

An outage occurs while the upgrade takes place. The time for the outage varies based on your engine version and the size of your DB instance.

For information about what Oracle versions are available on Amazon RDS, see Oracle Database Engine Release Notes (p. 1092).

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Overview of Upgrading

Amazon RDS takes two DB snapshots during the upgrade process. The first DB snapshot is of the DB instance before any upgrade changes have been made. If the upgrade doesn't work for your databases, you can restore this snapshot to create a DB instance running the old version. The second DB snapshot is taken after the upgrade completes.

> **Note**
> Amazon RDS only takes DB snapshots if you have set the backup retention period for your DB instance to a number greater than 0. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220).

After an upgrade is complete, you can't revert to the previous version of the database engine. If you want to return to the previous version, restore the DB snapshot that was taken before the upgrade to create a new DB instance.

If your DB instance is in a Multi-AZ deployment, both the primary and standby replicas are upgraded. If no operating system updates are required, the primary and standby DB instances are upgraded at the same time, and you experience an outage until the upgrade is complete.

If your DB instance is in a Multi-AZ deployment, and operating system updates are required, the operating system updates are applied when you request the database upgrade. In this case, the operating system is updated on the standby DB instance, and the standby DB instance is upgraded.

After that upgrade completes, the primary DB instance fails over to the standby DB instance, and the operating system is updated on the new standby DB instance (the former primary DB instance), and that database is upgraded.

Note
We don't recommend upgrading databases running on micro DB instances because they have limited CPU resources and the upgrade process can take hours to complete.
You can upgrade micro DB instances with small amounts of storage (10–20 GiB) by copying your data using Data Pump. Before you migrate your production DB instances, we recommend that you test by copying data using Data Pump.

Major Version Upgrades

Amazon RDS supports the following major version upgrades.

Current Version	Upgrade Supported
18.0.0.0	19.0.0.0
12.2.0.1	19.0.0.0 18.0.0.0
12.1.0.2	19.0.0.0 18.0.0.0 12.2.0.1
11.2.0.4	19.0.0.0 18.0.0.0 12.2.0.1 12.1.0.2.v5 and higher 12.1 versions

To perform a major version upgrade, modify the DB instance manually. Major version upgrades don't occur automatically.

In some cases, your current Oracle DB instance might be running on a DB instance class that isn't supported for the version to which you are upgrading. In such a case, you must migrate the DB instance to a supported DB instance class before you upgrade. For more information about the supported DB instance classes for each version and edition of Amazon RDS Oracle, see DB Instance Classes (p. 7).

Before you perform a major version upgrade, Oracle recommends that you gather optimizer statistics on the DB instance that you are upgrading. Gathering optimizer statistics can reduce DB instance downtime during the upgrade. To gather optimizer statistics, connect to the DB instance as the master user, and run the `DBMS_STATS.GATHER_DICTIONARY_STATS` procedure, as in the following example.

```
EXEC DBMS_STATS.GATHER_DICTIONARY_STATS;
```

For more information, see Gathering Optimizer Statistics to Decrease Oracle Database Downtime in the Oracle documentation.

Note
Major version upgrades aren't supported for deprecated Oracle versions, such as Oracle version 11.2.0.3 and 11.2.0.2.

Major version downgrades aren't supported.
A major version upgrade from 11g to 12c must upgrade to an Oracle Patch Set Update (PSU) that was released in the same month or later.
For example, a major version upgrade from Oracle version 11.2.0.4.v14 to Oracle version 12.1.0.2.v11 is supported. However, a major version upgrade from Oracle version 11.2.0.4.v14 to Oracle version 12.1.0.2.v9 isn't supported. This is because Oracle version 11.2.0.4.v14 was released in October 2017, and Oracle version 12.1.0.2.v9 was released in July 2017. For information about the release date for each Oracle PSU, see Oracle Database Engine Release Notes (p. 1092).

Oracle Minor Version Upgrades

A minor version upgrade applies an Oracle Database Patch Set Update (PSU) or Release Update (RU) in a major version.

An Amazon RDS for Oracle DB instance is scheduled to be upgraded automatically during its next maintenance window when it meets the following conditions:

- The DB instance has the **Auto minor version upgrade** option enabled.
- The DB instance is not running the latest minor DB engine version.

The DB instance is upgraded to the latest quarterly PSU or RU four to six weeks after it is made available by Amazon RDS for Oracle. For more information about PSUs and RUs, see Oracle Database Engine Release Notes (p. 1092).

The following minor version upgrades aren't supported.

Current Version	Upgrade Not Supported
12.1.0.2.v6	12.1.0.2.v7
12.1.0.2.v5	12.1.0.2.v7
12.1.0.2.v5	12.1.0.2.v6

Note
Minor version downgrades aren't supported.

Oracle SE2 Upgrade Paths

The following table shows supported upgrade paths to Standard Edition Two (SE2). For more information about the License Included and Bring Your Own License (BYOL) models, see Oracle Licensing (p. 847).

Your Existing Configuration	Supported SE2 Configuration
12.2.0.1 SE2, BYOL	12.2.0.1 SE2, BYOL or License Included
12.1.0.2 SE2, BYOL	12.2.0.1 SE2, BYOL or License Included 12.1.0.2 SE2, BYOL or License Included

Your Existing Configuration	Supported SE2 Configuration
11.2.0.4 SE1, BYOL or License Included 11.2.0.4 SE, BYOL	12.2.0.1 SE2, BYOL or License Included 12.1.0.2 SE2, BYOL or License Included

To upgrade from your existing configuration to a supported SE2 configuration, use a supported upgrade path. For more information, see Major Version Upgrades (p. 889).

Option and Parameter Group Considerations

Option Group Considerations

If your DB instance uses a custom option group, in some cases Amazon RDS can't automatically assign your DB instance a new option group. For example, this occurs when you upgrade to a new major version. In those cases, you must specify a new option group when you upgrade. We recommend that you create a new option group, and add the same options to it as in your existing custom option group.

For more information, see Creating an Option Group (p. 187) or Making a Copy of an Option Group (p. 189).

If your DB instance uses a custom option group that contains the APEX option, in some cases you can reduce the time it takes to upgrade your DB instance by upgrading your version of APEX at the same time as your DB instance. For more information, see Upgrading the APEX Version (p. 934).

Parameter Group Considerations

If your DB instance uses a custom parameter group, in some cases Amazon RDS can't automatically assign your DB instance a new parameter group. For example, this occurs when you upgrade to a new major version. In those cases, you must specify a new parameter group when you upgrade. We recommend that you create a new parameter group, and configure the parameters as in your existing custom parameter group.

For more information, see Creating a DB Parameter Group (p. 203) or Copying a DB Parameter Group (p. 207).

Testing an Upgrade

Before you perform a major version upgrade on your DB instance, you should thoroughly test your database and all applications that access the database for compatibility with the new version. We recommend that you use the following procedure.

To test a major version upgrade

1. Review the Oracle upgrade documentation for the new version of the database engine to see if there are compatibility issues that might affect your database or applications. For more information, see Database Upgrade Guide in the Oracle documentation.
2. If your DB instance uses a custom option group, create a new option group compatible with the new version you are upgrading to. For more information, see Option Group Considerations (p. 891).
3. If your DB instance uses a custom parameter group, create a new parameter group compatible with the new version you are upgrading to. For more information, see Parameter Group Considerations (p. 891).

4. Create a DB snapshot of the DB instance to be upgraded. For more information, see Creating a DB Snapshot (p. 301).
5. Restore the DB snapshot to create a new test DB instance. For more information, see Restoring from a DB Snapshot (p. 303).
6. Modify this new test DB instance to upgrade it to the new version, by using one of the following methods:
   - Console (p. 241)
   - AWS CLI (p. 242)
   - RDS API (p. 242)
7. Perform testing:
   - Run as many of your quality assurance tests against the upgraded DB instance as needed to ensure that your database and application work correctly with the new version.
   - Implement any new tests needed to evaluate the impact of any compatibility issues that you identified in step 1.
   - Test all stored procedures, functions, and triggers.
   - Direct test versions of your applications to the upgraded DB instance. Verify that the applications work correctly with the new version.
   - Evaluate the storage used by the upgraded instance to determine if the upgrade requires additional storage. You might need to choose a larger instance class to support the new version in production. For more information, see DB Instance Classes (p. 7).
8. If all tests pass, then perform the upgrade on your production DB instance. We recommend that you don't allow write operations to the DB instance until you confirm that everything is working correctly.

Upgrading an Oracle DB Instance

For information about manually or automatically upgrading an Oracle DB instance, see Upgrading a DB Instance Engine Version (p. 241).

Upgrading an Oracle DB Snapshot

If you have existing manual DB snapshots, you might want to upgrade a snapshot to a later version of the Oracle database engine.

When Oracle stops providing patches for a version, and therefore Amazon RDS deprecates the version, you can upgrade your snapshots that correspond to the deprecated version. For more information, see Oracle Engine Version Management (p. 866).

The following snapshot upgrades are currently supported.

Current Snapshot Version	Supported Snapshot Upgrade
12.1.0.1	12.1.0.2.v8
11.2.0.3	11.2.0.4.v11
11.2.0.2	11.2.0.4.v12

Amazon RDS supports upgrading snapshots in all AWS Regions.

Console

To upgrade an Oracle DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**, and then select the DB snapshot that you want to upgrade.
3. For **Actions**, choose **Modify Snapshot**. The **Modify DB Snapshot** page appears.
4. For **DB engine version**, choose the version to upgrade the snapshot to.
5. (Optional) For **Option group**, choose the option group for the upgraded DB snapshot. The same option group considerations apply when upgrading a DB snapshot as when upgrading a DB instance. For more information, see Option Group Considerations (p. 891).
6. Choose **Modify Snapshot** to save your changes.

   Alternatively, choose **Cancel** to cancel your changes.

AWS CLI

To upgrade an Oracle DB snapshot by using the AWS CLI, call the modify-db-snapshot command with the following parameters:

- `--db-snapshot-identifier` – The name of the DB snapshot.
- `--engine-version` – The version to upgrade the snapshot to.

You might also need to include the following parameter. The same option group considerations apply when upgrading a DB snapshot as when upgrading a DB instance. For more information, see Option Group Considerations (p. 891).

- `--option-group-name` – The option group for the upgraded DB snapshot.

Example

The following example upgrades a DB snapshot.

For Linux, macOS, or Unix:

```
aws rds modify-db-snapshot \
    --db-snapshot-identifier <mydbsnapshot> \
    --engine-version <11.2.0.4.v12> \
    --option-group-name <default:oracle-se1-11-2>
```

For Windows:

```
aws rds modify-db-snapshot ^
    --db-snapshot-identifier <mydbsnapshot> ^
    --engine-version <11.2.0.4.v12> ^
    --option-group-name <default:oracle-se1-11-2>
```

RDS API

To upgrade an Oracle DB snapshot by using the Amazon RDS API, call the ModifyDBSnapshot operation with the following parameters:

- `DBSnapshotIdentifier` – The name of the DB snapshot.
- `EngineVersion` – The version to upgrade the snapshot to.

You might also need to include the following parameter. The same option group considerations apply when upgrading a DB snapshot as when upgrading a DB instance. For more information, see Option Group Considerations (p. 891).

- `OptionGroupName` – The option group for the upgraded DB snapshot.

Example

The following example upgrades a DB snapshot.

```
https://rds.amazonaws.com/
    ?Action=ModifyDBSnapshot
    &DBSnapshotIdentifier=mydbsnapshot
    &EngineVersion=11.2.0.4.v12
    &OptionGroupName=default:oracle-se1-11-2
    &SignatureMethod=HmacSHA256
    &SignatureVersion=4
    &Version=2014-10-31
    &X-Amz-Algorithm=AWS4-HMAC-SHA256
    &X-Amz-Credential=AKIADQKE4SARGYLE/20131016/us-west-1/rds/aws4_request
    &X-Amz-Date=20131016T233051Z
    &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
    &X-Amz-Signature=087a8eb41cb1ab5f99e81575f23e73757ffc6a1e42d7d2b30b9cc0be988cff97
```

Related Topics

- Oracle Database Engine Release Notes (p. 1092)
- Upgrading the Oracle DB Engine (p. 888)
- Applying Updates for a DB Instance (p. 236)

Importing Data into Oracle on Amazon RDS

How you import data into an Amazon RDS DB instance depends on the amount of data you have and the number and variety of database objects in your database. For example, you can use Oracle SQL Developer to import a simple, 20 MB database. You can use Oracle Data Pump to import complex databases, or databases that are several hundred megabytes or several terabytes in size.

You can also use AWS Database Migration Service (AWS DMS) to import data into an Amazon RDS DB instance. AWS DMS can migrate databases without downtime and, for many database engines, continue ongoing replication until you are ready to switch over to the target database. You can migrate to Oracle from either the same database engine or a different database engine using AWS DMS. If you are migrating from a different database engine, you can use the AWS Schema Conversion Tool to migrate schema objects that are not migrated by AWS DMS. For more information about AWS DMS, see What is AWS Database Migration Service.

Before you use any of these migration techniques, we recommend the best practice of taking a backup of your database. After you import the data, you can back up your Amazon RDS DB instances by creating snapshots. Later, you can restore the database from the snapshots. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

> **Note**
> You can also import data into Oracle using files from Amazon S3. For example, you can download Data Pump files from Amazon S3 to the DB instance host. For more information, see Amazon S3 Integration (p. 915).

Importing Using Oracle SQL Developer

For small databases, you can use Oracle SQL Developer, a graphical Java tool distributed without cost by Oracle. You can install this tool on your desktop computer (Windows, Linux, or Mac) or on one of your servers. Oracle SQL Developer provides options for migrating data between two Oracle databases, or for migrating data from other databases, such as MySQL, to Oracle. Oracle SQL Developer is best suited for migrating small databases. We recommend that you read the Oracle SQL Developer product documentation before you begin migrating your data.

After you install SQL Developer, you can use it to connect to your source and target databases. Use the **Database Copy** command on the Tools menu to copy your data to your Amazon RDS instance.

To download Oracle SQL Developer, go to http://www.oracle.com/technetwork/developer-tools/sql-developer.

Oracle also has documentation on how to migrate from other databases, including MySQL and SQL Server. For more information, see http://www.oracle.com/technetwork/database/migration in the Oracle documentation.

Importing Using Oracle Data Pump

Oracle Data Pump is a long-term replacement for the Oracle Export/Import utilities. Oracle Data Pump is the preferred way to move large amounts of data from an Oracle installation to an Amazon RDS DB instance. You can use Oracle Data Pump for several scenarios:

- Import data from an Oracle database (either on-premises or Amazon EC2 instance) to an Amazon RDS for Oracle DB instance.
- Import data from an RDS Oracle DB instance to an Oracle database (either on-premises or Amazon EC2 instance).
- Import data between RDS Oracle DB instances (for example, to migrate data from EC2-Classic to VPC).

To download Oracle Data Pump utilities, see Oracle Database Software Downloads on the Oracle Technology Network website.

For compatibility considerations when migrating between versions of Oracle Database, see the Oracle documentation.

When you import data with Oracle Data Pump, you must transfer the dump file that contains the data from the source database to the target database. You can transfer the dump file using an Amazon S3 bucket or by using a database link between the two databases.

The following are best practices for using Oracle Data Pump to import data into an Amazon RDS for Oracle DB instance:

- Perform imports in `schema` or `table` mode to import specific schemas and objects.
- Limit the schemas you import to those required by your application.
- Do not import in `full` mode.

  Because Amazon RDS for Oracle does not allow access to `SYS` or `SYSDBA` administrative users, importing in `full` mode, or importing schemas for Oracle-maintained components, might damage the Oracle data dictionary and affect the stability of your database.
- When loading large amounts of data, transfer the dump file to the target Amazon RDS for Oracle DB instance, take a DB snapshot of your instance, and then test the import to verify that it succeeds. If database components are invalidated, you can delete the DB instance and re-create it from the DB snapshot. The restored DB instance includes any dump files staged on the DB instance when you took the DB snapshot.
- Do not import dump files that were created using the Oracle Data Pump export parameters `TRANSPORT_TABLESPACES`, `TRANSPORTABLE`, or `TRANSPORT_FULL_CHECK`. Amazon RDS for Oracle DB instances do not support importing these dump files.

The examples in this section show one way to import data into an Oracle database, but there are many ways to do so with Oracle Data Pump. For complete information about using Oracle Data Pump, see the Oracle documentation.

The examples in this section use the `DBMS_DATAPUMP` package. The same tasks can be accomplished by using the Oracle Data Pump command line utilities `impdp` and `expdp`. You can install these utilities on a remote host as part of an Oracle Client installation, including Oracle Instant Client.

Topics

Importing Data with Oracle Data Pump and an Amazon S3 Bucket

The following import process uses Oracle Data Pump and an Amazon S3 bucket. The process exports data on the source database using the Oracle DBMS_DATAPUMP package and puts the dump file in an Amazon S3 bucket. It then downloads the dump file from the Amazon S3 bucket to the DATA_PUMP_DIR directory on the target Amazon RDS Oracle DB instance. The final step imports the data from the copied dump file into the Amazon RDS Oracle DB instance using the DBMS_DATAPUMP package.

The process has the following requirements:

- You must have an Amazon S3 bucket available for file transfers, and the Amazon S3 bucket must be in the same AWS Region as the DB instance. For instructions, see Create a Bucket in the *Amazon Simple Storage Service Getting Started Guide*.

- You must prepare the Amazon S3 bucket for Amazon RDS integration by following the instructions in Prerequisites for Amazon RDS Oracle Integration with Amazon S3 (p. 915).
- You must ensure that you have enough storage space to store the dump file on the source instance and the target DB instance.

> **Note**
> This process imports a dump file into the DATA_PUMP_DIR directory, a preconfigured directory on all Oracle DB instances. This directory is located on the same storage volume as your data files. When you import the dump file, the existing Oracle data files use more space. Thus, you should make sure that your DB instance can accommodate that additional use of space. The imported dump file is not automatically deleted or purged from the DATA_PUMP_DIR directory. To remove the imported dump file, use UTL_FILE.FREMOVE, found on the Oracle website.

The import process using Oracle Data Pump and an Amazon S3 bucket has the following steps.

Topics

Step 1: Grant Privileges to the User on the Amazon RDS Target Instance

To grant privileges to the user on the RDS target instance, take the following steps:

1. Use SQL Plus or Oracle SQL Developer to connect to the Amazon RDS target Oracle DB instance into which the data will be imported. Connect as the Amazon RDS master user. For information about connecting to the DB instance, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).
2. Create the required tablespaces before you import the data. For more information, see Creating and Sizing Tablespaces (p. 1012).
3. If the user account into which the data is imported doesn't exist, create the user account and grant the necessary permissions and roles. If you plan to import data into multiple user schemas, create each user account and grant the necessary privileges and roles to it.

   For example, the following commands create a new user and grant the necessary permissions and roles to import the data into the user's schema.

```
create user schema_1 identified by <password>;
grant create session, resource to schema_1;
alter user schema_1 quota 100M on users;
```

   This example grants the new user the `CREATE SESSION` privilege and the `RESOURCE` role. Additional privileges and roles might be required depending on the database objects that you import.

   > **Note**
   > Replace *schema_1* with the name of your schema in this step and in the following steps.

Step 2: Use DBMS_DATAPUMP to Create a Dump File

Use SQL Plus or Oracle SQL Developer to connect to the source Oracle instance with an administrative user. If the source database is an Amazon RDS Oracle DB instance, connect with the Amazon RDS master user. Next, use the Oracle Data Pump utility to create a dump file.

The following script creates a dump file named *sample.dmp* in the DATA_PUMP_DIR directory that contains the `SCHEMA_1` schema. Replace `SCHEMA_1` with the name of the schema you want to export.

```
DECLARE
hdnl NUMBER;
BEGIN
hdnl := DBMS_DATAPUMP.OPEN( operation => 'EXPORT', job_mode => 'SCHEMA', job_name=>null);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample.dmp', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_dump_file);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_exp.log', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_log_file);
DBMS_DATAPUMP.METADATA_FILTER(hdnl,'SCHEMA_EXPR','IN (''SCHEMA_1'')');
DBMS_DATAPUMP.START_JOB(hdnl);
END;
/
```

> **Note**
> Data Pump jobs are started asynchronously. For information about monitoring a Data Pump job, see Monitoring Job Status in the Oracle documentation. You can view the contents of the export log by using the `rdsadmin.rds_file_util.read_text_file` procedure. For more information, see Reading Files in a DB Instance Directory (p. 1052).

Step 3: Upload the Dump File to Your Amazon S3 Bucket

Upload the dump file to the Amazon S3 bucket.

Use the Amazon RDS procedure `rdsadmin.rdsadmin_s3_tasks.upload_to_s3` to copy the dump file to the Amazon S3 bucket. The following example uploads all of the files from the `DATA_PUMP_DIR` directory to an Amazon S3 bucket named `mys3bucket`.

```
SELECT rdsadmin.rdsadmin_s3_tasks.upload_to_s3(
      p_bucket_name    =>  'mys3bucket',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The `SELECT` statement returns the ID of the task in a `VARCHAR2` data type.

For more information, see Uploading Files from an Oracle DB Instance to an Amazon S3 Bucket (p. 921).

Step 4: Copy the Exported Dump File from the Amazon S3 Bucket to the Target DB Instance

Use SQL Plus or Oracle SQL Developer to connect to the Amazon RDS target Oracle DB instance. Next, use the Amazon RDS procedure `rdsadmin.rdsadmin_s3_tasks.download_from_s3` to copy the dump file from the Amazon S3 bucket to the target DB instance. The following example downloads all of the files from an Amazon S3 bucket named `mys3bucket` to the `DATA_PUMP_DIR` directory.

```
SELECT rdsadmin.rdsadmin_s3_tasks.download_from_s3(
```

```
      p_bucket_name    =>  'mys3bucket',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The SELECT statement returns the ID of the task in a VARCHAR2 data type.

For more information, see Downloading Files from an Amazon S3 Bucket to an Oracle DB Instance (p. 923).

Step 5: Use DBMS_DATAPUMP to Import the Data File on the Target DB Instance

Use Oracle Data Pump to import the schema in the DB instance. Additional options such as METADATA_REMAP might be required.

Connect to the DB instance with the Amazon RDS master user account to perform the import.

```
DECLARE
hdnl NUMBER;
BEGIN
hdnl := DBMS_DATAPUMP.OPEN( operation => 'IMPORT', job_mode => 'SCHEMA', job_name=>null);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_copied.dmp', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_dump_file);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_imp.log', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_log_file);
DBMS_DATAPUMP.METADATA_FILTER(hdnl,'SCHEMA_EXPR','IN (''SCHEMA_1'')');
DBMS_DATAPUMP.START_JOB(hdnl);
END;
/
```

Note
Data Pump jobs are started asynchronously. For information about monitoring a Data Pump job, see Monitoring Job Status in the Oracle documentation. You can view the contents of the import log by using the rdsadmin.rds_file_util.read_text_file procedure. For more information, see Reading Files in a DB Instance Directory (p. 1052).

You can verify the data import by viewing the user's tables on the DB instance. For example, the following query returns the number of tables for *SCHEMA_1*.

```
select count(*) from dba_tables where owner='SCHEMA_1';
```

Step 6: Clean Up

After the data has been imported, you can delete the files that you don't want to keep. You can list the files in the DATA_PUMP_DIR using the following command.

```
select * from table(RDSADMIN.RDS_FILE_UTIL.LISTDIR('DATA_PUMP_DIR')) order by mtime;
```

To delete files in the DATA_PUMP_DIR that you no longer require, use the following command.

```
exec utl_file.fremove('DATA_PUMP_DIR','<file name>');
```

For example, the following command deletes the file named "sample_copied.dmp".

```
exec utl_file.fremove('DATA_PUMP_DIR','sample_copied.dmp');
```

Importing Data with Oracle Data Pump and a Database Link

The following import process uses Oracle Data Pump and the Oracle DBMS_FILE_TRANSFER package. The process connects to a source Oracle instance, which can be an on-premises or Amazon EC2 instance, or an Amazon RDS for Oracle DB instance. The process then exports data using the DBMS_DATAPUMP package. Next, it uses the DBMS_FILE_TRANSFER.PUT_FILE method to copy the dump file from the Oracle instance to the DATA_PUMP_DIR directory on the target Amazon RDS Oracle DB instance that is connected using a database link. The final step imports the data from the copied dump file into the Amazon RDS Oracle DB instance using the DBMS_DATAPUMP package.

The process has the following requirements:

- You must have execute privileges on the DBMS_FILE_TRANSFER and DBMS_DATAPUMP packages.
- You must have write privileges to the DATA_PUMP_DIR directory on the source DB instance.
- You must ensure that you have enough storage space to store the dump file on the source instance and the target DB instance.

> **Note**
> This process imports a dump file into the DATA_PUMP_DIR directory, a preconfigured directory on all Oracle DB instances. This directory is located on the same storage volume as your data files. When you import the dump file, the existing Oracle data files use more space. Thus, you should make sure that your DB instance can accommodate that additional use of space. The imported dump file is not automatically deleted or purged from the DATA_PUMP_DIR directory. To remove the imported dump file, use UTL_FILE.FREMOVE, found on the Oracle website.

The import process using Oracle Data Pump and the DBMS_FILE_TRANSFER package has the following steps.

Topics

Step 1: Grant Privileges to the User on the Amazon RDS Target Instance

To grant privileges to the user on the RDS target instance, take the following steps:

1. Use SQL Plus or Oracle SQL Developer to connect to the Amazon RDS target Oracle DB instance into which the data will be imported. Connect as the Amazon RDS master user. For information about connecting to the DB instance, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).
2. Create the required tablespaces before you import the data. For more information, see Creating and Sizing Tablespaces (p. 1012).
3. If the user account into which the data is imported doesn't exist, create the user account and grant the necessary permissions and roles. If you plan to import data into multiple user schemas, create each user account and grant the necessary privileges and roles to it.

   For example, the following commands create a new user and grant the necessary permissions and roles to import the data into the user's schema.

```
create user schema_1 identified by <password>;
grant create session, resource to schema_1;
alter user schema_1 quota 100M on users;
```

This example grants the new user the `CREATE SESSION` privilege and the `RESOURCE` role. Additional privileges and roles might be required depending on the database objects that you import.

Note
Replace *schema_1* with the name of your schema in this step and in the following steps.

Step 2: Grant Privileges to the User on the Source Database

Use SQL Plus or Oracle SQL Developer to connect to the Oracle instance that contains the data to be imported. If necessary, create a user account and grant the necessary permissions.

Note
If the source database is an Amazon RDS instance, you can skip this step. You use your Amazon RDS master user account to perform the export.

The following commands create a new user and grant the necessary permissions.

```
create user export_user identified by <password>;
grant create session, create table, create database link to export_user;
alter user export_user quota 100M on users;
grant read, write on directory data_pump_dir to export_user;
grant select_catalog_role to export_user;
grant execute on dbms_datapump to export_user;
grant execute on dbms_file_transfer to export_user;
```

Step 3: Use DBMS_DATAPUMP to Create a Dump File

Use SQL Plus or Oracle SQL Developer to connect to the source Oracle instance with an administrative user or with the user you created in step 2. If the source database is an Amazon RDS Oracle DB instance, connect with the Amazon RDS master user. Next, use the Oracle Data Pump utility to create a dump file.

The following script creates a dump file named *sample.dmp* in the DATA_PUMP_DIR directory.

```
DECLARE
hdnl NUMBER;
BEGIN
hdnl := DBMS_DATAPUMP.OPEN( operation => 'EXPORT', job_mode => 'SCHEMA', job_name=>null);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample.dmp', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_dump_file);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_exp.log', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_log_file);
DBMS_DATAPUMP.METADATA_FILTER(hdnl,'SCHEMA_EXPR','IN (''SCHEMA_1'')');
DBMS_DATAPUMP.START_JOB(hdnl);
END;
/
```

Note
Data Pump jobs are started asynchronously. For information about monitoring a Data Pump job, see Monitoring Job Status in the Oracle documentation. You can view the contents of the

export log by using the `rdsadmin.rds_file_util.read_text_file` procedure. For more information, see Reading Files in a DB Instance Directory (p. 1052).

Step 4: Create a Database Link to the Target DB Instance

Create a database link between your source instance and your target DB instance. Your local Oracle instance must have network connectivity to the DB instance in order to create a database link and to transfer your export dump file.

Perform this step connected with the same user account as the previous step.

If you are creating a database link between two DB instances inside the same VPC or peered VPCs, the two DB instances should have a valid route between them. The security group of each DB instance must allow ingress to and egress from the other DB instance. The security group inbound and outbound rules can refer to security groups from the same VPC or a peered VPC. For more information, see Adjusting Database Links for Use with DB Instances in a VPC (p. 1019).

The following command creates a database link named `to_rds` that connects to the Amazon RDS master user at the target DB instance.

```
create database link to_rds connect to <master_user_account> identified by <password>
using '(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=<dns or ip address of remote db>)
(PORT=<listener port>))(CONNECT_DATA=(SID=<remote SID>)))';
```

Step 5: Use DBMS_FILE_TRANSFER to Copy the Exported Dump File to the Target DB Instance

Use DBMS_FILE_TRANSFER to copy the dump file from the source database instance to the target DB instance. The following script copies a dump file named sample.dmp from the source instance to a target database link named *to_rds* (created in the previous step).

```
BEGIN
DBMS_FILE_TRANSFER.PUT_FILE(
source_directory_object       => 'DATA_PUMP_DIR',
source_file_name              => 'sample.dmp',
destination_directory_object  => 'DATA_PUMP_DIR',
destination_file_name         => 'sample_copied.dmp',
destination_database          => 'to_rds'
);
END;
/
```

Step 6: Use DBMS_DATAPUMP to Import the Data File to the Target DB Instance

Use Oracle Data Pump to import the schema in the DB instance. Additional options such as METADATA_REMAP might be required.

Connect to the DB instance with the Amazon RDS master user account to perform the import.

```
DECLARE
hdnl NUMBER;
BEGIN
hdnl := DBMS_DATAPUMP.OPEN( operation => 'IMPORT', job_mode => 'SCHEMA', job_name=>null);
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_copied.dmp', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_dump_file);
```

```
DBMS_DATAPUMP.ADD_FILE( handle => hdnl, filename => 'sample_imp.log', directory =>
 'DATA_PUMP_DIR', filetype => dbms_datapump.ku$_file_type_log_file);
DBMS_DATAPUMP.METADATA_FILTER(hdnl,'SCHEMA_EXPR','IN (''SCHEMA_1'')');
DBMS_DATAPUMP.START_JOB(hdnl);
END;
/
```

Note

Data Pump jobs are started asynchronously. For information about monitoring a Data Pump job, see Monitoring Job Status in the Oracle documentation. You can view the contents of the import log by using the `rdsadmin.rds_file_util.read_text_file` procedure. For more information, see Reading Files in a DB Instance Directory (p. 1052).

You can verify the data import by viewing the user's tables on the DB instance. For example, the following query returns the number of tables for *schema_1*.

```
select count(*) from dba_tables where owner='SCHEMA_1';
```

Step 7: Clean Up

After the data has been imported, you can delete the files that you don't want to keep. You can list the files in the DATA_PUMP_DIR using the following command.

```
select * from table(RDSADMIN.RDS_FILE_UTIL.LISTDIR('DATA_PUMP_DIR')) order by mtime;
```

To delete files in the DATA_PUMP_DIR that you no longer require, use the following command.

```
exec utl_file.fremove('DATA_PUMP_DIR','<file name>');
```

For example, the following command deletes the file named "`sample_copied.dmp`".

```
exec utl_file.fremove('DATA_PUMP_DIR','sample_copied.dmp');
```

Oracle Export/Import Utilities

The Oracle Export/Import utilities are best suited for migrations where the data size is small and data types such as binary float and double are not required. The import process creates the schema objects so you do not need to run a script to create them beforehand, making this process well suited for databases with small tables. The following example demonstrates how these utilities can be used to export and import specific tables.

To download Oracle export and import utilities, go to http://www.oracle.com/technetwork/database/enterprise-edition/downloads/index.html.

Export the tables from the source database using the command below. Substitute username/password as appropriate.

```
exp cust_dba@ORCL FILE=exp_file.dmp TABLES=(tab1,tab2,tab3) LOG=exp_file.log
```

The export process creates a binary dump file that contains both the schema and data for the specified tables. Now this schema and data can be imported into a target database using the command:

```
imp cust_dba@targetdb FROMUSER=cust_schema TOUSER=cust_schema \
```

```
TABLES=(tab1,tab2,tab3) FILE=exp_file.dmp LOG=imp_file.log
```

There are other variations of the Export and Import commands that might be better suited to your needs. See Oracle's documentation for full details.

Oracle SQL*Loader

Oracle SQL*Loader is well suited for large databases that have a limited number of objects in them. Since the process involved in exporting from a source database and loading to a target database is very specific to the schema, the following example creates the sample schema objects, exports from a source, and then loads it into a target database.

To download Oracle SQL*Loader, go to http://www.oracle.com/technetwork/database/enterprise-edition/downloads/index.html.

1. Create a sample source table using the command below.

```
create table customer_0 tablespace users as select rownum id, o.* from
all_objects o, all_objects x where rownum <= 1000000;
```

2. On the target Amazon RDS instance, create a destination table that is used to load the data.

```
create table customer_1 tablespace users as select 0 as id, owner,
object_name, created from all_objects where 1=2;
```

3. The data is exported from the source database to a flat file with delimiters. This example uses SQL*Plus for this purpose. For your data, you will likely need to generate a script that does the export for all the objects in the database.

```
alter session set nls_date_format = 'YYYY/MM/DD HH24:MI:SS'; set linesize 800
HEADING OFF FEEDBACK OFF array 5000 pagesize 0 spool customer_0.out SET
MARKUP HTML PREFORMAT ON SET COLSEP ',' SELECT id, owner, object_name,
created FROM customer_0; spool off
```

4. You need to create a control file to describe the data. Again, depending on your data, you will need to build a script that does this step.

```
cat << EOF > sqlldr_1.ctl
load data
infile customer_0.out
into table customer_1
APPEND
fields terminated by "," optionally enclosed by '"'
(
id              POSITION(01:10)         INTEGER EXTERNAL,
owner             POSITION(12:41)         CHAR,
object_name       POSITION(43:72)         CHAR,
created            POSITION(74:92)         date "YYYY/MM/DD HH24:MI:SS"
)
```

If needed, copy the files generated by the preceding code to a staging area, such as an Amazon EC2 instance.

5. Finally, import the data using SQL*Loader with the appropriate username and password for the target database.

```
sqlldr cust_dba@targetdb control=sqlldr_1.ctl BINDSIZE=10485760 READSIZE=10485760
 ROWS=1000
```

Oracle Materialized Views

You can also make use of Oracle materialized view replication to migrate large datasets efficiently. Replication allows you to keep the target tables in sync with the source on an ongoing basis, so the actual cutover to Amazon RDS can be done later, if needed. The replication is set up using a database link from the Amazon RDS instance to the source database.

One requirement for materialized views is to allow access from the target database to the source database. In the following example, access rules were enabled on the source database to allow the Amazon RDS target database to connect to the source over SQLNet.

1. Create a user account on both source and Amazon RDS target instances that can authenticate with the same password.

```
create user dblink_user identified by <password>
   default tablespace users
   temporary tablespace temp;

grant create session to dblink_user;

grant select any table to dblink_user;

grant select any dictionary to dblink_user;
```

2. Create a database link from the Amazon RDS target instance to the source instance using the newly created dblink_user.

```
create database link remote_site
   connect to dblink_user identified by <password>
   using '(description=(address=(protocol=tcp) (host=<myhost>)
   (port=<listener port>)) (connect_data=(sid=<sourcedb sid>)))';
```

3. Test the link:

```
select * from v$instance@remote_site;
```

4. Create a sample table with primary key and materialized view log on the source instance.

```
create table customer_0 tablespace users as select rownum id, o.* from
   all_objects o, all_objects x where rownum <= 1000000;

alter table customer_0 add constraint pk_customer_0 primary key (id) using index;

create materialized view log on customer_0;
```

5. On the target Amazon RDS instance, create a materialized view.

```
CREATE MATERIALIZED VIEW customer_0 BUILD IMMEDIATE REFRESH FAST AS
   SELECT * FROM cust_dba.customer_0@remote_site;
```

6. On the target Amazon RDS instance, refresh the materialized view.

```
exec DBMS_MV.REFRESH('CUSTOMER_0', 'f');
```

7. Drop the materialized view and include the PRESERVE TABLE clause to retain the materialized view container table and its contents.

```
DROP MATERIALIZED VIEW customer_0 PRESERVE TABLE;
```

The retained table has the same name as the dropped materialized view.

Working with Oracle Read Replicas for Amazon RDS

You usually use read replicas to configure replication between Amazon RDS DB instances. For general information about read replicas, see Working with Read Replicas (p. 250).

In this section, you can find specific information about working with read replicas on Amazon RDS for Oracle.

Topics

Configuring Read Replicas for Oracle

Oracle read replicas use Oracle Data Guard to replicate database changes from the source DB instance to its read replicas. For information about Oracle Data Guard, see Oracle Data Guard Concepts and Administration in the Oracle documentation.

Before a DB instance can serve as a source DB instance, you must enable automatic backups on the source DB instance. To do so, you set the backup retention period to a value other than 0. We recommend that you enable force logging mode on the DB instance. To enable force logging mode, connect to the DB instance and run the following procedure.

```
exec rdsadmin.rdsadmin_util.force_logging(p_enable => true);
```

For more information about this procedure, see Setting Force Logging (p. 1025).

If you plan changes to your logging configuration, we recommend that you complete the changes before making a DB instance the source for one or more read replicas. You can modify the logging configuration for a DB instance by using the Amazon RDS procedures `rdsadmin.rdsadmin_util.add_logfile` and `rdsadmin.rdsadmin_util.drop_logfile`. For more information, see Adding Online Redo Logs (p. 1026) and Dropping Online Redo Logs (p. 1027). As a best practice, we recommend that you not modify the logging configuration after read replicas are created. Modifications can cause the online redo logging configuration to get out of sync with the standby logging configuration.

Creating an Oracle read replica doesn't require an outage for the master DB instance. Amazon RDS sets the necessary parameters and permissions for the source DB instance and the read replica without any service interruption. A snapshot is taken of the source DB instance, and this snapshot becomes the read replica. No outage occurs when you delete a read replica.

You can create up to five read replicas from one source DB instance. Before you create a read replica, make sure that the setting of the `max_string_size` parameter is same on the source DB instance and the read replica. You can do this by associating them with the same parameter group. If you have different parameter groups for the source and the read replica, you can set `max_string_size` to the same value.

The Oracle DB engine version of the source DB instance and all of its read replicas must be the same. Amazon RDS upgrades the read replicas immediately after upgrading the source DB instance, regardless of a read replica's maintenance window. For major version upgrades of cross-Region read replicas, Amazon RDS automatically generates an option group for the target version, copies all options and option settings from the original option group to the new option group, and associates the upgraded cross-Region read replica with the new option group. For more information about upgrading the DB engine version, see Upgrading the Oracle DB Engine (p. 888).

For a read replica to receive and apply changes from the source, it should have sufficient compute and storage resources. If a read replica reaches compute, network, or storage resource capacity, the read replica stops receiving or applying changes from its source. You can modify the storage and CPU resources of a read replica independently from its source and other read replicas.

Read Replica Limitations with Oracle

The following are limitations for Oracle read replicas:

- You must have an Active Data Guard license.
- Oracle read replicas are only available on the Oracle Enterprise Edition (EE) engine.
- Oracle read replicas are available for Oracle version 12.1.0.2.v10 and higher 12.1 versions, for all 12.2 versions, for all 18 versions, and for all 19 versions.
- Oracle read replicas are only available for DB instances on the EC2-VPC platform.
- Oracle read replicas are only available for DB instances running on DB instance classes with two or more vCPUs. A source DB instance can't use the db.t3.micro instance class.
- Amazon RDS for Oracle doesn't intervene to mitigate high replica lag between a source DB instance and its read replicas. Ensure that the source DB instance and its read replicas are sized properly, in terms of compute and storage, to suit their operational load.
- An Oracle read replica that is in the same AWS Region as its source DB instance must belong to the same option group as the source DB instance. Modifications to the source option group or source option group membership propagate to read replicas. These changes are applied to the read replicas immediately after they are applied to the source DB instance, regardless of the read replica's maintenance window.

  For more information about option groups, see Working with Option Groups (p. 186).
- If a DB instance is a source for one or more cross-Region read replicas, it retains its redo logs until they are applied on all cross-Region read replicas. The redo logs might result in increased storage consumption.
- When you create an Oracle cross-Region read replica, Amazon RDS creates a dedicated option group for it.

  You can't remove an Oracle cross-Region read replica from its dedicated option group. No other DB instances can use the dedicated option group for an Oracle cross-Region read replica.

  Only the following nonreplicated options can be added to or removed from a dedicated option group:
  - NATIVE_NETWORK_ENCRYPTION
  - OEM
  - OEM_AGENT
  - SSL

  To add other options to an Oracle cross-Region read replica, add them to the source DB instance's option group. The option is also installed on all of the source DB instance's read replicas. For licensed options, you must ensure that there are sufficient licenses for the read replicas.

  When you promote an Oracle cross-Region read replica, the promoted read replica behaves the same as other Oracle DB instances, including the management of its options. You can promote a read replica explicitly or implicitly by deleting its source DB instance.

  For more information about option groups, see Working with Option Groups (p. 186).

- A login trigger on a primary instance must permit access to the `RDS_DATAGUARD` user and to any user whose `AUTHENTICATED_ENTITY` is `RDS_DATAGUARD` or `rdsdb`. Also, the trigger must not set the current schema for the `RDS_DATAGUARD` user.
- To avoid blocking connections from the Data Guard broker process, don't enable restricted sessions. For more information about restricted sessions, see Enabling and Disabling Restricted Sessions (p. 1003).

Troubleshooting an Oracle Read Replica Problem

You can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric. For information about replication lag time, see Monitoring Read Replication (p. 263).

If replication lag is too long, you can query the following views for information about the lag:

- `V$ARCHIVED_LOG` – Shows which commits have been applied to the read replica.
- `V$DATAGUARD_STATS` – Shows a detailed breakdown of the components that make up the `replicaLag` metric.
- `V$DATAGUARD_STATUS` – Shows the log output from Oracle's internal replication processes.

Oracle Character Sets Supported in Amazon RDS

The following table lists the Oracle database character sets that are supported in Amazon RDS. You can use a value from this table with the `--character-set-name` parameter of the AWS CLI create-db-instance command or with the `CharacterSetName` parameter of the Amazon RDS API CreateDBInstance operation.

Setting the NLS_LANG environment parameter in your client's environment is the simplest way to specify locale behavior for Oracle. This parameter sets the language and territory used by the client application and the database server. It also indicates the client's character set, which corresponds to the character set for data entered or displayed by a client application. Amazon RDS lets you set the character set when you create a DB instance. For more information on the NLS_LANG and character sets, see What is a Character set or Code Page? in the Oracle documentation.

Value	Description
AL32UTF8	Unicode 5.0 UTF-8 Universal character set (default)
AR8ISO8859P6	ISO 8859-6 Latin/Arabic
AR8MSWIN1256	Microsoft Windows Code Page 1256 8-bit Latin/ Arabic
BLT8ISO8859P13	ISO 8859-13 Baltic
BLT8MSWIN1257	Microsoft Windows Code Page 1257 8-bit Baltic
CL8ISO8859P5	ISO 88559-5 Latin/Cyrillic
CL8MSWIN1251	Microsoft Windows Code Page 1251 8-bit Latin/ Cyrillic
EE8ISO8859P2	ISO 8859-2 East European
EL8ISO8859P7	ISO 8859-7 Latin/Greek
EE8MSWIN1250	Microsoft Windows Code Page 1250 8-bit East European
EL8MSWIN1253	Microsoft Windows Code Page 1253 8-bit Latin/ Greek
IW8ISO8859P8	ISO 8859-8 Latin/Hebrew
IW8MSWIN1255	Microsoft Windows Code Page 1255 8-bit Latin/ Hebrew
JA16EUC	EUC 24-bit Japanese
JA16EUCTILDE	Same as JA16EUC except for mapping of wave dash and tilde to and from Unicode
JA16SJIS	Shift-JIS 16-bit Japanese
JA16SJISTILDE	Same as JA16SJIS except for mapping of wave dash and tilde to and from Unicode
KO16MSWIN949	Microsoft Windows Code Page 949 Korean

Value	Description
NE8ISO8859P10	ISO 8859-10 North European
NEE8ISO8859P4	ISO 8859-4 North and Northeast European
TH8TISASCII	Thai Industrial Standard 620-2533-ASCII 8-bit
TR8MSWIN1254	Microsoft Windows Code Page 1254 8-bit Turkish
US7ASCII	ASCII 7-bit American
UTF8	Unicode 3.0 UTF-8 Universal character set, CESU-8 compliant
VN8MSWIN1258	Microsoft Windows Code Page 1258 8-bit Vietnamese
WE8ISO8859P1	Western European 8-bit ISO 8859 Part 1
WE8ISO8859P15	ISO 8859-15 West European
WE8ISO8859P9	ISO 8859-9 West European and Turkish
WE8MSWIN1252	Microsoft Windows Code Page 1252 8-bit West European
ZHS16GBK	GBK 16-bit Simplified Chinese
ZHT16HKSCS	Microsoft Windows Code Page 950 with Hong Kong Supplementary Character Set HKSCS-2001. Character set conversion is based on Unicode 3.0.
ZHT16MSWIN950	Microsoft Windows Code Page 950 Traditional Chinese
ZHT32EUC	EUC 32-bit Traditional Chinese

You can also set the following National Language Support (NLS) initialization parameters at the instance level for an Oracle DB instance in Amazon RDS:

- NLS_DATE_FORMAT
- NLS_LENGTH_SEMANTICS
- NLS_NCHAR_CONV_EXCP
- NLS_TIME_FORMAT
- NLS_TIME_TZ_FORMAT
- NLS_TIMESTAMP_FORMAT
- NLS_TIMESTAMP_TZ_FORMAT

For information about modifying instance parameters, see Working with DB Parameter Groups (p. 202).

You can set other NLS initialization parameters in your SQL client. For example, the following statement sets the NLS_LANGUAGE initialization parameter to GERMAN in a SQL client that is connected to an Oracle DB instance:

```
ALTER SESSION SET NLS_LANGUAGE=GERMAN;
```

For information about connecting to an Oracle DB instance with a SQL client, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).

Options for Oracle DB Instances

Following, you can find a description of options, or additional features, that are available for Amazon RDS instances running the Oracle DB engine. To enable these options, you add them to an option group, and then associate the option group with your DB instance. For more information, see Working with Option Groups (p. 186).

Some options require additional memory to run on your DB instance. For example, Oracle Enterprise Manager Database Control uses about 300 MB of RAM. If you enable this option for a small DB instance, you might encounter performance problems due to memory constraints. You can adjust the Oracle parameters so that the database requires less RAM. Alternatively, you can scale up to a larger DB instance.

Amazon RDS supports the following options for Oracle DB instances.

Option	Option ID
Amazon S3 Integration (p. 915)	S3_INTEGRATION
Oracle Application Express (p. 927)	APEX APEX-DEV
Oracle Enterprise Manager (p. 935)	OEM OEM_AGENT
Oracle Java Virtual Machine (p. 951)	JVM
Oracle Label Security (p. 954)	OLS
Oracle Locator (p. 957)	LOCATOR
Oracle Multimedia (p. 960)	MULTIMEDIA
Oracle Native Network Encryption (p. 963)	NATIVE_NETWORK_ENCRYPTION
Oracle OLAP (p. 966)	OLAP
Oracle Secure Sockets Layer (p. 967)	SSL
Oracle Spatial (p. 976)	SPATIAL
Oracle SQLT (p. 979)	SQLT
Oracle Statspack (p. 984)	STATSPACK
Oracle Time Zone (p. 987)	Timezone
Oracle Transparent Data Encryption (p. 990)	TDE
Oracle UTL_MAIL (p. 992)	UTL_MAIL
Oracle XML DB (p. 994)	XMLDB

Amazon S3 Integration

You can transfer files between an Amazon RDS for Oracle DB instance and an Amazon S3 bucket. You can use Amazon S3 integration with Oracle features such as Data Pump. For example, you can download Data Pump files from Amazon S3 to the DB instance host.

> **Note**
> The DB instance and the Amazon S3 bucket must be in the same AWS Region.

Topics

Prerequisites for Amazon RDS Oracle Integration with Amazon S3

To work with Amazon RDS for Oracle integration with Amazon S3, the Amazon RDS DB instance must have access to an Amazon S3 bucket. For this, you create an AWS Identity and Access Management (IAM) policy and an IAM role. The Amazon VPC used by your DB instance doesn't need to provide access to the Amazon S3 endpoints.

> **Note**
> To add a role to a DB instance, the status of the DB instance must be `available`.

Console

To create an IAM policy to allow Amazon RDS access to an Amazon S3 bucket

1. Open the IAM Management Console.
2. In the navigation pane, choose **Policies**.
3. Choose **Create policy**.
4. On the **Visual editor** tab, choose **Choose a service**, and then choose **S3**.
5. For **Actions**, choose **Expand all**, and then choose the bucket permissions and object permissions needed for the IAM policy.

   Include the appropriate actions in the policy based on the type of access required:

   - `GetObject` – Required to transfer files from an Amazon S3 bucket to Amazon RDS.
   - `ListBucket` – Required to transfer files from an Amazon S3 bucket to Amazon RDS.
   - `PutObject` – Required to transfer files from Amazon RDS to an Amazon S3 bucket.

   Object permissions are permissions for object operations in Amazon S3, and need to be granted for objects in a bucket, not the bucket itself. For more information about permissions for object operations in Amazon S3, see Permissions for Object Operations.
6. Choose **Resources**, and choose **Add ARN** for **bucket**.
7. In the **Add ARN(s)** dialog box, provide the details about your resource, and choose **Add**.

   Specify the Amazon S3 bucket to allow access to. For instance, if you want to allow Amazon RDS to access the Amazon S3 bucket named `example-bucket`, then set the Amazon Resource Name (ARN) value to `arn:aws:s3:::example-bucket`.

8. If the **object** resource is listed, choose **Add ARN** for **object**.
9. In the **Add ARN(s)** dialog box, provide the details about your resource.

   For the Amazon S3 bucket, specify the Amazon S3 bucket to allow access to. For the object, you can choose **Any** to grant permissions to any object in the bucket.

   > **Note**
   > You can set **Amazon Resource Name (ARN)** to a more specific ARN value to allow Amazon RDS to access only specific files or folders in an Amazon S3 bucket. For more information about how to define an access policy for Amazon S3, see Managing Access Permissions to Your Amazon S3 Resources.
10. (Optional) Choose **Add additional permissions** to add another Amazon S3 bucket to the policy, and repeat the previous steps for the bucket.

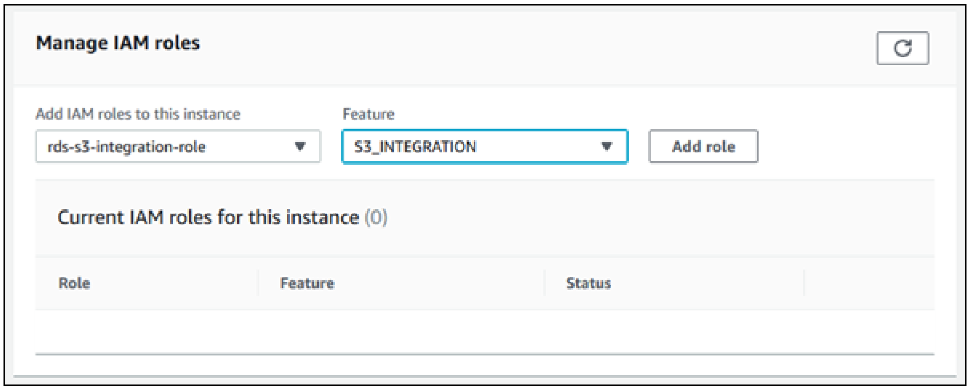
    > **Note**
    > You can repeat this to add corresponding bucket permission statements to your policy for each Amazon S3 bucket that you want Amazon RDS to access. Optionally, you can also grant access to all buckets and objects in Amazon S3.
11. Choose **Review policy**.
12. For **Name**, enter a name for your IAM policy, for example `rds-s3-integration-policy`. You use this name when you create an IAM role to associate with your DB instance. You can also add an optional **Description** value.
13. Choose **Create policy**.

To create an IAM role to allow Amazon RDS access to an Amazon S3 bucket

1. In the navigation pane, choose **Roles**.
2. Choose **Create role**.
3. For **AWS service**, choose **RDS**.
4. For **Select your use case**, choose **RDS – Add Role to Database**.
5. Choose **Next: Permissions**.
6. For **Search** under **Attach permissions policies**, enter the name of the IAM policy you created, and choose the policy when it appears in the list.
7. Choose **Next: Tags** and then **Next: Review**.
8. Set **Role name** to a name for your IAM role, for example `rds-s3-integration-role`. You can also add an optional **Role description** value.
9. Choose **Create Role**.

To associate your IAM role with your DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose the Oracle DB instance name to display its details.
3. On the **Connectivity & security** tab, in the **Manage IAM roles** section, choose the role to add under **Add IAM roles to this instance**.
4. For **Feature**, choose **S3_INTEGRATION**.



5. Choose **Add role**.

AWS CLI

To grant Amazon RDS access to an Amazon S3 bucket

1. Create an AWS Identity and Access Management (IAM) policy that grants Amazon RDS access to an Amazon S3 bucket.

   Include the appropriate actions in the policy based on the type of access required:

   - `GetObject` – Required to transfer files from an Amazon S3 bucket to Amazon RDS.
   - `ListBucket` – Required to transfer files from an Amazon S3 bucket to Amazon RDS.
   - `PutObject` – Required to transfer files from Amazon RDS to an Amazon S3 bucket.

   The following AWS CLI command creates an IAM policy named *`rds-s3-integration-policy`* with these options. It grants access to a bucket named *`your-s3-bucket-arn`*.

   Example

   For Linux, macOS, or Unix:

```
aws iam create-policy \
   --policy-name rds-s3-integration-policy \
   --policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Sid": "s3integration",
         "Action": [
           "s3:GetObject",
           "s3:ListBucket",
           "s3:PutObject"
         ],
         "Effect": "Allow",
         "Resource": [
           "arn:aws:s3:::your-s3-bucket-arn",
           "arn:aws:s3:::your-s3-bucket-arn/*"
         ]
       }
     ]
   }'
```

For Windows:

```
aws iam create-policy ^
   --policy-name rds-s3-integration-policy ^
   --policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Sid": "s3integration",
         "Action": [
           "s3:GetObject",
           "s3:ListBucket",
           "s3:PutObject"
         ],
         "Effect": "Allow",
         "Resource": [
           "arn:aws:s3:::your-s3-bucket-arn",
           "arn:aws:s3:::your-s3-bucket-arn/*"
         ]
       }
     ]
   }'
```

2. After the policy is created, note the Amazon Resource Name (ARN) of the policy. You need the ARN for a subsequent step.
3. Create an IAM role that Amazon RDS can assume on your behalf to access your Amazon S3 buckets.

   The following AWS CLI command creates the `rds-s3-integration-role` for this purpose.

   Example

   For Linux, macOS, or Unix:

```
aws iam create-role \
   --role-name rds-s3-integration-role \
   --assume-role-policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Principal": {
            "Service": "rds.amazonaws.com"
          },
         "Action": "sts:AssumeRole"
       }
     ]
   }'
```

   For Windows:

```
aws iam create-role ^
   --role-name rds-s3-integration-role ^
   --assume-role-policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
```

```
            "Effect": "Allow",
            "Principal": {
               "Service": "rds.amazonaws.com"
             },
            "Action": "sts:AssumeRole"
          }
        ]
      }'
```

For more information, see Creating a Role to Delegate Permissions to an IAM User in the *IAM User Guide*.

4. After the role is created, note the ARN of the role. You need the ARN for a subsequent step.
5. Attach the policy you created to the role you created.

   The following AWS CLI command attaches the policy to the role named *rds-s3-integration-role*.

   Example

   For Linux, macOS, or Unix:

```
aws iam attach-role-policy \
   --policy-arn your-policy-arn \
   --role-name rds-s3-integration-role
```

   For Windows:

```
aws iam attach-role-policy ^
   --policy-arn your-policy-arn ^
   --role-name rds-s3-integration-role
```

   Replace *your-policy-arn* with the policy ARN that you noted in a previous step.

6. Add the role to the Oracle DB instance.

   The following AWS CLI command adds the role to an Oracle DB instance named *mydbinstance*.

   Example

   For Linux, macOS, or Unix:

```
aws rds add-role-to-db-instance \
   --db-instance-identifier mydbinstance \
   --feature-name S3_INTEGRATION \
   --role-arn your-role-arn
```

   For Windows:

```
aws rds add-role-to-db-instance ^
   --db-instance-identifier mydbinstance ^
   --feature-name S3_INTEGRATION ^
```

```
    --role-arn your-role-arn
```

Replace *your-role-arn* with the role ARN that you noted in a previous step. `S3_INTEGRATION` must be specified for the `--feature-name` option.

Adding the Amazon S3 Integration Option

To use Amazon RDS for Oracle Integration with Amazon S3, your Amazon RDS Oracle DB instance must be associated with an option group that includes the `S3_INTEGRATION` option.

Console

To configure an option group for Amazon S3 integration

1. Create a new option group or identify an existing option group to which you can add the `S3_INTEGRATION` option.

   For information about creating an option group, see Creating an Option Group (p. 187).
2. Add the `S3_INTEGRATION` option to the option group.

   For information about adding an option to an option group, see Adding an Option to an Option Group (p. 190).
3. Create a new Oracle DB instance and associate the option group with it, or modify an Oracle DB instance to associate the option group with it.

   For information about creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

   For information about modifying an Oracle DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

AWS CLI

To configure an option group for Amazon S3 integration

1. Create a new option group or identify an existing option group to which you can add the `S3_INTEGRATION` option.

   For information about creating an option group, see Creating an Option Group (p. 187).
2. Add the `S3_INTEGRATION` option to the option group.

   For example, the following AWS CLI command adds the `S3_INTEGRATION` option to an option group named **`myoptiongroup`**.

   Example

   For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --option-group-name myoptiongroup \
    --options OptionName=S3_INTEGRATION,OptionVersion=1.0
```

   For Windows:

```
aws rds add-option-to-option-group ^
   --option-group-name myoptiongroup ^
   --options OptionName=S3_INTEGRATION,OptionVersion=1.0
```

3. Create a new Oracle DB instance and associate the option group with it, or modify an Oracle DB instance to associate the option group with it.

   For information about creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

   For information about modifying an Oracle DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Transferring Files Between Amazon RDS for Oracle and an Amazon S3 Bucket

You can use Amazon RDS procedures to upload files from an Oracle DB instance to an Amazon S3 bucket. You can also use Amazon RDS procedures to download files from an Amazon S3 bucket to an Oracle DB instance.

> **Note**
> These procedures upload or download the files in a single directory. You can't include subdirectories in these operations.

Topics

Uploading Files from an Oracle DB Instance to an Amazon S3 Bucket

To upload files from an Oracle DB instance to an Amazon S3 bucket, use the Amazon RDS procedure `rdsadmin.rdsadmin_s3_tasks.upload_to_s3`. For example, you can upload Oracle Recovery Manager (RMAN) backup files. For more information about performing RMAN backups, see Common DBA Recovery Manager (RMAN) Tasks for Oracle DB Instances (p. 1031).

The `rdsadmin.rdsadmin_s3_tasks.upload_to_s3` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_bucket_name`	VARCHAR2	–	required	The name of the Amazon S3 bucket to upload files to.
`p_directory_name`	VARCHAR2	–	required	The name of the Oracle directory object to upload files from. The directory can be any user-created directory object or the Data Pump directory, such as `DATA_PUMP_DIR`.

Parameter Name	Data Type	Default	Required	Description
				Note You can only upload files from the specified directory. You can't upload files in subdirectories in the specified directory.
`p_s3_prefix`	VARCHAR2	–	required	An Amazon S3 file name prefix that files are uploaded to. An empty prefix uploads all files to the top level in the specified Amazon S3 bucket and doesn't add a prefix to the file names. For example, if the prefix is `folder_1/oradb`, files are uploaded to `folder_1`. In this case, the `oradb` prefix is added to each file.
`p_prefix`	VARCHAR2	–	required	A file name prefix that file names must match to be uploaded. An empty prefix uploads all files in the specified directory.

The return value for the `rdsadmin.rdsadmin_s3_tasks.upload_to_s3` procedure is a task ID.

The following example uploads all of the files in the *`DATA_PUMP_DIR`* directory to the Amazon S3 bucket named *`mys3bucket`*.

```
SELECT rdsadmin.rdsadmin_s3_tasks.upload_to_s3(
      p_bucket_name    =>  'mys3bucket',
      p_prefix         =>  '',
      p_s3_prefix      =>  '',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The following example uploads all of the files with the prefix *`db`* in the *`DATA_PUMP_DIR`* directory to the Amazon S3 bucket named *`mys3bucket`*.

```
SELECT rdsadmin.rdsadmin_s3_tasks.upload_to_s3(
      p_bucket_name    =>  'mys3bucket',
      p_prefix         =>  'db',
      p_s3_prefix      =>  '',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The following example uploads all of the files in the *DATA_PUMP_DIR* directory to the Amazon S3 bucket named *mys3bucket*. The files are uploaded to a `dbfiles` folder.

```
SELECT rdsadmin.rdsadmin_s3_tasks.upload_to_s3(
      p_bucket_name    =>  'mys3bucket',
      p_prefix         =>  '',
      p_s3_prefix      =>  'dbfiles/',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The following example uploads all of the files in the *DATA_PUMP_DIR* directory to the Amazon S3 bucket named *mys3bucket*. The files are uploaded to a `dbfiles` folder and `ora` is added to the beginning of each file name.

```
SELECT rdsadmin.rdsadmin_s3_tasks.upload_to_s3(
      p_bucket_name    =>  'mys3bucket',
      p_prefix         =>  '',
      p_s3_prefix      =>  'dbfiles/ora',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

In each example, the `SELECT` statement returns the ID of the task in a `VARCHAR2` data type.

You can view the result by displaying the task's output file.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-task-
id.log'));
```

Replace *task-id* with the task ID returned by the procedure.

> **Note**
> Tasks are executed asynchronously.

Downloading Files from an Amazon S3 Bucket to an Oracle DB Instance

To download files from an Amazon S3 bucket to an Oracle DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_s3_tasks.download_from_s3`. The `rdsadmin.rdsadmin_s3_tasks.download_from_s3` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_bucket_name`	VARCHAR2	–	required	The name of the Amazon S3 bucket to download files from.
`p_directory_name`	VARCHAR2	–	required	The name of the Oracle directory object to download files to. The directory can be any user-created directory object or the Data Pump directory, such as `DATA_PUMP_DIR`.

Parameter Name	Data Type	Default	Required	Description
`p_s3_prefix`	VARCHAR2	''	optional	A file name prefix that file names must match to be downloaded. An empty prefix downloads all of the top level files in the specified Amazon S3 bucket, but not the files in folders in the bucket. The procedure downloads Amazon S3 objects only from the first level folder that matches the prefix. Nested directory structures matching the specified prefix are not downloaded. For example, suppose that an Amazon S3 bucket has the folder structure `folder_1/folder_2/folder_3`. Suppose also that you specify the `'folder_1/folder_2/'` prefix. In this case, only the files in `folder_2` are downloaded, not the files in `folder_1` or `folder_3`. If, instead, you specify the `'folder_1/folder_2'` prefix, all files in `folder_1` that match the `'folder_2'` prefix are downloaded, and no files in `folder_2` are downloaded.

The return value for the `rdsadmin.rdsadmin_s3_tasks.download_from_s3` procedure is a task ID.

The following example downloads all of the files in the Amazon S3 bucket named *`mys3bucket`* to the *`DATA_PUMP_DIR`* directory.

```
SELECT rdsadmin.rdsadmin_s3_tasks.download_from_s3(
      p_bucket_name    =>  'mys3bucket',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The following example downloads all of the files with the prefix *`db`* in the Amazon S3 bucket named *`mys3bucket`* to the *`DATA_PUMP_DIR`* directory.

```
SELECT rdsadmin.rdsadmin_s3_tasks.download_from_s3(
      p_bucket_name    =>  'mys3bucket',
```

```
      p_s3_prefix      =>  'db',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

The following example downloads all of the files in the folder *myfolder/* in the Amazon S3 bucket named *mys3bucket* to the *DATA_PUMP_DIR* directory. Use the prefix parameter setting to specify the Amazon S3 folder.

```
SELECT rdsadmin.rdsadmin_s3_tasks.download_from_s3(
      p_bucket_name    =>  'mys3bucket',
      p_s3_prefix      =>  'myfolder/',
      p_directory_name =>  'DATA_PUMP_DIR')
   AS TASK_ID FROM DUAL;
```

In each example, the `SELECT` statement returns the ID of the task in a `VARCHAR2` data type.

You can view the result by displaying the task's output file.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-task-
id.log'));
```

Replace *task-id* with the task ID returned by the procedure.

> **Note**
> Tasks are executed asynchronously.
> You can use the `UTL_FILE.FREMOVE` Oracle procedure to remove files from a directory. For more information, see FREMOVE Procedure in the Oracle documentation.

Monitoring the Status of a File Transfer

File transfer tasks publish Amazon RDS events when they start and when they complete. For information about viewing events, see Viewing Amazon RDS Events (p. 448).

You can view the status of an ongoing task in a bdump file. The bdump files are located in the `/rdsdbdata/log/trace` directory. Each bdump file name is in the following format.

```
dbtask-task-id.log
```

Replace *task-id* with the ID of the task that you want to monitor.

> **Note**
> Tasks are executed asynchronously.

You can use the `rdsadmin.rds_file_util.read_text_file` stored procedure to view the contents of bdump files. For example, the following query returns the contents of the *dbtask-1546988886389-2444.log* bdump file.

```
SELECT text FROM
 table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-1546988886389-2444.log'));
```

Removing the Amazon S3 Integration Option

You can remove Amazon S3 integration option from a DB instance.

To remove the Amazon S3 integration option from a DB instance, do one of the following:

- To remove the Amazon S3 integration option from multiple DB instances, remove the `S3_INTEGRATION` option from the option group to which the DB instances belong. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- To remove the Amazon S3 integration option from a single DB instance, modify the DB instance and specify a different option group that doesn't include the `S3_INTEGRATION` option. You can specify the default (empty) option group or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Application Express

Amazon RDS supports Oracle Application Express (APEX) through the use of the `APEX` and `APEX-DEV` options. Oracle APEX can be deployed as a run-time environment or as a full development environment for web-based applications. Using Oracle APEX, developers can build applications entirely within the web browser. For more information, see Oracle Application Express in the Oracle documentation.

Oracle APEX consists of two main components:

- A *repository* that stores the metadata for APEX applications and components. The repository consists of tables, indexes, and other objects that are installed in your Amazon RDS DB instance.
- A *listener* that manages HTTP communications with Oracle APEX clients. The listener accepts incoming connections from web browsers, forwards them to the Amazon RDS DB instance for processing, and then sends results from the repository back to the browsers. The APEX Listener was renamed Oracle Rest Data Services (ORDS) in Oracle 12c.

When you add the Amazon RDS APEX options to your DB instance, Amazon RDS installs the Oracle APEX repository only. Install the Oracle APEX Listener on a separate host, such as an Amazon EC2 instance, an on-premises server at your company, or your desktop computer.

The APEX option uses storage on the DB instance class for your DB instance. Following are the supported versions and approximate storage requirements for Oracle APEX.

APEX Version	Storage Requirements	Oracle 19c	Oracle 18c	Oracle 12c version 12.2	Oracle 12c version 12.1	Oracle 11g
Oracle APEX version 19.2.v1	149 MiB	Supported	Supported	Supported	Supported	Supported
Oracle APEX version 19.1.v1	148 MiB	Supported	Supported	Supported	Supported	Supported
Oracle APEX version 18.2.v1	146 MiB	Not supported	Supported	Supported	Supported	Supported
Oracle APEX version 18.1.v1	145 MiB	Not supported	Supported	Supported	Supported	Supported
Oracle APEX version 5.1.4.v1	220 MiB	Not supported	Supported	Supported	Supported	Supported
Oracle APEX version 5.1.2.v1	150 MiB	Not supported	Not supported	Not supported	Supported	Supported
Oracle APEX version 5.0.4.v1	140 MiB	Not supported	Not supported	Not supported	Supported	Supported
Oracle APEX version 4.2.6.v1	160 MiB	Not supported	Not supported	Not supported	Supported	Supported

APEX Version	Storage Requirements	Oracle 19c	Oracle 18c	Oracle 12c version 12.2	Oracle 12c version 12.1	Oracle 11g
Oracle APEX version 4.1.1.v1	130 MiB	Not supported	Not supported	Not supported	Not supported	Supported

Note
Oracle APEX 5 for Oracle 11g isn't supported when the DB instance class used by the DB instance has only one vCPU. For information about DB instance classes, see DB Instance Classes (p. 7).

Prerequisites for Oracle APEX and APEX Listener

The following are prerequisites for using Oracle APEX and APEX Listener:

- Have SQL*Plus on your DB instance to perform administrative tasks.
- Have the following software installed on the host computer that acts as the Oracle APEX Listener:
  - The Java Runtime Environment (JRE).
  - Oracle Net Services, to enable the Oracle APEX Listener to connect to your Amazon RDS instance.

Adding the Amazon RDS APEX Options

The general process for adding the Amazon RDS APEX options to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the options to the option group.
3. Associate the option group with the DB instance.

When you add the Amazon RDS APEX options, a brief outage occurs while your DB instance is automatically restarted.

To add the APEX options to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose the Oracle edition that you want to use. The APEX options are supported on all editions.

   b. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).

2. Add the options to the option group. If you want to deploy only the Oracle APEX run-time environment, add only the `APEX` option. If you want to deploy the full development environment, add both the `APEX` and `APEX-DEV` options.

   - For Oracle 12c, add the **APEX** and **APEX-DEV** options.
   - For Oracle 11g, first add the **XMLDB** option as a prerequisite, then add the **APEX** and **APEX-DEV** options.

For **Version**, choose the version of APEX that you want to use. If you don't choose a version, version 4.1.1.v1 is the default for 11g, and version 4.2.6.v1 is the default for 12c.

Important
If you add the APEX options to an existing option group that is already attached to one or more DB instances, a brief outage occurs. During this outage, all the DB instances are automatically restarted.

For more information about adding options, see Adding an Option to an Option Group (p. 190).

3. Apply the option group to a new or existing DB instance:
   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. When you add the APEX options to an existing DB instance, a brief outage occurs while your DB instance is automatically restarted. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Unlocking the Public User Account

After the Amazon RDS APEX options are installed, you must change the password for the APEX public user account, and then unlock the account. You can do this by using the Oracle SQL*Plus command line utility. Connect to your DB instance as the master user, and issue the following commands. Replace `new_password` with a password of your choice.

```
alter user APEX_PUBLIC_USER identified by new_password;
alter user APEX_PUBLIC_USER account unlock;
```

Configuring RESTful Services for Oracle APEX

To configure RESTful services in APEX (not needed for APEX 4.1.1.V1), use SQL*Plus to connect to your DB instance as the master user. After you do this, run the `rdsadmin.rdsadmin_run_apex_rest_config` stored procedure. When you run the stored procedure, you provide passwords for the following users:

- `APEX_LISTENER`
- `APEX_REST_PUBLIC_USER`

The stored procedure runs the `apex_rest_config.sql` script, which creates new database accounts for these users.

Note
Configuration isn't required for Oracle APEX version 4.1.1.v1. For this Oracle APEX version only, you don't need to run the stored procedure.

The following command runs the stored procedure.

```
exec rdsadmin.rdsadmin_run_apex_rest_config('apex_listener_password',
 'apex_rest_public_user_password');
```

Installing and Configuring a Listener for Use with Oracle APEX

You are now ready to install and configure a listener for use with Oracle APEX. You can use one of these products for this purpose:

- For APEX version 5.0 and later, use Oracle Rest Data Services (ORDS) version 19.1 and higher.
- For APEX version 4.1.1, use Oracle APEX Listener version 1.1.4.
- Oracle HTTP Server and `mod_plsql`.

For more information about these listener types, see About Choosing a Web Listener in the Oracle documentation.

> **Note**
> Amazon RDS doesn't support the Oracle XML DB HTTP server with the embedded PL/SQL gateway; you can't use this as a listener for APEX. In general, Oracle recommends against using the embedded PL/SQL gateway for applications that run on the internet.

Install the listener on a separate host such as an Amazon EC2 instance, an on-premises server at your company, or your desktop computer.

The following procedures show you how to install and configure either ORDS or the APEX Listener. We assume that the name of your host is `myapexhost.example.com`, and that your host is running Linux.

To set up for listener installation

1. Log in to `myapexhost.example.com` as `root`.
2. Create a nonprivileged OS user to own the listener installation. The following command creates a new user named *apexuser*.

```
useradd -d /home/apexuser apexuser
```

   The following command assigns a password to the new user.

```
passwd apexuser;
```

3. Log in to `myapexhost.example.com` as `apexuser`, and download the APEX installation file from Oracle to your `/home/apexuser` directory:
   - http://www.oracle.com/technetwork/developer-tools/apex/downloads/index.html
   - Oracle Application Express Prior Release Archives
4. Unzip the file in the `/home/apexuser` directory.

```
unzip apex_<version>.zip
```

   After you unzip the file, there is an `apex` directory in the `/home/apexuser` directory.
5. While you are still logged into `myapexhost.example.com` as `apexuser`, download the APEX Listener file from Oracle to your `/home/apexuser` directory: http://www.oracle.com/technetwork/developer-tools/apex-listener/downloads/index.html

While you are still in the directory from the previous procedure, install and run the listener program that you chose, as described in one of the procedures following:

- To install and configure ORDS for use with Oracle APEX (p. 931)

- To install APEX Listener for use with Oracle APEX (p. 933)

To install and configure ORDS for use with Oracle APEX

1. Create a new directory based on ORDS and open the listener file.

   Run the following code:

```
mkdir /home/apexuser/ORDS
cd /home/apexuser/ORDS
unzip ../ords.<version>.zip
```

2. Download the file ords.*version.number*.zip from Oracle REST Data Services.
3. Unzip the file in the `/home/apexuser/ORDS` directory.
4. Grant the master user the required privileges to install ORDS.

   After the Amazon RDS APEX option is installed, give the master user the required privileges to install the ORDS schema. You can do this by connecting to the database and running the following commands. Replace *master_user* with the name of your master user.

```
exec rdsadmin.rdsadmin_util.grant_sys_object('DBA_OBJECTS', 'master_user', 'SELECT',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('DBA_ROLE_PRIVS', 'master_user', 'SELECT',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('DBA_TAB_COLUMNS', 'master_user',
 'SELECT', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_CONS_COLUMNS', 'master_user',
 'SELECT', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_CONSTRAINTS', 'master_user',
 'SELECT', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_OBJECTS', 'master_user', 'SELECT',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_PROCEDURES', 'master_user',
 'SELECT', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_TAB_COLUMNS', 'master_user',
 'SELECT', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_TABLES', 'master_user', 'SELECT',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('USER_VIEWS', 'master_user', 'SELECT',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('WPIUTL', 'master_user', 'EXECUTE', true);
exec rdsadmin.rdsadmin_util.grant_sys_object('DBMS_SESSION', 'master_user', 'EXECUTE',
 true);
exec rdsadmin.rdsadmin_util.grant_sys_object('DBMS_UTILITY', 'master_user', 'EXECUTE',
 true);
```

   Note
   These commands apply to ORDS version 19.1 and 19.2.

5. Install the ORDS schema using the downloaded ords.war file.

```
java -jar ords.war setup
```

   The program prompts you for the following information. The default values are in brackets.

   - The location to store configuration data

     Enter `/home/apexuser/ORDS`.

- The name of the database server [localhost]: *DB_instance_endpoint*

  Choose the default or enter the correct value.
- The database listen port [1521]: *DB_instance_port*

  Choose the default or enter the correct value.
- Database service name or database SID [1]

  Choose `1` to specify the database service name, or choose `2` to specify the database SID.
- Database SID [xe]

  Choose the default or enter the correct value.
- Verify or install Oracle REST Data Services schema or skip this step [1]

  Choose `1`.
- Enter the database password for ORDS_PUBLIC_USER, and then confirm the password.
- Log in with administrator privileges to verify the Oracle REST Data Services schema.

  Enter the administrator user name: *master_user*

  Enter the database password for *master_user*: *master_user_password*

  Confirm the password: *master_user_password*
- Enter the default tablespace for ORDS_METADATA [SYSAUX].

  Enter the temporary tablespace for ORDS_METADATA [TEMP].

  Enter the default tablespace for ORDS_PUBLIC_USER [USERS].

  Enter the temporary tablespace for ORDS_PUBLIC_USER [TEMP].
- Enter 1 if you want to use PL/SQL Gateway or 2 to skip this step.

  If you're using Oracle Application Express or migrating from mod_plsql, you must enter 1 [1].

  Choose the default.
- PL/SQL Gateway database user name [APEX_PUBLIC_USER]

  Choose the default.
- Database password for APEX_PUBLIC_USER

  Enter the password.
- Specify passwords for Application Express RESTful Services database users (APEX_LISTENER, APEX_REST_PUBLIC_USER) or skip this step [1]

  Choose `2` for APEX 4.1.1.V1; choose `1` for all other APEX versions.
- [Not needed for APEX 4.1.1.v1] Database password for APEX_LISTENER

  Enter the password (if required).
- [Not needed for APEX 4.1.1.v1] Database password for APEX_REST_PUBLIC_USER

  Enter the password (if required).

After you install ORDS, configure it by following the instructions in To configure your listener (p. 933).

To install APEX Listener for use with Oracle APEX

1. Create a new directory based on the Apex Listener and open the listener file.

   Run the following code:

```
language="bash">mkdir /home/apexuser/apexlistener
cd /home/apexuser/apexlistener
unzip ../apex_listener.<version>.zip
```

2. Run the following code.

```
java -Dapex.home=./apex -Dapex.images=/home/apexuser/apex/images -Dapex.erase -jar ./
apex.war
```

3. Enter information for the program prompts following:

   - The APEX Listener Administrator user name. The default is *adminlistener*.
   - A password for the APEX Listener Administrator.
   - The APEX Listener Manager user name. The default is *managerlistener*.
   - A password for the APEX Listener Administrator.

   The program prints a URL that you need to complete the configuration, as follows.

```
INFO: Please complete configuration at: http://localhost:8080/apex/listenerConfigure
Database is not yet configured
```

4. Leave the APEX Listener running so that you can use Oracle Application Express. When you have finished this configuration procedure, you can run the listener in the background.
5. From your web browser, go to the URL provided by the APEX Listener program. The Oracle Application Express Listener administration window appears. Enter the following information:

   - **Username** – `APEX_PUBLIC_USER`
   - **Password** – the password for *APEX_PUBLIC_USER*. This password is the one that you specified earlier when you configured the APEX repository. For more information, see Unlocking the Public User Account (p. 929).
   - **Connection Type** – Basic
   - **Hostname** – the endpoint of your Amazon RDS DB instance, such as `mydb.f9rbfa893tft.us-east-1.rds.amazonaws.com`.
   - **Port** – 1521
   - **SID** – the name of the database on your Amazon RDS DB instance, such as `mydb`.
6. Choose **Apply**. The APEX administration window appears.

After you install the APEX Listener, configure it as described following.

To configure your listener

1. Set a password for the APEX `admin` user. To do this, use SQL*Plus to connect to your DB instance as the master user, and then run the following commands.

```
EXEC rdsadmin.rdsadmin_util.grant_apex_admin_role;
grant APEX_ADMINISTRATOR_ROLE to master;
@/home/apexuser/apex/apxchpwd.sql
```

Replace *master* with your master user name. When the `apxchpwd.sql` script prompts you, enter a new `admin` password.

2. For ORDS, start the APEX Listener. Run the following code.

```
java -jar ords.war
```

The first time you start the APEX Listener, you are prompted to provide the location of the APEX Static resources. This images folder is located in the `/apex/images` directory in the installation directory for APEX.

3. Return to the APEX administration window in your browser and choose **Administration**. Next, choose **Application Express Internal Administration**. When you are prompted for credentials, enter the following information:

   - **User name** – `admin`
   - **Password** – the password you set using the `apxchpwd.sql` script

   Choose **Login**, and then set a new password for the `admin` user.

Your listener is now ready for use.

Upgrading the APEX Version

Important
Back up your DB instance before you upgrade APEX. For more information, see Creating a DB Snapshot (p. 301) and Testing an Upgrade (p. 891).

To upgrade APEX with your DB instance, do the following:

- Create a new option group for the upgraded version of your DB instance.
- Add the upgraded versions of APEX and APEX-DEV to the new option group. Be sure to include any other options that your DB instance uses. For more information, see Option Group Considerations (p. 891).
- When you upgrade your DB instance, specify the new option group for your upgraded DB instance.

After you upgrade your version of APEX, the APEX schema for the previous version might still exist in your database. If you don't need it anymore, you can drop the old APEX schema from your database after you upgrade.

If you upgrade the APEX version and RESTful services were not configured in the previous APEX version, we recommend that you configure RESTful services. For more information, see Configuring RESTful Services for Oracle APEX (p. 929).

In some cases when you plan to do a major version upgrade of your DB instance, you might find that you're using an APEX version that isn't compatible with your target database version. In these cases, you can upgrade your version of APEX before you upgrade your DB instance. Upgrading APEX first can reduce the amount of time that it takes to upgrade your DB instance.

Note
After upgrading APEX, install and configure a listener for use with the upgraded version. For instructions, see Installing and Configuring a Listener for Use with Oracle APEX (p. 930).

Removing the APEX Option

You can remove the Amazon RDS APEX options from a DB instance. To remove the APEX options from a DB instance, do one of the following:

- To remove the APEX options from multiple DB instances, remove the APEX options from the option group they belong to. This change affects all DB instances that use the option group. When you remove the APEX options from an option group that is attached to multiple DB instances, a brief outage occurs while all the DB instances are restarted.

  For more information, see Removing an Option from an Option Group (p. 198).
- To remove the APEX options from a single DB instance, modify the DB instance and specify a different option group that doesn't include the APEX options. You can specify the default (empty) option group, or a different custom option group. When you remove the APEX options, a brief outage occurs while your DB instance is automatically restarted.

  For more information, see Modifying an Amazon RDS DB Instance (p. 220).

When you remove the APEX options from a DB instance, the APEX schema is removed from your database.

Oracle Enterprise Manager

Amazon RDS supports Oracle Enterprise Manager (OEM). OEM is the Oracle product line for integrated management of enterprise information technology.

Amazon RDS supports OEM through the following options.

Option	Option ID	Support For
OEM Database (p. 936)	`OEM`	OEM Database Express 12c OEM 11g Database Control
OEM Management Agent (p. 941)	`OEM_AGENT`	OEM Cloud Control for 13c OEM Cloud Control for 12c

> **Note**
> You can use OEM Database or OEM Management Agent, but not both.

Oracle Enterprise Manager Database Express

Amazon RDS supports Oracle Enterprise Manager (OEM) Database Express through the use of the OEM option. Amazon RDS supports the following versions of OEM database:

- Oracle Enterprise Manager Database Express for Oracle 19c, Oracle 18c, and Oracle 12c
- Oracle Enterprise Manager 11g Database Control for Oracle 11g

OEM Database Express and Database Control are similar tools that have a web-based interface for Oracle database administration. For more information about these tools, see Accessing Enterprise Manager Database Express 18c, Accessing Enterprise Manager Database Express 12c, and Accessing Enterprise Manager 11g Database Control in the Oracle documentation.

The following are some limitations to using OEM Database:

- OEM Database is not supported on the db.t3.micro or db.t3.small DB instance classes.

  For more information about DB instance classes, see DB Instance Class Support for Oracle (p. 850).
- OEM 11g Database Control is not compatible with the following time zones: America/Argentina/Buenos_Aires, America/Matamoros, America/Monterrey, America/Toronto, Asia/Ashgabat, Asia/Dhaka, Asia/Kathmandu, Asia/Kolkata, Asia/Ulaanbaatar, Atlantic/Cape_Verde, Australia/Eucla, Pacific/Kiritimati.

  For more information about time zone support, see Oracle Time Zone (p. 987).

OEM Database Option Settings

Amazon RDS supports the following settings for the OEM option.

Option Setting	Valid Values	Description
Port	An integer value	The port on the DB instance that listens for OEM Database. The default for OEM Database Express is 5500. The default for OEM 11g Database Control is 1158. For OEM 11g Database Control, set the port to 1158 or to a value in the 5500 to 5519 range.
Security Groups	—	A security group that has access to **Port**.

Adding the OEM Database Option

The general process for adding the OEM option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

When you add the OEM option for an Oracle 11g DB instance, no outage occurs, so you don't need to restart your DB instance. However, when you add the OEM option for an Oracle 12c, Oracle 18c, or Oracle 19c DB instance, a brief outage occurs while your DB instance is automatically restarted.

To add the OEM option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine** choose the oracle edition for your DB instance.
   b. For **Major engine version** choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the OEM option to the option group, and configure the option settings. For more information about adding options, see Adding an Option to an Option Group (p. 190). For more information about each setting, see OEM Database Option Settings (p. 936).

   Note
   If you add the OEM option to an existing option group that is already attached to one or more Oracle 19c, Oracle 18c, or Oracle 12c DB instances, a brief outage occurs while all the DB instances are automatically restarted.
3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. When you add the OEM option for an Oracle 19c, Oracle 18c, or Oracle 12c DB instance, a brief outage occurs while your DB instance is automatically restarted. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Note
You can also use the AWS CLI to add the OEM option. For examples, see Adding an Option to an Option Group (p. 190).

Using OEM Database

After you enable the OEM option, you can begin using the OEM Database tool from your web browser.

You can access either OEM Database Control or OEM Database Express from your web browser. For example, if the endpoint for your Amazon RDS DB instance is `mydb.f9rbfa893tft.us-east-1.rds.amazonaws.com`, and your OEM port is 1158, then the URL to access the OEM Database Control the following.

```
https://mydb.f9rbfa893tft.us-east-1.rds.amazonaws.com:1158/em
```

When you access either tool from your web browser, a login window appears that prompts you for a user name and password. Type the master user name and master password for your DB instance. You are now ready to manage your Oracle databases.

Modifying OEM Database Settings

After you enable OEM Database, you can modify the Security Groups setting for the option.

You can't modify the OEM port number after you have associated the option group with a DB instance. To change the OEM port number for a DB instance, do the following:

1. Create a new option group.
2. Add the OEM option with the new port number to the new option group.
3. Remove the existing option group from the DB instance.
4. Add the new option group to the DB instance.

For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see OEM Database Option Settings (p. 936).

Performing Database Tasks with OEM Database

You can use Amazon RDS procedures to run certain OEM Database Express tasks. By running these procedures, you can do the tasks listed following.

> **Note**
> OEM Database Express tasks run asynchronously.

Tasks

Switching the Website Front End for OEM Database Express to Adobe Flash

> **Note**
> This task is only available on Oracle DB instances running version 19c or later.

Starting with Oracle 19c, Oracle has deprecated the former OEM Database Express user interface, which was based on Adobe Flash. Instead, OEM Database Express now uses an interface built with Oracle JET. If you experience difficulties with the new interface, you can switch back to the deprecated Flash-based interface. Difficulties you might experience with the new interface include being stuck on a `Loading` screen after logging in to OEM Database Express. You might also miss certain features that were present in the Flash-based version of OEM Database Express.

To switch the OEM Database Express website front end to Adobe Flash, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_flash`. This procedure is equivalent to the `execemx emx` SQL command.

Security best practices discourage the use of Adobe Flash. Although you can revert to the Flash-based OEM Database Express, we recommend the use of the JET-based OEM Database Express websites if possible. If you revert to using Adobe Flash and want to switch back to using Oracle JET, use the `rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_jet` procedure. After an Oracle database upgrade, a newer version of Oracle JET might resolve JET-related issues in OEM Database Express. For more information about switching to Oracle JET, see Switching the Website Front End for OEM Database Express to Oracle JET (p. 939).

> **Note**
> Running this task from the source DB instance for a read replica also causes the read replica to switch its OEM Database Express website front ends to Adobe Flash.

The following procedure invocation creates a task to switch the OEM Database Express website to Adobe Flash and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_flash() as TASK_ID from DUAL;
```

You can view the result by displaying the task's output file.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-task-id.log'));
```

Replace *task-id* with the task ID returned by the procedure. For more information about the Amazon RDS procedure `rdsadmin.rds_file_util.read_text_file`, see Reading Files in a DB Instance Directory (p. 1052)

You can also view the contents of the task's output file in the AWS Management Console by searching the log entries in the **Logs & events** section for the `task-id`.

Switching the Website Front End for OEM Database Express to Oracle JET

> **Note**
> This task is only available on Oracle DB instances running version 19c or later.

To switch the OEM Database Express website front end to Oracle JET, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_jet`. This procedure is equivalent to the `execemx omx` SQL command.

By default, the OEM Database Express websites for Oracle DB instances running 19c or later use Oracle JET. If you used the `rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_flash` procedure to switch the OEM Database Express website front end to Adobe Flash, you can switch back to Oracle JET. To do this, use the `rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_jet` procedure. For more information about switching to Adobe Flash, see Switching the Website Front End for OEM Database Express to Adobe Flash (p. 938).

> **Note**
> Running this task from the source DB instance for a read replica also causes the read replica to switch its OEM Database Express website front ends to Oracle JET.

The following procedure invocation creates a task to switch the OEM Database Express website to Oracle JET and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_tasks.em_express_frontend_to_jet() as TASK_ID from DUAL;
```

You can view the result by displaying the task's output file.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-task-id.log'));
```

Replace *task-id* with the task ID returned by the procedure. For more information about the Amazon RDS procedure `rdsadmin.rds_file_util.read_text_file`, see Reading Files in a DB Instance Directory (p. 1052)

You can also view the contents of the task's output file in the AWS Management Console by searching the log entries in the **Logs & events** section for the `task-id`.

Removing the OEM Database Option

You can remove the OEM option from a DB instance. When you remove the OEM option for an Oracle 19c, Oracle 18c, or Oracle 12c DB instance, a brief outage occurs while your DB instance is automatically restarted. So, after you remove the OEM option, you don't need to restart your DB instance. When you remove the OEM option for an Oracle 11g DB instance, there is not outage, and you don't need to restart your DB instance.

To remove the OEM option from a DB instance, do one of the following:

- Remove the OEM option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the OEM option. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Management Agent for Enterprise Manager Cloud Control

Amazon RDS supports Oracle Enterprise Manager (OEM) Management Agent through the use of the `OEM_AGENT` option. Amazon RDS supports Management Agent for the following versions of OEM:

- Oracle Enterprise Manager Cloud Control for 13c
- Oracle Enterprise Manager Cloud Control for 12c

Management Agent is a software component that monitors targets running on hosts and communicates that information to the middle-tier Oracle Management Service (OMS). For more information, see Overview of Oracle Enterprise Manager Cloud Control 12c and Overview of Oracle Enterprise Manager Cloud Control 13c in the Oracle documentation.

Following are the supported Oracle versions for each Management Agent version.

Management Agent Version	Oracle 19c	Oracle 18c	Oracle 12c version 12.2	Oracle 12c version 12.1	Oracle 11g
13.3.0.0.v2	Supported	Supported	Supported	Supported	Supported
13.3.0.0.v1	Supported	Supported	Supported	Supported	Supported
13.2.0.0.v3	Supported	Supported	Supported	Supported	Supported
13.2.0.0.v2	Supported	Supported	Supported	Supported	Supported
13.2.0.0.v1	Supported	Supported	Supported	Supported	Supported
13.1.0.0.v1	Supported	Supported	Supported	Supported	Supported
12.1.0.5.v1	Not supported	Supported	Supported	Supported	Supported
12.1.0.4.v1	Not supported	Supported	Supported	Supported	Supported

The following are some limitations to using Management Agent:

- Administrative tasks such as job execution and database patching, that require host credentials, are not supported.
- Host metrics and the process list are not guaranteed to reflect the actual system state.
- Autodiscovery is not supported. You must manually add database targets.
- OMS module availability depends on your database edition. For example, the database performance diagnosis and tuning module is only available for Oracle Database Enterprise Edition.
- Management Agent consumes additional memory and computing resources. If you experience performance problems after enabling the `OEM_AGENT` option, we recommend that you scale up to a larger DB instance class. For more information, see DB Instance Classes (p. 7) and Modifying an Amazon RDS DB Instance (p. 220).
- Because operating system access on the alert log isn't granted to the user running the `OEM_AGENT` on the Amazon RDS host, it isn't possible to collect metrics for `DB Alert Log` and `DB Alert Log Error Status` in OEM.

Prerequisites for Management Agent

The following are prerequisites for using Management Agent:

- An Amazon RDS DB instance running Oracle version 19.0.0.0, 18.0.0.0, 12.2.0.1, 12.1.0.2, or 11.2.0.4.
- At least 8.5 GiB of storage space for OEM 13c Release 3.
- At least 5.5 GiB of storage space for OEM 13c Release 2.
- At least 4.5 GiB of storage space for OEM 13c Release 1.
- At least 2.5 GiB of storage space for OEM 12c.
- For Oracle version 19.0.0.0, the minimum `AGENT_VERSION` is 13.1.0.0.v1.
- An Oracle Management Service (OMS), configured to connect to your Amazon RDS DB instance.

  For an Amazon RDS DB instance running Oracle version 18.0.0.0 or higher, meet the following requirements:
  - For OMS 13c2, apply the Enterprise Manager 13.2 Master Bundle Patch List, which includes plugins 13.2.1, 13.2.2, 13.2.3, 13.2.4 (Oracle Doc ID 2219797.1).
  - For OMS 13c2, apply the OMS PSU System Patch 28970534.
  - For OMS 13c2, apply the OMS-Side Plugin System 13.2.2.0.190131 Patch 29201709.

  For an Amazon RDS DB instance running Oracle version 12.2.0.1 or lower, meet the following requirements:
  - For OMS 13c Release 2 with Oracle patch 25163555 applied, use OEM Agent 13.2.0.0.v2 or later.

    Use OMSPatcher to apply the patch.
  - For unpatched OMS 13c Release 2, use OEM Agent 13.2.0.0.v1.

  Use OMSPatcher to apply patches.
- In most cases, you need to configure your VPC to allow connections from OMS to your DB instance. If you are not familiar with Amazon Virtual Private Cloud (Amazon VPC), we recommend that you complete the steps in Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449) before continuing.
- If you are using Management Agent versions `OEM_AGENT 13.2.0.0.v3` and `13.3.0.0.v2`, and you want to use TCPS connectivity, follow the instructions in Configuring Third Party CA Certificates for Communication With Target Databases in the Oracle documentation. Also, update the JDK on your OMS by following the instructions in the Oracle document with the Oracle Doc ID 2241358.1. Doing so ensures that OMS supports all the cipher suites that the database supports.

  Note
  TCPS connectivity between the Management Agent and the DB instance is only supported for Management Agent versions `OEM_AGENT 13.2.0.0.v3` and `13.3.0.0.v2`.

Additional configuration is required to allow your OMS host and your Amazon RDS DB instance to communicate. You must also do the following:

- To connect from the Management Agent to your OMS, if your OMS is behind a firewall, you must add the IP addresses of your DB instances to your OMS.

  Make sure the firewall for the OMS allows traffic from both the DB listener port (default 1521) and the OEM Agent port (default 3872), originating from the IP address of the DB instance.
- To connect from your OMS to the Management Agent, if your OMS has a publicly resolvable host name, you must add the OMS address to a security group. Your security group must have inbound rules that allow access to the DB listener port and the Management Agent port. For an example of creating a security and adding inbound rules, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).
- To connect from your OMS to the Management Agent, if your OMS doesn't have a publicly resolvable host name, use one of the following:

- If your OMS is hosted on an Amazon Elastic Compute Cloud (Amazon EC2) instance in a private VPC, you can set up VPC peering to connect from OMS to Management Agent. For more information, see A DB Instance in a VPC Accessed by an EC2 Instance in a Different VPC (p. 1437).
- If your OMS is hosted on-premises, you can set up a VPN connection to allow access from OMS to Management Agent. For more information, see A DB Instance in a VPC Accessed by a Client Application Through the Internet (p. 1438) or VPN Connections.

Option Settings for Management Agent

Amazon RDS supports the following settings for the Management Agent option.

Option Setting	Required	Valid Values	Description

Version (`AGENT_VERSION`)	Yes	`13.3.0.0.v2`
		`13.3.0.0.v1`
		`13.2.0.0.v3`
		`13.2.0.0.v2`
		`13.2.0.0.v1`
		`13.1.0.0.v1`
		`12.1.0.5.v1`
		`12.1.0.4.v1`
			The version of the Management Agent software.
			The AWS CLI option name is `OptionVersion`.
			Note
			In the AWS GovCloud (US-West) Region, 12.1 and 13.1 versions aren't available.

Port (`AGENT_PORT`)	Yes	An integer value	The port on the DB instance that listens for the OMS host. The default is 3872. Your OMS host must belong to a security group that has access to this port. The AWS CLI option name is `Port`.
Security Groups	Yes	Existing security groups	A security group that has access to **Port**. Your OMS host must belong to this security group. The AWS CLI option name is `VpcSecurityGroupMemberships` or `DBSecurityGroupMemberships`.
OMS_HOST	Yes	A string value, for example *`my.example.oms`*	The publicly accessible host name or IP address of the OMS. The AWS CLI option name is `OMS_HOST`.
OMS_PORT	Yes	An integer value	The HTTPS upload port on the OMS Host that listens for the Management Agent. To determine the HTTPS upload port, connect to the OMS host, and run the following command (which requires the `SYSMAN` password): `emctl status oms -details` The AWS CLI option name is `OMS_PORT`.

Option Setting	Required	Valid Values	Description
AGENT_REGISTRATION_PASSWORD	Yes	A string value	The password that the Management Agent uses to authenticate itself with the OMS. We recommend that you create a persistent password in your OMS before enabling the OEM_AGENT option. With a persistent password you can share a single Management Agent option group among multiple Amazon RDS databases. The AWS CLI option name is AGENT_REGISTRATION_PASSWORD.
ALLOW_TLS_ONLY	No	true, false (default)	A value that configures the OEM Agent to support only the TLSv1 protocol while the agent listens as a server. This setting is only supported for 12.1 agent versions. Later agent versions only support Transport Layer Security (TLS) by default.
MINIMUM_TLS_VERSION	No	TLSv1 (default), TLSv1.2	A value that specifies the minimum TLS version supported by the OEM Agent while the agent listens as a server. This setting is only supported for agent versions 13.1.0.0.v1 and higher. Earlier agent versions only support the TLSv1 setting.
TLS_CIPHER_SUITE	No	TLS_RSA_WITH_AES_128_CBC_SHA (Default supported by all agent versions) TLS_RSA_WITH_AES_128_CBC_SHA256 (Requires version 13.1.0.0.v1 or above) TLS_RSA_WITH_AES_256_CBC_SHA (Requires version 13.2.0.0.v3 or above) TLS_RSA_WITH_AES_256_CBC_SHA256 (Requires version 13.2.0.0.v3 or above)	A value that specifies the TLS cipher suite used by the OEM Agent while the agent listens as a server.

Adding the Management Agent Option

The general process for adding the Management Agent option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

If you encounter errors, you can check My Oracle Support documents for information about resolving specific problems.

After you add the Management Agent option, you don't need to restart your DB instance. As soon as the option group is active, the OEM Agent is active.

If your OMS host is using an untrusted third-party certificate, Amazon RDS returns the following error.

```
You successfully installed the OEM_AGENT option. Your OMS host is using an untrusted third
 party certificate.
Configure your OMS host with the trusted certificates from your third party.
```

If this error is returned, the Management Agent option isn't enabled until the problem is corrected. For information about correcting the problem, see the My Oracle Support document 2202569.1.

Console

To add the Management Agent option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine** choose the oracle edition for your DB instance.

   b. For **Major engine version** choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **OEM_AGENT** option to the option group, and configure the option settings. For more information about adding options, see Adding an Option to an Option Group (p. 190). For more information about each setting, see Option Settings for Management Agent (p. 943).
3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

AWS CLI

The following example uses the AWS CLI add-option-to-option-group command to add the `OEM_AGENT` option to an option group called `myoptiongroup`.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --option-group-name "myoptiongroup" \
    --options
 OptionName=OEM_AGENT,OptionVersion=13.1.0.0.v1,Port=3872,VpcSecurityGroupMemberships=sg-1234567890,Opt
{Name=OMS_PORT,Value=4903},{Name=AGENT_REGISTRATION_PASSWORD,Value=password}] \
    --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
    --option-group-name "myoptiongroup" ^
    --options
 OptionName=OEM_AGENT,OptionVersion=13.1.0.0.v1,Port=3872,VpcSecurityGroupMemberships=sg-1234567890,Opt
{Name=OMS_PORT,Value=4903},{Name=AGENT_REGISTRATION_PASSWORD,Value=password}] ^
    --apply-immediately
```

Using the Management Agent

After you enable the Management Agent option, take the following steps to begin using it.

To use the Management Agent

1. Unlock and reset the DBSNMP account credential. Do this by running the following code on your target database on your DB instance and using your master user account.

```
ALTER USER dbsnmp IDENTIFIED BY new_password ACCOUNT UNLOCK;
```

2. Add your targets to the OMS console manually:

   a. In your OMS console, choose **Setup**, **Add Target**, **Add Targets Manually**.

   b. Choose **Add Targets Declaratively by Specifying Target Monitoring Properties**.

   c. For **Target Type**, choose **Database Instance**.

   d. For **Monitoring Agent**, choose the agent with the identifier that is the same as your RDS DB instance identifier.

   e. Choose **Add Manually**.

   f. Enter the endpoint for the Amazon RDS DB instance, or choose it from the host name list. Make sure that the specified host name matches the endpoint of the Amazon RDS DB instance.

      For information about finding the endpoint for your Amazon RDS DB instance, see Finding the Endpoint of Your DB Instance (p. 874).

   g. Specify the following database properties:

      - For **Target name**, enter a name.
      - For **Database system name**, enter a name.
      - For **Monitor username**, enter **dbsnmp**.
      - For **Monitor password**, enter the password from step 1.
      - For **Role**, enter **normal**.
      - For **Oracle home path**, enter **/oracle**.
      - For **Listener Machine name**, the agent identifier already appears.
      - For **Port**, enter the database port. The RDS default port is 1521.
      - For **Database name**, enter the name of your database.

   h. Choose **Test Connection**.

   i. Choose **Next**. The target database appears in your list of monitored resources.

Modifying Management Agent Settings

After you enable the Management Agent, you can modify settings for the option. For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see Option Settings for Management Agent (p. 943).

Performing Database Tasks with the Management Agent

You can use Amazon RDS procedures to run certain EMCTL commands on the Management Agent. By running these procedures, you can do the tasks listed following.

Note
Tasks are executed asynchronously.

Tasks

Getting the Management Agent's Status

To get the Management Agent's status, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.get_status_oem_agent`. This procedure is equivalent to the `emctl status agent` command.

The following procedure creates a task to get the Management Agent's status and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.get_status_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Restarting the Management Agent

To restart the Management Agent, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.get_status_oem_agent`. This procedure is equivalent to running the `emctl stop agent` and `emctl start agent` commands.

The following procedure creates a task to restart the Management Agent and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.restart_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Listing the Targets Monitored by the Management Agent

To list the targets monitored by the Management Agent, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.list_targets_oem_agent`. This procedure is equivalent to running the `emctl config agent listtargets` command.

The following procedure creates a task to list the targets monitored by the Management Agent and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.list_targets_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Listing the Collection Threads Monitored by the Management Agent

To list of all the running, ready, and scheduled collection threads monitored by the Management Agent, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.list_clxn_threads_oem_agent`. This procedure is equivalent to the `emctl status agent scheduler` command.

The following procedure creates a task to list the collection threads and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.list_clxn_threads_oem_agent() as TASK_ID from
 DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Clearing the Management Agent's State

To clear the Management Agent's state, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.clearstate_oem_agent`. This procedure is equivalent to running the `emctl clearstate agent` command.

The following procedure creates a task that clears the Management Agent's state and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.clearstate_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Having the Management Agent Upload Its OMS

To have the Management Agent upload the Oracle Management Server (OMS) associated with it, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.upload_oem_agent`. This procedure is equivalent to running the `emclt upload agent` command.

The following procedure creates a task that has the Management Agent upload its associated OMS and return the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.upload_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Pinging the OMS

To ping the Management Agent's OMS, run the Amazon RDS procedure `rdsadmin.rdsadmin_oem_agent_tasks.ping_oms_oem_agent`. This procedure is equivalent to running the `emctl pingOMS` command.

The following procedure creates a task that pings the Management Agent's OMS and returns the ID of the task.

```
SELECT rdsadmin.rdsadmin_oem_agent_tasks.ping_oms_oem_agent() as TASK_ID from DUAL;
```

To view the result by displaying the task's output file, see Viewing the Status of an Ongoing Task (p. 949).

Viewing the Status of an Ongoing Task

You can view the status of an ongoing task in a bdump file. The bdump files are located in the `/rdsdbdata/log/trace` directory. Each bdump file name is in the following format.

```
dbtask-task-id.log
```

When you want to monitor a task, replace *`task-id`* with the ID of the task that you want to monitor.

To view the contents of bdump files, run the Amazon RDS procedure `rdsadmin.rds_file_util.read_text_file`. The following query returns the contents of the `dbtask-1546988886389-2444.log` bdump file.

```
SELECT text FROM
 table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-1546988886389-2444.log'));
```

For more information about the Amazon RDS procedure `rdsadmin.rds_file_util.read_text_file`, see Reading Files in a DB Instance Directory (p. 1052).

Removing the Management Agent Option

You can remove the OEM Agent from a DB instance. After you remove the OEM Agent, you don't need to restart your DB instance.

To remove the OEM Agent from a DB instance, do one of the following:

- Remove the OEM Agent option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the OEM Agent option. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Java Virtual Machine

Amazon RDS supports Oracle Java Virtual Machine (JVM) through the use of the `JVM` option. Oracle Java provides a SQL schema and functions that facilitate Oracle Java features in an Oracle database. For more information, see Introduction to Java in Oracle Database in the Oracle documentation.

You can use Oracle JVM with the following Oracle Database versions:

- Oracle 19c, 19.0.0.0, all versions
- Oracle 18c, 18.0.0.0, all versions
- Oracle 12c, 12.2.0.1, all versions
- Oracle 12c, 12.1.0.2.v13 or later
- Oracle 11g, 11.2.0.4.v17 or later

Java implementation in Amazon RDS has a limited set of permissions. The master user is granted the `RDS_JAVA_ADMIN` role, which grants a subset of the privileges granted by the `JAVA_ADMIN` role. To list the privileges granted to the `RDS_JAVA_ADMIN` role, run the following query on your DB instance:

```
SELECT * FROM dba_java_policy
   WHERE grantee IN ('RDS_JAVA_ADMIN', 'PUBLIC')
   AND enabled = 'ENABLED'
   ORDER BY type_name, name, grantee;
```

Prerequisites for Oracle JVM

The following are prerequisites for using Oracle Java:

- Your DB instance must be inside a virtual private cloud (VPC). For more information, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
- Your DB instance must be of a large enough class. Oracle Java isn't supported for the db.t3.micro or db.t3.small DB instance classes. For more information, see DB Instance Classes (p. 7).
- Your DB instance must have **Auto Minor Version Upgrade** enabled. This option enables your DB instance to receive minor DB engine version upgrades automatically when they become available. Amazon RDS uses this option to update your DB instance to the latest Oracle Patch Set Update (PSU) or Release Update (RU). For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- If your DB instance is running on major version 11.2, you must install the `XMLDB` option. For more information, see Oracle XML DB (p. 994).

Best Practices for Oracle JVM

The following are best practices for using Oracle Java:

- For maximum security, use the `JVM` option with Secure Sockets Layer (SSL). For more information, see Oracle Secure Sockets Layer (p. 967).
- Configure your DB instance to restrict network access. For more information, see Scenarios for Accessing a DB Instance in a VPC (p. 1435) and Working with a DB Instance in a VPC (p. 1442).

Adding the Oracle JVM Option

The following is the general process for adding the `JVM` option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

There is a brief outage while the `JVM` option is added. After you add the option, you don't need to restart your DB instance. As soon as the option group is active, Oracle Java is available.

> **Note**
> During this outage, password verification functions are disabled briefly. You can also expect to see events related to password verification functions during the outage. Password verification functions are enabled again before the Oracle DB instance is available.

To add the JVM option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   - For **Engine**, choose the DB engine used by the DB instance (**oracle-ee**, **oracle-se**, **oracle-se1**, or **oracle-se2**).
   - For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **JVM** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
4. Grant the required permissions to users.

   The Amazon RDS master user has the permissions to use the `JVM` option by default. If other users require these permissions, connect to the DB instance as the master user in a SQL client and grant the permissions to the users.

   The following example grants the permissions to use the `JVM` option to the `test_proc` user.

   ```
   create user test_proc identified by password;
   CALL dbms_java.grant_permission('TEST_PROC',
    'oracle.aurora.security.JServerPermission', 'LoadClassInPackage.*', '');
   ```

   After the user is granted the permissions, the following query should return output.

   ```
   select * from dba_java_policy where grantee='TEST_PROC';
   ```

   > **Note**
   > The Oracle user name is case-sensitive, and it usually has all uppercase characters.

Removing the Oracle JVM Option

You can remove the `JVM` option from a DB instance. There is a brief outage while the option is removed. After you remove the `JVM` option, you don't need to restart your DB instance.

> **Warning**
> Removing the `JVM` option can result in data loss if the DB instance is using data types that were enabled as part of the option. Back up your data before proceeding. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To remove the `JVM` option from a DB instance, do one of the following:

- Remove the `JVM` option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the `JVM` option. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Label Security

Amazon RDS supports Oracle Label Security for Oracle Enterprise Edition, version 12c, through the use of the OLS option.

Most database security controls access at the object level. Oracle Label Security provides fine-grained control of access to individual table rows. For example, you can use Label Security to enforce regulatory compliance with a policy-based administration model. You can use Label Security policies to control access to sensitive data, and restrict access to only users with the appropriate clearance level. For more information, see Introduction to Oracle Label Security in the Oracle documentation.

> **Important**
> For Oracle 19c, Oracle 18c, and Oracle 12c version 12.2 on Amazon RDS, Oracle Label Security is a permanent and persistent option. You can't remove Oracle Label Security from an Oracle version 19c, 18c, or 12.2 DB instance.

Prerequisites for Oracle Label Security

The following are prerequisites for using Oracle Label Security:

- Your DB instance must use the Bring Your Own License model. For more information, see Oracle Licensing (p. 847).
- You must have a valid license for Oracle Enterprise Edition with Software Update License and Support.
- Your Oracle license must include the Label Security option.

Adding the Oracle Label Security Option

The general process for adding the Oracle Label Security option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

After you add the Label Security option, as soon as the option group is active, Label Security is active.

To add the Label Security option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose **oracle-ee**.
   b. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **OLS** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).

   > **Important**
   > If you add Label Security to an existing option group that is already attached to one or more DB instances, all the DB instances are restarted.
3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).

- For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. When you add the Label Security option to an existing DB instance, a brief outage occurs while your DB instance is automatically restarted. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Using Oracle Label Security

To use Oracle Label Security, you create policies that control access to specific rows in your tables. For more information, see Creating an Oracle Label Security Policy in the Oracle documentation.

When you work with Label Security, you perform all actions as the LBAC_DBA role. The master user for your DB instance is granted the LBAC_DBA role. You can grant the LBAC_DBA role to other users so that they can administer Label Security policies.

For Amazon RDS for Oracle 19c, 18c, and 12.2 DB instances, you must grant access to the `OLS_ENFORCEMENT` package to any new users who require access to Oracle Label Security. To grant access to the `OLS_ENFORCEMENT` package, connect to the DB instance as the master user and run the following SQL statement:

```
GRANT ALL ON LBACSYS.OLS_ENFORCEMENT TO username;
```

You can configure Label Security through the Oracle Enterprise Manager (OEM) Cloud Control. Amazon RDS supports the OEM Cloud Control through the Management Agent option. For more information, see Oracle Management Agent for Enterprise Manager Cloud Control (p. 941).

Removing the Oracle Label Security Option

You can remove Oracle Label Security from a DB instance.

To remove Label Security from a DB instance, do one of the following:

- To remove Label Security from multiple DB instances, remove the Label Security option from the option group they belong to. This change affects all DB instances that use the option group. When you remove Label Security from an option group that is attached to multiple DB instances, all the DB instances are restarted. For more information, see Removing an Option from an Option Group (p. 198).
- To remove Label Security from a single DB instance, modify the DB instance and specify a different option group that doesn't include the Label Security option. You can specify the default (empty) option group, or a different custom option group. When you remove the Label Security option, a brief outage occurs while your DB instance is automatically restarted. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Troubleshooting

The following are issues you might encounter when you use Oracle Label Security.

Issue	Troubleshooting Suggestions
When you try to create a policy, you see an error message similar to the following: `insufficient authorization for the SYSDBA package`.	A known issue with Oracle's Label Security feature prevents users with usernames of 16 or 24 characters from running Label Security commands. You can create a new user with a different number of characters,

Issue	Troubleshooting Suggestions
	grant LBAC_DBA to the new user, log in as the new user, and run the OLS commands as the new user. For additional information, please contact Oracle support.

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle Locator

Amazon RDS supports Oracle Locator through the use of the `LOCATOR` option. Oracle Locator provides capabilities that are typically required to support internet and wireless service-based applications and partner-based GIS solutions. Oracle Locator is a limited subset of Oracle Spatial. For more information, see Oracle Locator in the Oracle documentation.

> **Important**
> If you use Oracle Locator, Amazon RDS automatically updates your DB instance to the latest Oracle PSU if there are security vulnerabilities with a Common Vulnerability Scoring System (CVSS) score of 9+ or other announced security vulnerabilities.

Amazon RDS supports Oracle Locator for the following editions and versions of Oracle:

- Oracle Standard Edition (SE2) or Enterprise Edition, version 19.0.0.0, all versions
- Oracle Standard Edition (SE2) or Enterprise Edition, version 18.0.0.0, all versions
- Oracle Standard Edition (SE2) or Enterprise Edition, version 12.2.0.1, all versions
- Oracle Standard Edition (SE2) or Enterprise Edition, version 12.1.0.2.v13 or later
- Oracle Standard Edition (SE, SE1) or Enterprise Edition, version 11.2.0.4.v17 or later

Prerequisites for Oracle Locator

The following are prerequisites for using Oracle Locator:

- Your DB instance must be inside a virtual private cloud (VPC). For more information, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
- Your DB instance must be of sufficient class. Oracle Locator is not supported for the db.t3.micro or db.t3.small DB instance classes. For more information, see DB Instance Class Support for Oracle (p. 850).
- Your DB instance must have **Auto Minor Version Upgrade** enabled. This option enables your DB instance to receive minor DB engine version upgrades automatically when they become available and is required for any options that install the Oracle Java Virtual Machine (JVM). Amazon RDS uses this option to update your DB instance to the latest Oracle Patch Set Update (PSU) or Release Update (RU). For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- If your DB instance is running on major version 11.2, you must install the `XMLDB` option. For more information, see Oracle XML DB (p. 994).

Best Practices for Oracle Locator

The following are best practices for using Oracle Locator:

- For maximum security, use the `LOCATOR` option with Secure Sockets Layer (SSL). For more information, see Oracle Secure Sockets Layer (p. 967).
- Configure your DB instance to restrict access to your DB instance. For more information, see Scenarios for Accessing a DB Instance in a VPC (p. 1435) and Working with a DB Instance in a VPC (p. 1442).

Adding the Oracle Locator Option

The following is the general process for adding the `LOCATOR` option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.

3. Associate the option group with the DB instance.

If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `LOCATOR` option is added. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you add the option, you don't need to restart your DB instance. As soon as the option group is active, Oracle OLAP is available.

> **Note**
> During this outage, password verification functions are disabled briefly. You can also expect to see events related to password verification functions during the outage. Password verification functions are enabled again before the Oracle DB instance is available.

To add the `LOCATOR` option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose the oracle edition for your DB instance.

   b. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **LOCATOR** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Using Oracle Locator

After you enable the Oracle Locator option, you can begin using it. You should only use Oracle Locator features. Don't use any Oracle Spatial features unless you have a license for Oracle Spatial.

For a list of features that are supported for Oracle Locator, see Features Included with Locator in the Oracle documentation.

For a list of features that are not supported for Oracle Locator, see Features Not Included with Locator in the Oracle documentation.

Removing the Oracle Locator Option

You can remove the `LOCATOR` option from a DB instance. If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `OLAP` option is removed. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you remove the `LOCATOR` option, you don't need to restart your DB instance.

> **Warning**
> Removing the `LOCATOR` option can result in data loss if the DB instance is using data types that were enabled as part of the option. Back up your data before proceeding. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To remove the `LOCATOR` option from a DB instance, do one of the following:

- Remove the `LOCATOR` option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the `LOCATOR` option. This change affects a single DB instance. You can specify the default (empty) option group or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Related Topics

- Oracle Spatial (p. 976)
- Options for Oracle DB Instances (p. 914)
- Working with Option Groups (p. 186)

Oracle Multimedia

Amazon RDS supports Oracle Multimedia through the use of the `MULTIMEDIA` option. You can use Oracle Multimedia to store, manage, and retrieve images, audio, video, and other heterogeneous media data. For more information, see Oracle Multimedia in the Oracle documentation.

> **Important**
> If you use Oracle Multimedia, Amazon RDS automatically updates your DB instance to the latest Oracle PSU if there are security vulnerabilities with a Common Vulnerability Scoring System (CVSS) score of 9+ or other announced security vulnerabilities.

Amazon RDS supports Oracle Multimedia for the following editions and versions of Oracle:

- Oracle Standard Edition (SE2) or Oracle Enterprise Edition, version 18.0.0.0, all versions
- Oracle Standard Edition (SE2) or Oracle Enterprise Edition, version 12.2.0.1, all versions
- Oracle Standard Edition (SE2) or Oracle Enterprise Edition, version 12.1.0.2.v13 or later
- Oracle Standard Edition (SE and SE1) or Oracle Enterprise Edition, version 11.2.0.4.v17 or later

> **Note**
> Oracle desupported Oracle Multimedia in Oracle Database 19c. So, Oracle Multimedia isn't supported for Oracle 19c DB instances. For more information, see Desupport of Oracle Multimedia in the Oracle documentation.

Prerequisites for Oracle Multimedia

The following are prerequisites for using Oracle Multimedia:

- Your DB instance must be inside a virtual private cloud (VPC). For more information, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
- Your DB instance must be of sufficient class. Oracle Multimedia is not supported for the db.t3.micro or db.t3.small DB instance classes. For more information, see DB Instance Class Support for Oracle (p. 850).
- Your DB instance must have **Auto Minor Version Upgrade** enabled. This option enables your DB instance to receive minor DB engine version upgrades automatically when they become available and is required for any options that install the Oracle Java Virtual Machine (JVM). Amazon RDS uses this option to update your DB instance to the latest Oracle Patch Set Update (PSU) or Release Update (RU). For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- If your DB instance is running on major version 11.2, you must install the `XMLDB` option. For more information, see Oracle XML DB (p. 994).

Best Practices for Oracle Multimedia

The following are best practices for using Oracle Multimedia:

- For maximum security, use the `MULTIMEDIA` option with Secure Sockets Layer (SSL). For more information, see Oracle Secure Sockets Layer (p. 967).
- Configure your DB instance to restrict access to your DB instance. For more information, see Scenarios for Accessing a DB Instance in a VPC (p. 1435) and Working with a DB Instance in a VPC (p. 1442).

Adding the Oracle Multimedia Option

The following is the general process for adding the `MULTIMEDIA` option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `MULTIMEDIA` option is added. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you add the option, you don't need to restart your DB instance. As soon as the option group is active, Oracle OLAP is available.

> **Note**
> During this outage, password verification functions are disabled briefly. You can also expect to see events related to password verification functions during the outage. Password verification functions are enabled again before the Oracle DB instance is available.

To add the `MULTIMEDIA` option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

    a. For **Engine**, choose **oracle-ee**.

    b. For **Major engine version**, choose the version of your DB instance.

    For more information, see Creating an Option Group (p. 187).
2. Add the **MULTIMEDIA** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:
    - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
    - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Removing the Oracle Multimedia Option

You can remove the `MULTIMEDIA` option from a DB instance. If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `OLAP` option is removed. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you remove the `MULTIMEDIA` option, you don't need to restart your DB instance.

> **Warning**
> Removing the `MULTIMEDIA` option can result in data loss if the DB instance is using data types that were enabled as part of the option. Back up your data before proceeding. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To remove the `MULTIMEDIA` option from a DB instance, do one of the following:

- Remove the `MULTIMEDIA` option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the `MULTIMEDIA` option. This change affects a single DB instance. You can specify the default (empty) option group or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Native Network Encryption

Amazon RDS supports Oracle native network encryption (NNE). With native network encryption, you can encrypt data as it moves to and from a DB instance. Amazon RDS supports NNE for all editions of Oracle.

A detailed discussion of Oracle native network encryption is beyond the scope of this guide, but you should understand the strengths and weaknesses of each algorithm and key before you decide on a solution for your deployment. For information about the algorithms and keys that are available through Oracle native network encryption, see Configuring Network Data Encryption in the Oracle documentation. For more information about AWS security, see the AWS Security Center.

> **Note**
> You can use Native Network Encryption or Secure Sockets Layer, but not both. For more information, see Oracle Secure Sockets Layer (p. 967).

NNE Option Settings

Amazon RDS supports the following settings for the NNE option.

Option Setting	Valid Values	Default Value	Description
SQLNET.ENCRYPTION_SERVER	`Accepted`, `Rejected`, `Requested`, `Required`	`Requested`	The encryption behavior when a client, or a server acting as a client, connects to the DB instance. `Requested` indicates that the DB instance does not require traffic from the client to be encrypted.
SQLNET.CRYPTO_CHECKSUM_SERVER	`Accepted`, `Rejected`, `Requested`, `Required`	`Requested`	The data integrity behavior when a client, or a server acting as a client, connects to the DB instance. `Requested` indicates that the DB instance does not require the client to perform a checksum.
SQLNET.ENCRYPTION_TYPES_SERVER	`RC4_256`, `AES256`, `AES192`, `3DES168`, `RC4_128`, `AES128`, `3DES112`, `RC4_56`, `DES`, `RC4_40`, `DES40`	`RC4_256`, `AES256`, `AES192`, `3DES168`, `RC4_128`, `AES128`, `3DES112`, `RC4_56`, `DES`, `RC4_40`, `DES40`	A list of encryption algorithms used by the DB instance. The DB instance will use each algorithm, in order, to attempt to decrypt the client input until an algorithm succeeds or until the end of the list is reached. Amazon RDS uses the following default list from Oracle. You can change the order or limit the algorithms that the DB instance will accept. 1. `RC4_256`: RSA RC4 (256-bit key size) 2. `AES256`: AES (256-bit key size) 3. `AES192`: AES (192-bit key size) 4. `3DES168`: 3-key Triple-DES (112-bit effective key size)

Option Setting	Valid Values	Default Value	Description
			5. `RC4_128`: RSA RC4 (128-bit key size) 6. `AES128`: AES (128-bit key size) 7. `3DES112`: 2-key Triple-DES (80-bit effective key size) 8. `RC4_56`: RSA RC4 (56-bit key size) 9. `DES`: Standard DES (56-bit key size) 10`RC4_40`: RSA RC4 (40-bit key size) 11`DES40`: DES40 (40-bit key size)
SQLNET.CRYPTO_CHECKSUM_TYPES_SERVER	`SHA256`, `SHA384`, `SHA512`, `SHA1`, `MD5`	`SHA256`, `SHA384`, `SHA512`, `SHA1`, `MD5`	The checksum algorithm.

Adding the NNE Option

The general process for adding the NNE option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

After you add the NNE option, as soon as the option group is active, NNE is active.

To add the NNE option to a DB instance

1. For **Engine**, choose the Oracle edition that you want to use. NNE is supported on all editions.
2. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
3. Add the **NNE** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).

   Note
   After you add the NNE option, you don't need to restart your DB instances. As soon as the option group is active, NNE is active.
4. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. After you add the NNE option, you don't need to restart your DB instance. As soon as the option group is active, NNE is active. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Using NNE

With Oracle native network encryption, you can also specify network encryption on the client side. On the client (the computer used to connect to the DB instance), you can use the sqlnet.ora file to specify the following client settings: SQLNET.CRYPTO_CHECKSUM_CLIENT , SQLNET.CRYPTO_CHECKSUM_TYPES_CLIENT, SQLNET.ENCRYPTION_CLIENT, and SQLNET.ENCRYPTION_TYPES_CLIENT. For information, see Configuring Network Data Encryption and Integrity for Oracle Servers and Clients in the Oracle documentation.

Sometimes, the DB instance will reject a connection request from an application, for example, if there is a mismatch between the encryption algorithms on the client and on the server.

To test Oracle native network encryption , add the following lines to the sqlnet.ora file on the client:

```
DIAG_ADR_ENABLED=off
TRACE_DIRECTORY_CLIENT=/tmp
TRACE_FILE_CLIENT=nettrace
TRACE_LEVEL_CLIENT=16
```

These lines generate a trace file on the client called `/tmp/nettrace*` when the connection is attempted. The trace file contains information on the connection. For more information about connection-related issues when you are using Oracle Native Network Encryption, see About Negotiating Encryption and Integrity in the Oracle documentation.

Modifying NNE Settings

After you enable NNE, you can modify settings for the option. For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see NNE Option Settings (p. 963).

Removing the NNE Option

You can remove NNE from a DB instance.

To remove NNE from a DB instance, do one of the following:

- To remove NNE from multiple DB instances, remove the NNE option from the option group they belong to. This change affects all DB instances that use the option group. After you remove the NNE option, you don't need to restart your DB instances. For more information, see Removing an Option from an Option Group (p. 198).
- To remove NNE from a single DB instance, modify the DB instance and specify a different option group that doesn't include the NNE option. You can specify the default (empty) option group, or a different custom option group. After you remove the NNE option, you don't need to restart your DB instance. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle OLAP

Amazon RDS supports Oracle OLAP through the use of the `OLAP` option. This option provides On-line Analytical Processing (OLAP) for Oracle DB instances. You can use Oracle OLAP to analyze large amounts of data by creating dimensional objects and cubes in accordance with the OLAP standard. For more information, see the Oracle documentation.

Important
If you use Oracle OLAP, Amazon RDS automatically updates your DB instance to the latest Oracle PSU if there are security vulnerabilities with a Common Vulnerability Scoring System (CVSS) score of 9+ or other announced security vulnerabilities.

Amazon RDS supports Oracle OLAP for the following editions and versions of Oracle:

- Oracle Enterprise Edition, version 19.0.0.0, all versions
- Oracle Enterprise Edition, version 18.0.0.0, all versions
- Oracle Enterprise Edition, version 12.2.0.1, all versions
- Oracle Enterprise Edition, version 12.1.0.2.v13 or later

Prerequisites for Oracle OLAP

The following are prerequisites for using Oracle OLAP:

- You must have an Oracle OLAP license from Oracle. For more information, see Licensing Information in the Oracle documentation.
- Your DB instance must be inside a virtual private cloud (VPC). For more information, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
- Your DB instance must be of a sufficient instance class. Oracle OLAP isn't supported for the db.t3.micro or db.t3.small DB instance classes. For more information, see DB Instance Class Support for Oracle (p. 850).
- Your DB instance must have **Auto Minor Version Upgrade** enabled. This option enables your DB instance to receive minor DB engine version upgrades automatically when they become available and is required for any options that install the Oracle Java Virtual Machine (JVM). Amazon RDS uses this option to update your DB instance to the latest Oracle Patch Set Update (PSU) or Release Update (RU). For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- Your DB instance must not have a user named `OLAPSYS`. If it does, the OLAP option installation fails.

Best Practices for Oracle OLAP

The following are best practices for using Oracle OLAP:

- For maximum security, use the `OLAP` option with Secure Sockets Layer (SSL). For more information, see Oracle Secure Sockets Layer (p. 967).
- Configure your DB instance to restrict access to your DB instance. For more information, see Scenarios for Accessing a DB Instance in a VPC (p. 1435) and Working with a DB Instance in a VPC (p. 1442).

Adding the Oracle OLAP Option

The following is the general process for adding the `OLAP` option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `OLAP` option is added. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you add the option, you don't need to restart your DB instance. As soon as the option group is active, Oracle OLAP is available.

To add the OLAP option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:
   - For **Engine**, choose the Oracle edition for your DB instance.
   - For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **OLAP** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:
   - For a new DB instance, apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Using Oracle OLAP

After you enable the Oracle OLAP option, you can begin using it. For a list of features that are supported for Oracle OLAP, see the Oracle documentation.

Removing the Oracle OLAP Option

You can remove the `OLAP` option from a DB instance. If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `OLAP` option is removed. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you remove the `OLAP` option, you don't need to restart your DB instance.

> **Warning**
> Removing the `OLAP` option can result in data loss if the DB instance is using data types that were enabled as part of the option. Back up your data before proceeding. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To remove the `OLAP` option from a DB instance, do one of the following:

- Remove the `OLAP` option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the `OLAP` option. This change affects a single DB instance. You can specify the default (empty) option group or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Oracle Secure Sockets Layer

You enable Secure Sockets Layer (SSL) encryption for an Oracle DB instance by adding the Oracle SSL option to the option group associated with an Oracle DB instance. You specify the port you want to communicate over using SSL. You must configure SQL*Plus as shown in this following section.

You enable SSL encryption for an Oracle DB instance by adding the Oracle SSL option to the option group associated with the DB instance. Amazon RDS uses a second port, as required by Oracle, for SSL connections. This approach allows both clear text and SSL-encrypted communication to occur at the same time between a DB instance and SQL*Plus. For example, you can use the port with clear text communication to communicate with other resources inside a VPC while using the port with SSL-encrypted communication to communicate with resources outside the VPC.

Note
You can use Secure Sockets Layer or Native Network Encryption, but not both. For more information, see Oracle Native Network Encryption (p. 963).

You can use SSL encryption with the following Oracle database versions and editions:

- 19.0.0.0: All versions, all editions including Standard Edition Two
- 18.0.0.0: All versions, all editions including Standard Edition Two
- 12.2.0.1: All versions, all editions including Standard Edition Two
- 12.1.0.2: All versions, all editions including Standard Edition Two
- 11.2.0.4: All versions, Enterprise Edition
- 11.2.0.4: Version 6 and later, Standard Edition, Standard Edition One, Enterprise Edition

Note
You cannot use both SSL and Oracle native network encryption (NNE) on the same instance. If you use SSL encryption, you must disable any other connection encryption.

TLS Versions for the Oracle SSL Option

Amazon RDS for Oracle supports Transport Layer Security (TLS) versions 1.0 and 1.2. To use the Oracle SSL option, use the `SQLNET.SSL_VERSION` option setting. The following values are allowed for this option setting:

- `"1.0"` – Clients can connect to the DB instance using TLS 1.0 only.
- `"1.2"` – Clients can connect to the DB instance using TLS 1.2 only.
- `"1.2 or 1.0"` – Clients can connect to the DB instance using either TLS 1.2 or 1.0.

To use the Oracle SSL option, the `SQLNET.SSL_VERSION` option setting is also required:

- For existing Oracle SSL options, `SQLNET.SSL_VERSION` is set to `"1.0"` automatically. You can change the setting if necessary.
- When you add a new Oracle SSL option, you must set `SQLNET.SSL_VERSION` explicitly to a valid value.

The following table shows the TLS option settings that are supported for different Oracle engine versions and editions.

Oracle Engine Version	SQLNET.SSL_VERSION = "1.0"	SQLNET.SSL_VERSION = "1.2"	SQLNET.SSL_VERSION = "1.2 or 1.0"
18.0.0.0 (All editions)	Supported	Supported	Supported
12.2.0.1 (All editions)	Supported	Supported	Supported
12.1.0.2 (All editions)	Supported	Supported	Supported

Oracle Engine Version	SQLNET.SSL_VERSION = "1.0"	SQLNET.SSL_VERSION = "1.2"	SQLNET.SSL_VERSION = "1.2 or 1.0"
11.2.0.4 (Oracle EE)	Supported	Supported for 11.2.0.4.v8 and later	Supported for 11.2.0.4.v8 and later
11.2.0.4 (Oracle SE1)	Supported	Not supported	Not supported
11.2.0.4 (Oracle SE)	Supported	Not supported	Not supported

Cipher Suites for the Oracle SSL Option

Amazon RDS for Oracle supports multiple SSL cipher suites. By default, the Oracle SSL option is configured to use the `SSL_RSA_WITH_AES_256_CBC_SHA` cipher suite. To specify a different cipher suite to use over SSL connections, use the `SQLNET.CIPHER_SUITE` option setting. Following are the allowed values for this option setting:

- `"SSL_RSA_WITH_AES_256_CBC_SHA"` – The default setting, which is compatible with TLS 1.0 and TLS 1.2
- `"SSL_RSA_WITH_AES_256_CBC_SHA256"` – Only compatible with TLS 1.2
- `"SSL_RSA_WITH_AES_256_GCM_SHA384"` – Only compatible with TLS 1.2

For existing Oracle SSL options, `SQLNET.CIPHER_SUITE` is set to `"SSL_RSA_WITH_AES_256_CBC_SHA"` automatically. You can change the setting if necessary.

The following table shows the cipher suite option settings that are supported for different Oracle engine versions and editions.

Oracle Engine Version	SQLNET.CIPHER_SUITE = "SSL_RSA_WITH_AES_25	SQLNET.CIPHER_SUITE = "SSL_RSA_WITH_AES_25	SQLNET.CIPHER_SUITE = "SSL_RSA_WITH_AES_256_GCM_SHA
19.0.0.0 (All editions)	Supported	Supported	Supported
18.0.0.0 (All editions)	Supported	Supported	Supported
12.2.0.1 (All editions)	Supported	Supported	Supported
12.1.0.2 (All editions)	Supported	Supported	Supported
11.2.0.4 (Oracle EE)	Supported	Not supported	Not supported
11.2.0.4 (Oracle SE1)	Supported	Not supported	Not supported
11.2.0.4 (Oracle SE)	Supported	Not supported	Not supported

FIPS Support

Amazon RDS for Oracle enables you to use the Federal Information Processing Standard (FIPS) standard for 140-2. FIPS 140-2 is a United States government standard that defines cryptographic module security requirements. You enable the FIPS standard by setting the setting `FIPS.SSLFIPS_140` to `TRUE` for the Oracle SSL option. When FIPS 140-2 is configured for SSL, the cryptographic libraries are designed to encrypt data between the client and the Oracle DB instance.

You can enable the FIPS setting with the following Oracle database versions and editions:

- 19.0.0.0: All versions, all editions including Standard Edition Two
- 18.0.0.0: All versions, all editions including Standard Edition Two
- 12.2.0.1: All versions, all editions including Standard Edition Two
- 12.1.0.2: Version 2 and later, all editions including Standard Edition Two

Clients must use the cipher suite that is FIPS-compliant. When establishing a connection, the client and Oracle DB instance negotiate which cipher suite to use when transmitting messages back and forth. The following table shows the FIPS-compliant SSL cipher suites for each TLS version.

SQLNET.SSL_VERSION	Supported Cipher Suites
1.0	SSL_RSA_WITH_AES_256_CBC_SHA
1.2	SSL_RSA_WITH_AES_256_CBC_SHA SSL_RSA_WITH_AES_256_GCM_SHA384

For more information, see Oracle Database FIPS 140-2 Settings in the Oracle documentation.

Adding the SSL Option

To use SSL, your Amazon RDS Oracle DB instance must be associated with an option group that includes the `SSL` option.

Console

To add the SSL option to an option group

1. Create a new option group or identify an existing option group to which you can add the `SSL` option.

   For information about creating an option group, see Creating an Option Group (p. 187).
2. Add the `SSL` option to the option group.

   If you want to use only FIPS-verified cipher suites for SSL connections, set the option `FIPS.SSLFIPS_140` to `TRUE`. For information about the FIPS standard, see FIPS Support (p. 969).

   For information about adding an option to an option group, see Adding an Option to an Option Group (p. 190).
3. Create a new Oracle DB instance and associate the option group with it, or modify an Oracle DB instance to associate the option group with it.

   For information about creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

   For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

AWS CLI

To add the SSL option to an option group

1. Create a new option group or identify an existing option group to which you can add the `SSL` option.

   For information about creating an option group, see Creating an Option Group (p. 187).
2. Add the `SSL` option to the option group.

   Specify the following option settings:

- `Port` – The SSL port number
- `VpcSecurityGroupMemberships` – The VPC security group for which the option is enabled
- `SQLNET.SSL_VERSION` – The TLS version that client can use to connect to the DB instance

For example, the following AWS CLI command adds the `SSL` option to an option group named `ora-option-group`.

Example

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group --option-group-name ora-option-group \
  --options
 'OptionName=SSL,Port=2484,VpcSecurityGroupMemberships="sg-68184619",OptionSettings=[{Name=SQLNET.S
```

For Windows:

```
aws rds add-option-to-option-group --option-group-name ora-option-group ^
  --options
 'OptionName=SSL,Port=2484,VpcSecurityGroupMemberships="sg-68184619",OptionSettings=[{Name=SQLNET.S
```

3. Create a new Oracle DB instance and associate the option group with it, or modify an Oracle DB instance to associate the option group with it.

   For information about creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

   For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Configuring SQL*Plus to Use SSL with an Oracle DB Instance

You must configure SQL*Plus before connecting to an Oracle DB instance that uses the Oracle SSL option.

> **Note**
> To allow access to the DB instance from the appropriate clients, ensure that your security groups are configured correctly. For more information, see Controlling Access with Security Groups (p. 1414). Also, these instructions are for SQL*Plus and other clients that directly use an Oracle home. For JDBC connections, see Setting Up an SSL Connection Over JDBC (p. 973).

To configure SQL*Plus to use SSL to connect to an Oracle DB instance

1. Set the `ORACLE_HOME` environment variable to the location of your Oracle home directory.

   The path to your Oracle home directory depends on your installation. The following example sets the `ORACLE_HOME` environment variable.

```
prompt>export ORACLE_HOME=/home/user/app/user/product/12.1.0/dbhome_1
```

   For information about setting Oracle environment variables, see SQL*Plus Environment Variables in the Oracle documentation, and also see the Oracle installation guide for your operating system.

2. Append `$ORACLE_HOME/lib` to the `LD_LIBRARY_PATH` environment variable.

   The following is an example that sets the LD_LIBRARY_PATH environment variable.

```
prompt>export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$ORACLE_HOME/lib
```

3. Create a directory for the Oracle wallet at `$ORACLE_HOME/ssl_wallet`.

   The following is an example that creates the Oracle wallet directory.

```
prompt>mkdir $ORACLE_HOME/ssl_wallet
```

4. Download the root certificate that works for all AWS Regions and put the file in the ssl_wallet directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

5. In the `$ORACLE_HOME/network/admin` directory, modify or create the tnsnames.ora file and include the following entry.

```
<net_service_name>= (DESCRIPTION = (ADDRESS_LIST = (ADDRESS = (PROTOCOL = TCPS)
   (HOST = <endpoint>) (PORT = <ssl port number>)))(CONNECT_DATA = (SID = <database
 name>))
   (SECURITY = (SSL_SERVER_CERT_DN =
 "C=US,ST=Washington,L=Seattle,O=Amazon.com,OU=RDS,CN=<endpoint>")))
```

6. In the same directory, modify or create the sqlnet.ora file and include the following parameters.

   Note
   To communicate with entities over a TLS secured connection, Oracle requires a wallet with the necessary certificates for authentication. You can use Oracle's ORAPKI utility to create and maintain Oracle wallets, as shown in step 7. For more information, see Setting Up Oracle Wallet Using ORAPKI in the Oracle documentation.

```
WALLET_LOCATION = (SOURCE = (METHOD = FILE) (METHOD_DATA = (DIRECTORY = $ORACLE_HOME/
ssl_wallet)))
SSL_CLIENT_AUTHENTICATION = FALSE
SSL_VERSION = 1.0
SSL_CIPHER_SUITES = (SSL_RSA_WITH_AES_256_CBC_SHA)
SSL_SERVER_DN_MATCH = ON
```

   Note
   You can set `SSL_VERSION` to a higher value if your DB instance supports it.

7. Run the following commands to create the Oracle wallet.

```
prompt>orapki wallet create -wallet $ORACLE_HOME/ssl_wallet -auto_login_only

prompt>orapki wallet add -wallet $ORACLE_HOME/ssl_wallet -trusted_cert -cert
      $ORACLE_HOME/ssl_wallet/rds-ca-2019-root.pem -auto_login_only
```

Replace the file name with the one you downloaded.

Connecting to an Oracle DB Instance Using SSL

After you configure SQL*Plus to use SSL as described previously, you can connect to the Oracle DB instance with the SSL option. Optionally, you can first export the `TNS_ADMIN` value that points to the directory that contains the tnsnames.ora and sqlnet.ora files. Doing so ensures that SQL*Plus can find these files consistently. The following example exports the `TNS_ADMIN` value.

```
export TNS_ADMIN = ${ORACLE_HOME}/network/admin
```

Connect to the DB instance. For example, you can connect using SQL*Plus and a *<net_service_name>* in a tnsnames.ora file.

```
sqlplus <mydbuser>@<net_service_name>
```

You can also connect to the DB instance using SQL*Plus without using a tnsnames.ora file by using the following command.

```
sqlplus '<mydbuser>@(DESCRIPTION = (ADDRESS = (PROTOCOL = TCPS)(HOST = <endpoint>) (PORT
 = <ssl port number>))(CONNECT_DATA = (SID = <database name>)))'
```

You can also connect to the Oracle DB instance without using SSL. For example, the following command connects to the DB instance through the clear text port without SSL encryption.

```
sqlplus '<mydbuser>@(DESCRIPTION = (ADDRESS = (PROTOCOL = TCP)(HOST = <endpoint>) (PORT
 = <port number>))(CONNECT_DATA = (SID = <database name>)))'
```

If you want to close Transmission Control Protocol (TCP) port access, create a security group with no IP address ingresses and add it to the instance. This addition closes connections over the TCP port, while still allowing connections over the SSL port that are specified from IP addresses within the range permitted by the SSL option security group.

Setting Up an SSL Connection Over JDBC

To use an SSL connection over JDBC, you must create a keystore, trust the Amazon RDS root CA certificate, and use the code snippet specified following.

To create the keystore in JKS format, use the following command. For more information about creating the keystore, see the Oracle documentation.

```
keytool -keystore clientkeystore -genkey -alias client
```

Next, take the following steps to trust the Amazon RDS root CA certificate.

To trust the Amazon RDS root CA certificate

1. Download the root certificate that works for all AWS Regions and put the file in the ssl_wallet directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Convert the certificate to .der format using the following command.

   ```
   openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
   ```

   Replace the file name with the one you downloaded.
3. Import the certificate into the keystore using the following command.

   ```
   keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
   ```
4. Confirm that the key store was created successfully.

   ```
   keytool -list -v -keystore clientkeystore.jks
   ```

   Enter the keystore password when you are prompted for it.

The following code example shows how to set up the SSL connection using JDBC.

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.SQLException;
import java.util.Properties;

public class OracleSslConnectionTest {
    private static final String DB_SERVER_NAME = "<dns-name-provided-by-amazon-rds>";
    private static final Integer SSL_PORT = "<ssl-option-port-configured-in-option-group>";
    private static final String DB_SID = "<oracle-sid>";
    private static final String DB_USER = "<user name>";
    private static final String DB_PASSWORD = "<password>";
    // This key store has only the prod root ca.
    private static final String KEY_STORE_FILE_PATH = "<file-path-to-keystore>";
    private static final String KEY_STORE_PASS = "<keystore-password>";

    public static void main(String[] args) throws SQLException {
        final Properties properties = new Properties();
        final String connectionString = String.format(
                "jdbc:oracle:thin:@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCPS)(HOST=%s)(PORT=%d))
(CONNECT_DATA=(SID=%s)))",
                DB_SERVER_NAME, SSL_PORT, DB_SID);
        properties.put("user", DB_USER);
        properties.put("password", DB_PASSWORD);
        properties.put("oracle.jdbc.J2EE13Compliant", "true");
        properties.put("javax.net.ssl.trustStore", KEY_STORE_FILE_PATH);
        properties.put("javax.net.ssl.trustStoreType", "JKS");
```

```
        properties.put("javax.net.ssl.trustStorePassword", KEY_STORE_PASS);
        final Connection connection = DriverManager.getConnection(connectionString,
 properties);
        // If no exception, that means handshake has passed, and an SSL connection can be
 opened
    }
}
```

Enforcing a DN Match with an SSL Connection

You can use the Oracle parameter `SSL_SERVER_DN_MATCH` to enforce that the distinguished name (DN) for the database server matches its service name. If you enforce the match verifications, then SSL ensures that the certificate is from the server. If you don't enforce the match verification, then SSL performs the check but allows the connection, regardless if there is a match. If you do not enforce the match, you allow the server to potentially fake its identify.

To enforce DN matching, add the DN match property and use the connection string specified below.

Add the property to the client connection to enforce DN matching.

```
properties.put("oracle.net.ssl_server_dn_match", "TRUE”);
```

Use the following connection string to enforce DN matching when using SSL.

```
final String connectionString = String.format(
    "jdbc:oracle:thin:@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCPS)(HOST=%s)(PORT=%d))" +
    "(CONNECT_DATA=(SID=%s))" +
    "(SECURITY = (SSL_SERVER_CERT_DN =
\"C=US,ST=Washington,L=Seattle,O=Amazon.com,OU=RDS,CN=%s\")))",
    DB_SERVER_NAME, SSL_PORT, DB_SID, DB_SERVER_NAME);
```

Oracle Spatial

Amazon RDS supports Oracle Spatial through the use of the `SPATIAL` option. Oracle Spatial provides a SQL schema and functions that facilitate the storage, retrieval, update, and query of collections of spatial data in an Oracle database. For more information, see Spatial Concepts in the Oracle documentation.

> **Important**
> If you use Oracle Spatial, Amazon RDS automatically updates your DB instance to the latest Oracle PSU if there are security vulnerabilities with a Common Vulnerability Scoring System (CVSS) score of 9+ or other announced security vulnerabilities.

Amazon RDS supports Oracle Spatial for the following editions and versions of Oracle:

- Oracle Enterprise Edition, version 19.0.0.0, all versions
- Oracle Enterprise Edition, version 18.0.0.0, all versions
- Oracle Enterprise Edition, version 12.2.0.1, all versions
- Oracle Enterprise Edition, version 12.1.0.2.v13 or later
- Oracle Enterprise Edition, version 11.2.0.4.v17 or later

Prerequisites for Oracle Spatial

The following are prerequisites for using Oracle Spatial:

- Your DB instance must be inside a virtual private cloud (VPC). For more information, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
- Your DB instance must be of sufficient class. Oracle Spatial is not supported for the db.t3.micro or db.t3.small DB instance classes. For more information, see DB Instance Class Support for Oracle (p. 850).
- Your DB instance must have **Auto Minor Version Upgrade** enabled. This option enables your DB instance to receive minor DB engine version upgrades automatically when they become available and is required for any options that install the Oracle Java Virtual Machine (JVM). Amazon RDS uses this option to update your DB instance to the latest Oracle Patch Set Update (PSU) or Release Update (RU). For more information, see Modifying an Amazon RDS DB Instance (p. 220).
- If your DB instance is running on major version 11.2, you must install the `XMLDB` option. For more information, see Oracle XML DB (p. 994).
- An Oracle Spatial license from Oracle. For more information, see Oracle Spatial and Graph in the Oracle documentation.

Best Practices for Oracle Spatial

The following are best practices for using Oracle Spatial:

- For maximum security, use the `SPATIAL` option with Secure Sockets Layer (SSL). For more information, see Oracle Secure Sockets Layer (p. 967).
- Configure your DB instance to restrict access to your DB instance. For more information, see Scenarios for Accessing a DB Instance in a VPC (p. 1435) and Working with a DB Instance in a VPC (p. 1442).

Adding the Oracle Spatial Option

The following is the general process for adding the `SPATIAL` option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `SPATIAL` option is added. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you add the option, you don't need to restart your DB instance. As soon as the option group is active, Oracle OLAP is available.

> **Note**
> During this outage, password verification functions are disabled briefly. You can also expect to see events related to password verification functions during the outage. Password verification functions are enabled again before the Oracle DB instance is available.

To add the `SPATIAL` option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose **oracle-ee**.

   b. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **SPATIAL** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:
   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Removing the Oracle Spatial Option

You can remove the `SPATIAL` option from a DB instance. If Oracle Java Virtual Machine (JVM) is *not* installed on the DB instance, there is a brief outage while the `OLAP` option is removed. There is no outage if Oracle Java Virtual Machine (JVM) is already installed on the DB instance. After you remove the `SPATIAL` option, you don't need to restart your DB instance.

> **Warning**
> Removing the `SPATIAL` option can result in data loss if the DB instance is using data types that were enabled as part of the option. Back up your data before proceeding. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

To remove the `SPATIAL` option from a DB instance, do one of the following:

- Remove the `SPATIAL` option from the option group it belongs to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- Modify the DB instance and specify a different option group that doesn't include the `SPATIAL` option. This change affects a single DB instance. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Related Topics

- Oracle Locator (p. 957)
- Options for Oracle DB Instances (p. 914)
- Working with Option Groups (p. 186)

Oracle SQLT

Amazon RDS supports Oracle SQLTXPLAIN (SQLT) through the use of the SQLT option.

The Oracle `EXPLAIN PLAN` statement can determine the execution plan of a SQL statement. It can verify whether the Oracle optimizer chooses a certain execution plan, such as a nested loops join. It also helps you understand the optimizer's decisions, such as why it chose a nested loops join over a hash join. So `EXPLAIN PLAN` helps you understand the statement's performance.

SQLT is an Oracle utility that produces a report. The report includes object statistics, object metadata, optimizer-related initialization parameters, and other information that a database administrator can use to tune a SQL statement for optimal performance. SQLT produces an HTML report with hyperlinks to all of the sections in the report.

Unlike Automatic Workload Repository or Statspack reports, SQLT works on individual SQL statements. SQLT is a collection of SQL, PL/SQL, and SQL*Plus files that collect, store, and display performance data.

Following are the supported Oracle versions for each SQLT version.

SQLT Version	Oracle 19c	Oracle 18c	Oracle 12c version 12.2	Oracle 12c version 12.1	Oracle 11g
12.2.180725	Supported	Supported	Supported	Supported	Supported
12.2.180331	Not supported	Supported	Supported	Supported	Supported
12.1.160429	Not supported	Not supported	Supported	Supported	Supported

To download SQLT and access instructions for using it:

- Log in to your My Oracle Support account, and open the following documents:
- To download SQLT: Document 215187.1
- For SQLT usage instructions: Document 1614107.1
- For frequently asked questions about SQLT: Document 1454160.1
- For information about reading SQLT output: Document 1456176.1
- For interpreting the Main report: Document 1922234.1

You can use SQLT with any edition of the following Oracle Database versions:

- Oracle 19c, 19.0.0.0
- Oracle 18c, 18.0.0.0
- Oracle 12c, 12.2.0.1
- Oracle 12c, 12.1.0.2
- Oracle 11g, 11.2.0.4

Amazon RDS does not support the following SQLT methods:

- `XPLORE`
- `XHUME`

Prerequisites for SQLT

The following are prerequisites for using SQLT:

- You must remove users and roles that are required by SQLT, if they exist.

  The SQLT option creates the following users and roles on a DB instance:
  - `SQLTXPLAIN` user
  - `SQLTXADMIN` user
  - `SQLT_USER_ROLE` role

  If your DB instance has any of these users or roles, log in to the DB instance using a SQL client, and drop them using the following statements:

```
DROP USER SQLTXPLAIN CASCADE;
DROP USER SQLTXADMIN CASCADE;
DROP ROLE SQLT_USER_ROLE CASCADE;
```

- You must remove tablespaces that are required by SQLT, if they exist.

  The SQLT option creates the following tablespaces on a DB instance:
  - `RDS_SQLT_TS`
  - `RDS_TEMP_SQLT_TS`

  If your DB instance has these tablespaces, log in to the DB instance using a SQL client, and drop them.

SQLT Option Settings

SQLT can work with licensed features that are provided by the Oracle Tuning Pack and the Oracle Diagnostics Pack. The Oracle Tuning Pack includes the SQL Tuning Advisor, and the Oracle Diagnostics Pack includes the Automatic Workload Repository. The SQLT settings enable or disable access to these features from SQLT.

Amazon RDS supports the following settings for the SQLT option.

Option Setting	Valid Values	Default Value	Description
`LICENSE_PACK`	`T`, `D`, `N`	`T`	The Oracle Management Packs that you want to access with SQLT. Enter one of the following values: • `T` indicates that you have a license for the Oracle Tuning Pack and the Oracle Diagnostics Pack, and you want to access the SQL Tuning Advisor and Automatic Workload Repository from SQLT. • `D` indicates that you have a license for the Oracle Diagnostics Pack, and you want to access the Automatic Workload Repository from SQLT. • `N` indicates that you don't have a license for the Oracle Tuning Pack and the Oracle Diagnostics Pack, or that you have a license for one or both of them, but you don't want SQLT to access them.

Option Setting	Valid Values	Default Value	Description
			Note Amazon RDS does not provide licenses for these Oracle Management Packs. If you indicate that you want to use a pack that is not included in your DB instance, you can use SQLT with the DB instance. However, SQLT can't access the pack, and the SQLT report doesn't include the data for the pack. For example, if you specify `T`, but the DB instance doesn't include the Oracle Tuning Pack, SQLT works on the DB instance, but the report it generates doesn't contain data related to the Oracle Tuning Pack.
`VERSION`	`2016-04-29.v1`, `2018-03-31.v1`, `2018-07-25.v1`	`2016-04-29.v1`	The version of SQLT that you want to install. **Note** For Oracle version 19.0.0.0, the only supported version is `2018-07-25.v1`. This version is also the default for Oracle version 19.0.0.0.

Adding the SQLT Option

The following is the general process for adding the SQLT option to a DB instance:

1. Create a new option group, or copy or modify an existing option group.
2. Add the SQLT option to the option group.
3. Associate the option group with the DB instance.

After you add the SQLT option, as soon as the option group is active, SQLT is active.

To add the SQLT option to a DB instance

1. Determine the option group that you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose the Oracle edition that you want to use. The SQLT option is supported on all editions.

   b. For **Major engine version**, choose the version of your DB instance.

   For more information, see Creating an Option Group (p. 187).
2. Add the **SQLT** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:
   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).
4. (Optional) Verify the SQLT installation on each DB instance with the SQLT option.

a. Use a SQL client to connect to the DB instance as the master user.

   For information about connecting to an Oracle DB instance using a SQL client, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).

b. Run the following query:

```
SELECT sqltxplain.sqlt$a.get_param('tool_version') sqlt_version FROM DUAL;
```

   The query returns the current version of the SQLT option on Amazon RDS. `12.1.160429` is an example of a version of SQLT that is available on Amazon RDS.

5. Change the passwords of the users that are created by the SQLT option.

   a. Use a SQL client to connect to the DB instance as the master user.
   b. Run the following SQL statement to change the password for the `SQLTXADMIN` user:

```
ALTER USER SQLTXADMIN IDENTIFIED BY new_password ACCOUNT UNLOCK;
```

   c. Run the following SQL statement to change the password for the `SQLTXPLAIN` user:

```
ALTER USER SQLTXPLAIN IDENTIFIED BY new_password ACCOUNT UNLOCK;
```

Note
Upgrading SQLT requires uninstalling an older version of SQLT and then installing the new version. So, all SQLT metadata can be lost when you upgrade SQLT. A major version upgrade of a database also uninstalls and re-installs SQLT. An example of a major version upgrade is an upgrade from Oracle 11g to Oracle 12c.

Using SQLT

SQLT works with the Oracle SQL*Plus utility.

To use SQLT

1. Download the SQLT .zip file from Document 215187.1 on the My Oracle Support site.

   Note
   You can't download SQLT 12.1.160429 from the My Oracle Support site. Oracle has deprecated this older version.
2. Unzip the SQLT .zip file.
3. From a command prompt, change to the `sqlt/run` directory on your file system.
4. From the command prompt, open SQL*Plus, and connect to the DB instance as the master user.

   For information about connecting to a DB instance using SQL*Plus, see Connecting to a DB Instance Running the Oracle Database Engine (p. 874).
5. Get the SQL ID of a SQL statement:

```
SELECT SQL_ID FROM V$SQL WHERE SQL_TEXT='sql_statement';
```

Your output is similar to the following:

```
SQL_ID
-------------
chvsmttqjzjkn
```

6. Analyze a SQL statement with SQLT:

```
START sqltxtract.sql sql_id sqltxplain_user_password
```

   For example, for the SQL ID `chvsmttqjzjkn`, enter the following:

```
START sqltxtract.sql chvsmttqjzjkn sqltxplain_user_password
```

   SQLT generates the HTML report and related resources as a .zip file in the directory from which the SQLT command was run.

7. (Optional) To enable application users to diagnose SQL statements with SQLT, grant `SQLT_USER_ROLE` to each application user with the following statement:

```
GRANT SQLT_USER_ROLE TO application_user_name;
```

   Note
   Oracle does not recommend running SQLT with the `SYS` user or with users that have the `DBA` role. It is a best practice to run SQLT diagnostics using the application user's account, by granting `SQLT_USER_ROLE` to the application user.

Upgrading the SQLT Option

With Amazon RDS for Oracle, you can upgrade the SQLT option from your existing version to a higher version. To upgrade the SQLT option, complete steps 1–3 in Using SQLT (p. 982) for the new version of SQLT. Also, if you granted privileges for the previous version of SQLT in step 7 of that section, grant the privileges again for the new SQLT version.

Upgrading the SQLT option results in the loss of the older SQLT version's metadata. The older SQLT version's schema and related objects are dropped, and the newer version of SQLT is installed. For more information about the changes in the latest SQLT version, see Document 1614201.1 on the My Oracle Support site.

Note
Version downgrades are not supported.

Modifying SQLT Settings

After you enable SQLT, you can modify the `LICENSE_PACK` and `VERSION` settings for the option.

For more information about how to modify option settings, see Modifying an Option Setting (p. 195). For more information about each setting, see SQLT Option Settings (p. 980).

Removing the SQLT Option

You can remove SQLT from a DB instance.

To remove SQLT from a DB instance, do one of the following:

- To remove SQLT from multiple DB instances, remove the SQLT option from the option group to which the DB instances belong. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- To remove SQLT from a single DB instance, modify the DB instance and specify a different option group that doesn't include the SQLT option. You can specify the default (empty) option group or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle Statspack

The Oracle Statspack option installs and enables the Oracle Statspack performance statistics feature. Oracle Statspack is a collection of SQL, PL/SQL, and SQL*Plus scripts that collect, store, and display performance data. For information about using Oracle Statspack, see Oracle Statspack in the Oracle documentation.

> **Note**
> Oracle Statspack is no longer supported by Oracle and has been replaced by the more advanced Automatic Workload Repository (AWR). AWR is available only for Oracle Enterprise Edition customers who have purchased the Diagnostics Pack. Oracle Statspack can be used with any Oracle DB engine on Amazon RDS.

The following steps show you how to work with Oracle Statspack on Amazon RDS:

1. If you have an existing DB instance that has the PERFSTAT account already created and you want to use Oracle Statspack with it, you must drop the PERFSTAT account before adding the Statspack option to the option group associated with your DB instance. If you attempt to add the Statspack option to an option group associated with a DB instance that already has the PERFSTAT account created, you get an error and the RDS event RDS-Event-0058 is generated.

   If you have already installed Statspack, and the PERFSTAT account is associated with Statspack, then skip this step, and do not drop the PERFSTAT user.

   You can drop the PERFSTAT account by running the following command:

   ```
   DROP USER perfstat CASCADE;
   ```

2. Add the Statspack option to an option group and then associate that option group with your DB instance. Amazon RDS installs the Statspack scripts on the DB instance and then sets up the PERFSTAT

user account, the account you use to run the Statspack scripts. If you have installed Statspack, skip this step.

3. After Amazon RDS has installed Statspack on your DB instance, you must log in to the DB instance using your master user name and master password. You must then reset the PERFSTAT password from the randomly generated value Amazon RDS created when Statspack was installed. After you have reset the PERFSTAT password, you can log in using the PERFSTAT user account and run the Statspack scripts.

   Use the following command to reset the password:

   ```
   ALTER USER perfstat IDENTIFIED BY <new_password> ACCOUNT UNLOCK;
   ```

4. Starting with Oracle 19c, you must explicitly grant the `CREATE JOB` privilege to the PERFSTAT user. You can skip this step if you are using Oracle 18c or lower.

   Use the following command to grant the `CREATE JOB` privilege to the PERFSTAT user:

   ```
   GRANT CREATE JOB TO perfstat;
   ```

5. After you have logged on using the PERFSTAT account, you can either manually create a Statspack snapshot or create a job that will take a Statspack snapshot after a given time interval. For example, the following job creates a Statspack snapshot every hour:

   ```
   variable jn number;
   execute dbms_job.submit(:jn, 'statspack.snap;',sysdate,'trunc(SYSDATE+1/24,''HH24'')');
   commit;
   ```

6. Once you have created at least two Statspack snapshots, you can view them using the following query:

   ```
   select snap_id, snap_time from stats$snapshot order by 1;
   ```

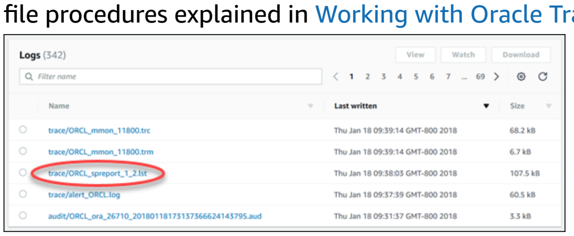
7. To create a Statspack report, you choose two snapshots to analyze and run the following Amazon RDS command:

   ```
   exec RDSADMIN.RDS_RUN_SPREPORT(<begin snap>,<end snap>);
   ```

   For example, the following Amazon RDS command would create a report based on the interval between Statspack snapshots 1 and 2:

   ```
   exec RDSADMIN.RDS_RUN_SPREPORT(1,2);
   ```

The file name of the Statspack report that is generated includes the number of the two Statspack snapshots used. For example, a report file created using Statspack snapshots 1 and 2 would be named ORCL_spreport_1_2.lst. You can download the Statspack report by selecting the report in the **Log** section of the DB instance details on the RDS console and choosing **Download** or you can use the trace file procedures explained in Working with Oracle Trace Files (p. 476).



If an error occurs when producing the report, an error file is created using the same naming conventions but with an extension of .err. For example, if an error occurred while creating a report using Statspack snapshots 1 and 7, the report file would be named ORCL_spreport_1_7.err. You can download the error report by selecting the report in the Log section of the RDS console and choosing **Download** or use the trace file procedures explained in Working with Oracle Trace Files (p. 476).

Oracle Statspack does some basic checking before running the report, so you could also see error messages displayed at the command prompt. For example, if you attempt to generate a report based on an invalid range, such as the beginning Statspack snapshot value is larger than the ending Statspack snapshot value, the error message is displayed at the command prompt and no error file is created.

```
exec RDSADMIN.RDS_RUN_SPREPORT(2,1);
*
ERROR at line 1:
ORA-20000: Invalid snapshot IDs. Find valid ones in perfstat.stats$snapshot.
```

If you use an invalid number for one of the Statspack snapshots, the error message will also be displayed at the command prompt. For example, if you have 20 Statspack snapshots but request that a report be run using Statspack snapshots 1 and 50, the command prompt will display an error.

```
exec RDSADMIN.RDS_RUN_SPREPORT(1,50);
*
ERROR at line 1:
ORA-20000: Could not find both snapshot IDs
```

For more information about how to use Oracle Statspack, including information on adjusting the amount of data captured by adjusting the snapshot level, go to the Oracle Statspack documentation page.

To remove Oracle Statspack files, use the following command:

```
execute statspack.purge(<begin snap>, <end snap>);
```

Oracle Time Zone

You can use the time zone option to change the system time zone used by your Oracle DB instance. For example, you might change the time zone of a DB instance to be compatible with an on-premises environment, or a legacy application. The time zone option changes the time zone at the host level. Changing the time zone impacts all date columns and values, including `SYSDATE` and `SYSTIMESTAMP`.

The time zone option differs from the `rdsadmin_util.alter_db_time_zone` command. The `alter_db_time_zone` command changes the time zone only for certain data types. The time zone option changes the time zone for all date columns and values. For more information about `alter_db_time_zone`, see Setting the Database Time Zone (p. 1014).

Prerequisites for Time Zone

The time zone option is a permanent and persistent option. You can't remove the option from an option group after you add it. You can't remove the option group from a DB instance after you add it. You can't modify the time zone setting of the option to a different time zone.

We strongly urge you to take a DB snapshot of your DB instance before adding the time zone option to a DB instance. By using a snapshot you can recover the DB instance if you set the time zone option incorrectly. For more information, see Creating a DB Snapshot (p. 301).

We strongly urge you to test the time zone option on a test DB instance before you add it to a production DB instance. Adding the time zone option can cause problems with tables that use system date to add dates or times. You should analyze your data and applications to determine the impact of changing the time zone.

Time Zone Option Settings

Amazon RDS supports the following settings for the time zone option.

Option Setting	Valid Values	Description
`TIME_ZONE`	One of the available time zones. For the full list, see Available Time Zones (p. 989).	The new time zone for your DB instance.

Adding the Time Zone Option

The general process for adding the time zone option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

When you add the time zone option, a brief outage occurs while your DB instance is automatically restarted.

Console

To add the time zone option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

a. For **Engine** choose the oracle edition for your DB instance.

b. For **Major engine version** choose the version of your DB instance.

For more information, see Creating an Option Group (p. 187).

2. Add the **Timezone** option to the option group, and configure the option settings.

   Important
   If you add the time zone option to an existing option group that is already attached to one or more DB instances, a brief outage occurs while all the DB instances are automatically restarted.

   For more information about adding options, see Adding an Option to an Option Group (p. 190). For more information about each setting, see Time Zone Option Settings (p. 987).

3. Apply the option group to a new or existing DB instance:

   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. When you add the time zone option to an existing DB instance, a brief outage occurs while your DB instance is automatically restarted. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

AWS CLI

The following example uses the AWS CLI add-option-to-option-group command to add the `Timezone` option and the `TIME_ZONE` option setting to an option group called `myoptiongroup`. The time zone is set to `Africa/Cairo`.

For Linux, macOS, or Unix:

```
aws rds add-option-to-option-group \
    --option-group-name "myoptiongroup" \
    --options "OptionName=Timezone,OptionSettings=[{Name=TIME_ZONE,Value=Africa/Cairo}]" \
    --apply-immediately
```

For Windows:

```
aws rds add-option-to-option-group ^
    --option-group-name "myoptiongroup" ^
    --options "OptionName=Timezone,OptionSettings=[{Name=TIME_ZONE,Value=Africa/Cairo}]" ^
    --apply-immediately
```

Modifying Time Zone Settings

The time zone option is a permanent and persistent option. You can't remove the option from an option group after you add it. You can't remove the option group from a DB instance after you add it. You can't modify the time zone setting of the option to a different time zone. If you set the time zone incorrectly, restore a snapshot of your DB instance from before you added the time zone option.

Removing the Time Zone Option

The time zone option is a permanent and persistent option. You can't remove the option from an option group after you add it. You can't remove the option group from a DB instance after you add it. To remove the time zone option, restore a snapshot of your DB instance from before you added the time zone option.

Available Time Zones

The following values can be used for the time zone option.

Zone	Time Zone
Africa	Africa/Cairo, Africa/Casablanca, Africa/Harare, Africa/Lagos, Africa/Luanda, Africa/Monrovia, Africa/Nairobi, Africa/Tripoli, Africa/Windhoek
America	America/Araguaina, America/Argentina/Buenos_Aires, America/Asuncion, America/Bogota, America/Caracas, America/Chicago, America/Chihuahua, America/Cuiaba, America/Denver, America/Detroit, America/Fortaleza, America/Godthab, America/Guatemala, America/Halifax, America/Lima, America/Los_Angeles, America/Manaus, America/Matamoros, America/Mexico_City, America/Monterrey, America/Montevideo, America/New_York, America/Phoenix, America/Santiago, America/Sao_Paulo, America/Tijuana, America/Toronto
Asia	Asia/Amman, Asia/Ashgabat, Asia/Baghdad, Asia/Baku, Asia/Bangkok, Asia/Beirut, Asia/Calcutta, Asia/Damascus, Asia/Dhaka, Asia/Hong_Kong, Asia/Irkutsk, Asia/Jakarta, Asia/Jerusalem, Asia/Kabul, Asia/Karachi, Asia/Kathmandu, Asia/Kolkata, Asia/Krasnoyarsk, Asia/Magadan, Asia/Manila, Asia/Muscat, Asia/Novosibirsk, Asia/Rangoon, Asia/Riyadh, Asia/Seoul, Asia/Shanghai, Asia/Singapore, Asia/Taipei, Asia/Tehran, Asia/Tokyo, Asia/Ulaanbaatar, Asia/Vladivostok, Asia/Yakutsk, Asia/Yerevan
Atlantic	Atlantic/Azores, Atlantic/Cape_Verde
Australia	Australia/Adelaide, Australia/Brisbane, Australia/Darwin, Australia/Eucla, Australia/Hobart, Australia/Lord_Howe, Australia/Perth, Australia/Sydney
Brazil	Brazil/DeNoronha, Brazil/East
Canada	Canada/Newfoundland, Canada/Saskatchewan
Etc	Etc/GMT-3
Europe	Europe/Amsterdam, Europe/Athens, Europe/Berlin, Europe/Dublin, Europe/Helsinki, Europe/Kaliningrad, Europe/London, Europe/Madrid, Europe/Moscow, Europe/Paris, Europe/Prague, Europe/Rome, Europe/Sarajevo
Pacific	Pacific/Apia, Pacific/Auckland, Pacific/Chatham, Pacific/Fiji, Pacific/Guam, Pacific/Honolulu, Pacific/Kiritimati, Pacific/Marquesas, Pacific/Samoa, Pacific/Tongatapu, Pacific/Wake
US	US/Alaska, US/Central, US/East-Indiana, US/Eastern, US/Pacific
UTC	UTC

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle Transparent Data Encryption

Amazon RDS supports Oracle Transparent Data Encryption (TDE), a feature of the Oracle Advanced Security option available in Oracle Enterprise Edition. This feature automatically encrypts data before it is written to storage and automatically decrypts data when the data is read from storage.

Oracle Transparent Data Encryption is used in scenarios where you need to encrypt sensitive data in case data files and backups are obtained by a third party or when you need to address security-related regulatory compliance issues.

The TDE option is a permanent option that can't be removed from an option group. You can't disable TDE from a DB instance once that instance is associated with an option group with the Oracle TDE option. You can change the option group of a DB instance that is using the TDE option, but the option group associated with the DB instance must include the TDE option. You can also modify an option group that includes the TDE option by adding or removing other options.

A detailed explanation about Oracle Transparent Data Encryption is beyond the scope of this guide. For information about using Oracle Transparent Data Encryption, see Securing Stored Data Using Transparent Data Encryption. For more information about Oracle Advanced Security, see Oracle Advanced Security in the Oracle documentation. For more information on AWS security, see the AWS Security Center.

> **Note**
> You can't share a DB snapshot that uses this option. For more information about sharing DB snapshots, see Sharing a DB Snapshot (p. 315).

TDE Encryption Modes

Oracle Transparent Data Encryption supports two encryption modes: TDE tablespace encryption and TDE column encryption. TDE tablespace encryption is used to encrypt entire application tables. TDE column encryption is used to encrypt individual data elements that contain sensitive data. You can also apply a hybrid encryption solution that uses both TDE tablespace and column encryption.

> **Note**
> Amazon RDS manages the Oracle Wallet and TDE master key for the DB instance. You do not need to set the encryption key using the command `ALTER SYSTEM set encryption key`.

For information about TDE best practices, see Oracle Advanced Security Transparent Data Encryption Best Practices.

Once the option is enabled, you can check the status of the Oracle Wallet by using the following command:

```
SELECT * FROM v$encryption_wallet;
```

To create an encrypted tablespace, use the following command:

```
CREATE TABLESPACE encrypt_ts ENCRYPTION DEFAULT STORAGE (ENCRYPT);
```

To specify the encryption algorithm, use the following command:

```
CREATE TABLESPACE encrypt_ts ENCRYPTION USING 'AES256' DEFAULT STORAGE (ENCRYPT);
```

Note that the previous commands for encrypting a tablespace are the same as the commands you would use with an Oracle installation not on Amazon RDS, and the ALTER TABLE syntax to encrypt a column is also the same as the commands you would use for an Oracle installation not on Amazon RDS.

You should determine if your DB instance is associated with an option group that has the **TDE** option. To view the option group that a DB instance is associated with, you can use the RDS console, the describe-db-instance AWS CLI command, or the API operation DescribeDBInstances.

To comply with several security standards, Amazon RDS is working to implement automatic periodic master key rotation.

Adding the TDE Option

The process for using Oracle Transparent Data Encryption (TDE) with Amazon RDS is as follows:

1. If the DB instance is not associated with an option group that has the **TDE** option enabled, you must either create an option group and add the **TDE** option or modify the associated option group to add the **TDE** option. For information about creating or modifying an option group, see Working with Option Groups (p. 186). For information about adding an option to an option group, see Adding an Option to an Option Group (p. 190).
2. Associate the DB instance with the option group with the **TDE** option. For information about associating a DB instance with an option group, see Modifying an Amazon RDS DB Instance (p. 220).

Removing the TDE Option

If you no longer want to use the TDE option with a DB instance, you must decrypt all your data on the DB instance, copy the data to a new DB instance that is not associated with an option group with TDE enabled, and then delete the original instance. You can rename the new instance to be the same name as the previous DB instance if you prefer.

Using TDE with Data Pump

You can use Oracle Data Pump to import or export encrypted dump files. Amazon RDS supports the password encryption mode (ENCRYPTION_MODE=PASSWORD) for Oracle Data Pump. Amazon RDS does not support transparent encryption mode (ENCRYPTION_MODE=TRANSPARENT) for Oracle Data Pump. For more information about using Oracle Data Pump with Amazon RDS, see Importing Using Oracle Data Pump (p. 896).

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle UTL_MAIL

Amazon RDS supports Oracle UTL_MAIL through the use of the UTL_MAIL option and SMTP servers. You can send email directly from your database by using the UTL_MAIL package. Amazon RDS supports UTL_MAIL for the following versions of Oracle:

- Oracle version 19.0.0.0, all versions
- Oracle version 18.0.0.0, all versions
- Oracle version 12.2.0.1, all versions
- Oracle version 12.1.0.2.v5 and later
- Oracle version 11.2.0.4.v9 and later

The following are some limitations to using UTL_MAIL:

- UTL_MAIL does not support Transport Layer Security (TLS) and therefore emails are not encrypted.

  To connect securely to remote SSL/TLS resources by creating and uploading custom Oracle wallets, follow the instructions in Using utl_http, utl_tcp, and utl_smtp with an Oracle DB Instance (p. 870).

  The specific certificates that are required for your wallet vary by service. For AWS services, these can typically be found in the Amazon Trust Services Repository.
- UTL_MAIL does not support authentication with SMTP servers.
- You can only send a single attachment in an email.
- You can't send attachments larger than 32 K.
- You can only use ASCII and Extended Binary Coded Decimal Interchange Code (EBCDIC) character encodings.
- SMTP port (25) is throttled based on the elastic network interface owner's policies.

When you enable UTL_MAIL, only the master user for your DB instance is granted the execute privilege. If necessary, the master user can grant the execute privilege to other users so that they can use UTL_MAIL.

> **Important**
> We recommend that you enable Oracle's built-in auditing feature to track the use of UTL_MAIL procedures.

Prerequisites for Oracle UTL_MAIL

The following are prerequisites for using Oracle UTL_MAIL:

- One or more SMTP servers, and the corresponding IP addresses or public or private Domain Name Server (DNS) names. For more information about private DNS names resolved through a custom DNS server, see Setting Up a Custom DNS Server (p. 1010).
- For Oracle versions prior to 12c, your DB instance must also use the XML DB option. For more information, see Oracle XML DB (p. 994).

Adding the Oracle UTL_MAIL Option

The general process for adding the Oracle UTL_MAIL option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.

3. Associate the option group with the DB instance.

After you add the UTL_MAIL option, as soon as the option group is active, UTL_MAIL is active.

To add the UTL_MAIL option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

    a. For **Engine**, choose the edition of Oracle you want to use.

    b. For **Major engine version**, choose the version of your DB instance.

    For more information, see Creating an Option Group (p. 187).
2. Add the **UTL_MAIL** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:

    - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
    - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Using Oracle UTL_MAIL

After you enable the UTL_MAIL option, you must configure the SMTP server before you can begin using it.

You configure the SMTP server by setting the SMTP_OUT_SERVER parameter to a valid IP address or public DNS name. For the SMTP_OUT_SERVER parameter, you can specify a comma-separated list of the addresses of multiple servers. If the first server is unavailable, UTL_MAIL tries the next server, and so on.

You can set the default SMTP_OUT_SERVER for a DB instance by using a DB parameter group. You can set the SMTP_OUT_SERVER parameter for a session by running the following code on your database on your DB instance.

```
ALTER SESSION SET smtp_out_server = mailserver.domain.com:25;
```

After the UTL_MAIL option is enabled, and your SMTP_OUT_SERVER is configured, you can send mail by using the `SEND` procedure. For more information, see UTL_MAIL in the Oracle documentation.

Removing the Oracle UTL_MAIL Option

You can remove Oracle UTL_MAIL from a DB instance.

To remove UTL_MAIL from a DB instance, do one of the following:

- To remove UTL_MAIL from multiple DB instances, remove the UTL_MAIL option from the option group they belong to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- To remove UTL_MAIL from a single DB instance, modify the DB instance and specify a different option group that doesn't include the UTL_MAIL option. You can specify the default (empty) option

group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Troubleshooting

The following are issues you might encounter when you use UTL_MAIL with Amazon RDS.

- Throttling. SMTP port (25) is throttled based on the elastic network interface owner's policies. If you can successfully send email by using UTL_MAIL, and you see the error `ORA-29278: SMTP transient error: 421 Service not available`, you are possibly being throttled. If you experience throttling with email delivery, we recommend that you implement a backoff algorithm. For more information about backoff algorithms, see Error Retries and Exponential Backoff in AWS and How to handle a "Throttling – Maximum sending rate exceeded" error.

  You can request that this throttle be removed. For more information, see How do I remove the throttle on port 25 from my EC2 instance?.

Related Topics

- Working with Option Groups (p. 186)
- Options for Oracle DB Instances (p. 914)

Oracle XML DB

Oracle XML DB adds native XML support to your DB instance. With XML DB, you can store and retrieve structured or unstructured XML, in addition to relational data.

XML DB is pre-installed on Oracle version 12c and later. Amazon RDS supports Oracle XML DB for version 11g through the use of the XMLDB option. After you apply the XMLDB option to your DB instance, you have full access to the Oracle XML DB repository; no post-installation tasks are required.

> **Note**
> The Amazon RDS XMLDB option does not provide support for the Oracle XML DB Protocol Server.

Adding the Oracle XML DB Option

The general process for adding the Oracle XML DB option to a DB instance is the following:

1. Create a new option group, or copy or modify an existing option group.
2. Add the option to the option group.
3. Associate the option group with the DB instance.

After you add the XML DB option, as soon as the option group is active, XML DB is active.

To add the XML DB option to a DB instance

1. Determine the option group you want to use. You can create a new option group or use an existing option group. If you want to use an existing option group, skip to the next step. Otherwise, create a custom DB option group with the following settings:

   a. For **Engine**, choose the edition of Oracle you want to use.
   b. For **Major engine version**, choose **11.2**.

For more information, see Creating an Option Group (p. 187).

2. Add the **XMLDB** option to the option group. For more information about adding options, see Adding an Option to an Option Group (p. 190).
3. Apply the option group to a new or existing DB instance:
   - For a new DB instance, you apply the option group when you launch the instance. For more information, see Creating an Amazon RDS DB Instance (p. 136).
   - For an existing DB instance, you apply the option group by modifying the instance and attaching the new option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Removing the Oracle XML DB Option

You can remove the XML DB option from a DB instance running version 11g.

To remove the XML DB option from a DB instance running version 11g, do one of the following:

- To remove the XMLDB option from multiple DB instances, remove the XMLDB option from the option group they belong to. This change affects all DB instances that use the option group. For more information, see Removing an Option from an Option Group (p. 198).
- To remove the XMLDB option from a single DB instance, modify the DB instance and specify a different option group that doesn't include the XMLDB option. You can specify the default (empty) option group, or a different custom option group. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Common DBA Tasks for Oracle DB Instances

Following, you can find a description for Amazon RDS–specific implementations of some common DBA tasks for RDS DB instances running the Oracle database engine. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and restricts access to certain system procedures and tables that require advanced privileges.

The following are common DBA tasks for DB instances running Oracle:

- System Tasks (p. 1001)

Disconnecting a Session (p. 1001)	Amazon RDS method: `rdsadmin.rdsadmin_util.disconnect` Oracle method: `alter system disconnect session`
Killing a Session (p. 1002)	Amazon RDS method: `rdsadmin.rdsadmin_util.kill` Oracle method: `alter system kill session`
Canceling a SQL Statement in a Session (p. 1002)	Amazon RDS method: `rdsadmin.rdsadmin_util.cancel` Oracle method: `alter system cancel sql`
Enabling and Disabling Restricted Sessions (p. 1003)	Amazon RDS method: `rdsadmin.rdsadmin_util.restricted_s` Oracle method: `alter system enable restricted session`
Flushing the Shared Pool (p. 1004)	Amazon RDS method: `rdsadmin.rdsadmin_util.flush_shared` Oracle method: `alter system flush shared_pool`
Flushing the Buffer Cache (p. 1004)	Amazon RDS method: `rdsadmin.rdsadmin_util.flush_buffer` Oracle method: `alter system flush buffer_cache`
Granting SELECT or EXECUTE Privileges to SYS Objects (p. 1004)	Amazon RDS method: `rdsadmin.rdsadmin_util.grant_sys_ob` Oracle method: `grant`
Revoking SELECT or EXECUTE Privileges on SYS Objects (p. 1006)	Amazon RDS method: `rdsadmin.rdsadmin_util.revoke_sys_o` Oracle method: `revoke`
Granting Privileges to Non-Master Users (p. 1006)	Amazon RDS method: `grant`

	Oracle method: `grant`
Creating Custom Functions to Verify Passwords (p. 1007)	Amazon RDS method: `rdsadmin.rdsadmin_password_verify.c` Amazon RDS method: `rdsadmin.rdsadmin_password_verify.c`
Setting Up a Custom DNS Server (p. 1010)	—

- Database Tasks (p. 1011)

Changing the Global Name of a Database (p. 1012)	Amazon RDS method: `rdsadmin.rdsadmin_util.rename_global_name` Oracle method: `alter database rename`
Creating and Sizing Tablespaces (p. 1012)	Amazon RDS method: `create tablespace` Oracle method: `alter database`
Setting the Default Tablespace (p. 1013)	Amazon RDS method: `rdsadmin.rdsadmin_util.alter_default_tablespace` Oracle method: `alter database default tablespace`
Setting the Default Temporary Tablespace (p. 1013)	Amazon RDS method: `rdsadmin.rdsadmin_util.alter_default_temp_tablespace` Oracle method: `alter database default temporary tablespace`
Checkpointing a Database (p. 1013)	Amazon RDS method: `rdsadmin.rdsadmin_util.checkpoint` Oracle method: `alter system checkpoint`
Setting Distributed Recovery (p. 1013)	Amazon RDS method: `rdsadmin.rdsadmin_util.enable_distr_recovery` Oracle method: `alter system enable distributed recovery`
Setting the Database Time Zone (p. 1014)	Amazon RDS method: `rdsadmin.rdsadmin_util.alter_db_time_zone` Oracle method: `alter database set time_zone`
Working with Oracle External Tables (p. 1014)	—
Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015)	Amazon RDS method: `rdsadmin.rdsadmin_diagnostic_util` procedures Oracle method: `dbms_workload_repository` package
Adjusting Database Links for Use with DB Instances in a VPC (p. 1019)	—

Setting the Default Edition for a DB Instance (p. 1019)	Amazon RDS method: `rdsadmin.rdsadmin_util.alter_default_edition` Oracle method: `alter database default edition`
Enabling Auditing for the SYS.AUD$ Table (p. 1019)	Amazon RDS method: `rdsadmin.rdsadmin_master_util.audit_all_sys_aud_table` Oracle method: `audit`
Disabling Auditing for the SYS.AUD$ Table (p. 1020)	Amazon RDS method: `rdsadmin.rdsadmin_master_util.noaudit_all_sys_aud_table` Oracle method: `noaudit`
Cleaning Up Interrupted Online Index Builds (p. 1020)	Amazon RDS method: `rdsadmin.rdsadmin_dbms_repair.online_index_clean` Oracle method: `dbms_repair.online_index_clean`
Skipping Corrupt Blocks (p. 1021)	Amazon RDS method: Several `rdsadmin.rdsadmin_dbms_repair` procedures Oracle method: `dbms_repair` package
Resizing the Temporary Tablespace in a Read Replica (p. 1023)	Amazon RDS method: `rdsadmin.rdsadmin_util.resize_temp_tablespace` or `rdsadmin.rdsadmin_util.resize_tempfile` procedure Oracle method: —
Purging the Recycle Bin (p. 1024)	Amazon RDS method: `exec rdsadmin.rdsadmin_util.purge_dba_recyclebin` Oracle method: `purge dba_recyclebin`

- Log Tasks (p. 1025)

Setting Force Logging (p. 1025)	Amazon RDS method: `rdsadmin.rdsadmin_util.force_loggin` Oracle method: `alter database force logging`
Setting Supplemental Logging (p. 1025)	Amazon RDS method: `rdsadmin.rdsadmin_util.alter_supple` Oracle method: `alter database add supplemental log`
Switching Online Log Files (p. 1026)	Amazon RDS method: `rdsadmin.rdsadmin_util.switch_logfi` Oracle method: `alter system switch logfile`

Modifying DBMS_SCHEDULER Jobs (p. 1049)	Amazon RDS method: `dbms_scheduler.set_attribute` Oracle method: `dbms_scheduler.set_attribute`
Disabling SYS-Owned Oracle Scheduler Jobs (p. 1049)	Amazon RDS method: `rdsadmin.rdsadmin_dbms_scheduler.di` Oracle method: `dbms_scheduler.disable`
Enabling SYS-Owned Oracle Scheduler Jobs (p. 1049)	Amazon RDS method: `rdsadmin.rdsadmin_dbms_scheduler.en` Oracle method: `dbms_scheduler.enable`
Modifying the Repeat Interval for Jobs of CALENDAR Type (p. 1050)	Amazon RDS method: `rdsadmin.rdsadmin_dbms_scheduler.se` Oracle method: `dbms_scheduler.set_attribute`
Modifying the Repeat Interval for Jobs of NAMED Type (p. 1050)	Amazon RDS method: `rdsadmin.rdsadmin_dbms_scheduler.se` Oracle method: `dbms_scheduler.set_attribute`

- Miscellaneous Tasks (p. 1051)

Creating New Directories in the Main Data Storage Space (p. 1051)	Amazon RDS method: `rdsadmin.rdsadmin_util.create_direc` Oracle method: `create directory`
Listing Files in a DB Instance Directory (p. 1052)	Amazon RDS method: `rdsadmin.rds_file_util.listdir` Oracle method: —
Reading Files in a DB Instance Directory (p. 1052)	Amazon RDS method: `rdsadmin.rds_file_util.read_text_fi` Oracle method: —

You can also use Amazon RDS procedures for Amazon S3 integration with Oracle and for running OEM Management Agent database tasks. For more information, see Amazon S3 Integration (p. 915) and Performing Database Tasks with the Management Agent (p. 947).

Common DBA System Tasks for Oracle DB Instances

Following, you can find how to perform certain common DBA tasks related to the system on your Amazon RDS DB instances running Oracle. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and restricts access to certain system procedures and tables that require advanced privileges.

Topics

Disconnecting a Session

To disconnect the current session by ending the dedicated server process, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.disconnect`. The `disconnect` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`sid`	number	—	Yes	The session identifier.
`serial`	number	—	Yes	The serial number of the session.
`method`	varchar	'IMMEDIATE'	No	Valid values are `'IMMEDIATE'` or `'POST_TRANSACTION'`.

The following example disconnects a session.

```
begin
    rdsadmin.rdsadmin_util.disconnect(
        sid    => sid,
        serial => serial_number);
end;
/
```

To get the session identifier and the session serial number, query the `V$SESSION` view. The following example gets all sessions for the user `AWSUSER`.

```
select SID, SERIAL#, STATUS from V$SESSION where USERNAME = 'AWSUSER';
```

The database must be open to use this method. For more information about disconnecting a session, see ALTER SYSTEM in the Oracle documentation.

Killing a Session

To kill a session, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.kill`. The `kill` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`sid`	number	—	Yes	The session identifier.
`serial`	number	—	Yes	The serial number of the session.
`method`	varchar	null	No	Valid values are `'IMMEDIATE'` or `'PROCESS'`.

The following example kills a session.

```
begin
    rdsadmin.rdsadmin_util.kill(
        sid    => sid,
        serial => serial_number);
end;
/
```

To get the session identifier and the session serial number, query the `V$SESSION` view. The following example gets all sessions for the user `AWSUSER`.

```
select SID, SERIAL#, STATUS from V$SESSION where USERNAME = 'AWSUSER';
```

You can specify either `IMMEDIATE` or `PROCESS` as a value for the `method` parameter. By specifying `PROCESS` as the `method` value, you can kill the processes associated with a session. Do this only if killing the session using `IMMEDIATE` as the `method` value was unsuccessful.

Canceling a SQL Statement in a Session

To cancel a SQL statement in a session, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.cancel`.

> **Note**
> This procedure is supported for Oracle version 18.0.0.0 and later.

The `cancel` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`sid`	number	—	Yes	The session identifier.
`serial`	number	—	Yes	The serial number of the session.

Parameter Name	Data Type	Default	Required	Description
sql_id	varchar2	null	No	The SQL identifier of the SQL statement.

The following example cancels a SQL statement in a session.

```
begin
    rdsadmin.rdsadmin_util.cancel(
        sid    => sid,
        serial => serial_number,
        sql_id => sql_id);
end;
/
```

To get the session identifier, the session serial number, and the SQL identifier of a SQL statement, query the `V$SESSION` view. The following example gets all sessions and SQL identifiers for the user `AWSUSER`.

```
select SID, SERIAL#, SQL_ID, STATUS from V$SESSION where USERNAME = 'AWSUSER';
```

Enabling and Disabling Restricted Sessions

To enable and disable restricted sessions, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.restricted_session`. The `restricted_session` procedure has the following parameters.

Parameter Name	Data Type	Default	Yes	Description
p_enable	boolean	true	No	Set to `true` to enable restricted sessions, `false` to disable restricted sessions.

The following example shows how to enable and disable restricted sessions.

```
/* Verify that the database is currently unrestricted. */

select LOGINS from V$INSTANCE;

LOGINS
-------
ALLOWED


/* Enable restricted sessions */

exec rdsadmin.rdsadmin_util.restricted_session(p_enable => true);


/* Verify that the database is now restricted. */

select LOGINS from V$INSTANCE;

LOGINS
----------
RESTRICTED
```

```
/* Disable restricted sessions */

exec rdsadmin.rdsadmin_util.restricted_session(p_enable => false);


/* Verify that the database is now unrestricted again. */

select LOGINS from V$INSTANCE;

LOGINS
-------
ALLOWED
```

Flushing the Shared Pool

To flush the shared pool, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.flush_shared_pool`. The `flush_shared_pool` procedure has no parameters.

The following example flushes the shared pool.

```
exec rdsadmin.rdsadmin_util.flush_shared_pool;
```

Flushing the Buffer Cache

To flush the buffer cache, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.flush_buffer_cache`. The `flush_buffer_cache` procedure has no parameters.

The following example flushes the buffer cache.

```
exec rdsadmin.rdsadmin_util.flush_buffer_cache;
```

Granting SELECT or EXECUTE Privileges to SYS Objects

Usually you transfer privileges by using roles, which can contain many objects. To grant privileges to a single object, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.grant_sys_object`. The procedure grants only privileges that the master account already has through a role or direct grant.

The `grant_sys_object` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_obj_name`	varchar2	—	Yes	The name of the object to grant privileges for. The object can be a directory, function, package, procedure, sequence, table, or view. Object names must be spelled exactly as they appear in `DBA_OBJECTS`. Most system objects are defined in uppercase, so we recommend that you try that first.

Parameter Name	Data Type	Default	Required	Description
`p_grantee`	varchar2	—	Yes	The name of the object to grant privileges to. The object can be a schema or a role.
`p_privilege`	varchar2	null	Yes	—
`p_grant_option`	boolean	false	No	Set to `true` to use the with grant option. The `p_grant_option` parameter is supported for Oracle versions 11.2.0.4.v8 and later, 12.1.0.2.v4 and later, all 12.2.0.1 versions, all 18.0.0.0 versions, and all 19.0.0 versions.

The following example grants select privileges on an object named `V_$SESSION` to a user named `USER1`.

```
begin
    rdsadmin.rdsadmin_util.grant_sys_object(
        p_obj_name  => 'V_$SESSION',
        p_grantee   => 'USER1',
        p_privilege => 'SELECT');
end;
/
```

The following example grants select privileges on an object named `V_$SESSION` to a user named `USER1` with the grant option.

```
begin
    rdsadmin.rdsadmin_util.grant_sys_object(
        p_obj_name     => 'V_$SESSION',
        p_grantee      => 'USER1',
        p_privilege    => 'SELECT',
        p_grant_option => true);
end;
/
```

To be able to grant privileges on an object, your account must have those privileges granted to it directly with the grant option, or via a role granted using `with admin option`. In the most common case, you may want to grant `SELECT` on a DBA view that has been granted to the `SELECT_CATALOG_ROLE` role. If that role isn't already directly granted to your user using `with admin option`, then you can't transfer the privilege. If you have the DBA privilege, then you can grant the role directly to another user.

The following example grants the `SELECT_CATALOG_ROLE` and `EXECUTE_CATALOG_ROLE` to `USER1`. Since the `with admin option` is used, `USER1` can now grant access to SYS objects that have been granted to `SELECT_CATALOG_ROLE`.

```
grant SELECT_CATALOG_ROLE to USER1 with admin option;
grant EXECUTE_CATALOG_ROLE to USER1 with admin option;
```

Objects already granted to `PUBLIC` do not need to be re-granted. If you use the `grant_sys_object` procedure to re-grant access, the procedure call succeeds.

Revoking SELECT or EXECUTE Privileges on SYS Objects

To revoke privileges on a single object, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.revoke_sys_object`. The procedure only revokes privileges that the master account already has by using a role or direct grant.

The `revoke_sys_object` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_obj_name`	varchar2	—	Yes	The name of the object to revoke privileges for. The object can be a directory, function, package, procedure, sequence, table, or view. Object names must be spelled exactly as they appear in `DBA_OBJECTS`. Most system objects are defined in upper case, so we recommend you try that first.
`p_revokee`	varchar2	—	Yes	The name of the object to revoke privileges for. The object can be a schema or a role.
`p_privilege`	varchar2	null	Yes	—

The following example revokes select privileges on an object named `V_$SESSION` from a user named `USER1`.

```
begin
    rdsadmin.rdsadmin_util.revoke_sys_object(
        p_obj_name  => 'V_$SESSION',
        p_revokee   => 'USER1',
        p_privilege => 'SELECT');
end;
/
```

Granting Privileges to Non-Master Users

You can grant select privileges for many objects in the `SYS` schema by using the `SELECT_CATALOG_ROLE` role. The `SELECT_CATALOG_ROLE` role gives users `SELECT` privileges on data dictionary views. The following example grants the role `SELECT_CATALOG_ROLE` to a user named `user1`.

```
grant SELECT_CATALOG_ROLE to user1;
```

You can grant execute privileges for many objects in the `SYS` schema by using the `EXECUTE_CATALOG_ROLE` role. The `EXECUTE_CATALOG_ROLE` role gives users `EXECUTE` privileges for packages and procedures in the data dictionary. The following example grants the role `EXECUTE_CATALOG_ROLE` to a user named *user1*.

```
grant EXECUTE_CATALOG_ROLE to user1;
```

The following example gets the permissions that the roles `SELECT_CATALOG_ROLE` and `EXECUTE_CATALOG_ROLE` allow.

```
  select *
    from ROLE_TAB_PRIVS
   where ROLE in ('SELECT_CATALOG_ROLE','EXECUTE_CATALOG_ROLE')
order by ROLE, TABLE_NAME asc;
```

The following example creates a non-master user named `user1`, grants the `CREATE SESSION` privilege, and grants the `SELECT` privilege on a database named *sh.sales*.

```
create user user1 identified by password;
grant CREATE SESSION to user1;
grant SELECT on sh.sales TO user1;
```

Creating Custom Functions to Verify Passwords

You can create a custom password verification function in two ways. If you want to use standard verification logic, and to store your function in the `SYS` schema, use the `create_verify_function` procedure. If you want to use custom verification logic, or you don't want to store your function in the `SYS` schema, use the `create_passthrough_verify_fcn` procedure.

The create_verify_function Procedure

The `create_verify_function` procedure is supported for Oracle version 11.2.0.4.v9 and later, Oracle version 12.1.0.2.v5 and later, all 12.2.0.1 versions, all 18.0.0.0 versions, and all 19.0.0 versions.

You can create a custom function to verify passwords by using the Amazon RDS procedure `rdsadmin.rdsadmin_password_verify.create_verify_function`. The `create_verify_function` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_verify_function_name`	varchar2	—	Yes	The name for your custom function. This function is created for you in the SYS schema. You assign this function to user profiles.
`p_min_length`	number	8	No	The minimum number of characters required.
`p_max_length`	number	256	No	The maximum number of characters allowed.
`p_min_letters`	number	1	No	The minimum number of letters required.
`p_min_uppercase`	number	0	No	The minimum number of uppercase letters required.
`p_min_lowercase`	number	0	No	The minimum number of lowercase letters required.

Parameter Name	Data Type	Default	Required	Description
`p_min_digits`	number	1	No	The minimum number of digits required.
`p_min_special`	number	0	No	The minimum number of special characters required.
`p_min_different_chars`	number	3	No	The minimum number of different characters required between the old and new password.
`p_disallow_username`	boolean	true	No	Set to `true` to disallow the username in the password.
`p_disallow_reverse`	boolean	true	No	Set to `true` to disallow the reverse of the user name in the password.
`p_disallow_db_name`	boolean	true	No	Set to `true` to disallow the database or server name in the password.
`p_disallow_simple_strings`	boolean	true	No	Set to `true` to disallow simple strings as the password.
`p_disallow_whitespace`	boolean	false	No	Set to `true` to disallow white space characters in the password.
`p_disallow_at_sign`	boolean	false	No	Set to `true` to disallow the @ character in the password.

You can create multiple password verification functions.

There are restrictions on the name of your custom function. Your custom function can't have the same name as an existing system object. The name can be no more than 30 characters long. Also, the name must include one of the following strings: `PASSWORD`, `VERIFY`, `COMPLEXITY`, `ENFORCE`, or `STRENGTH`.

The following example creates a function named `CUSTOM_PASSWORD_FUNCTION`. The function requires that a password has at least 12 characters, 2 uppercase characters, 1 digit, and 1 special character, and that the password disallows the @ character.

```
begin
    rdsadmin.rdsadmin_password_verify.create_verify_function(
        p_verify_function_name => 'CUSTOM_PASSWORD_FUNCTION',
        p_min_length           => 12,
        p_min_uppercase        => 2,
        p_min_digits           => 1,
        p_min_special          => 1,
        p_disallow_at_sign     => true);
end;
/
```

To see the text of your verification function, query `DBA_SOURCE`. The following example gets the text of a custom password function named `CUSTOM_PASSWORD_FUNCTION`.

```
col text format a150

  select TEXT
    from DBA_SOURCE
   where OWNER = 'SYS' and NAME = 'CUSTOM_PASSWORD_FUNCTION'
order by LINE;
```

To associate your verification function with a user profile, use `alter profile`. The following example associates a verification function with the `DEFAULT` user profile.

```
alter profile DEFAULT limit PASSWORD_VERIFY_FUNCTION CUSTOM_PASSWORD_FUNCTION;
```

To see what user profiles are associated with what verification functions, query `DBA_PROFILES`. The following example gets the profiles that are associated with the custom verification function named `CUSTOM_PASSWORD_FUNCTION`.

```

select * from DBA_PROFILES where RESOURCE_NAME = 'PASSWORD' and LIMIT =
 'CUSTOM_PASSWORD_FUNCTION';


PROFILE                    RESOURCE_NAME                    RESOURCE  LIMIT
-------------------------  -------------------------------- --------
 ------------------------
DEFAULT                    PASSWORD_VERIFY_FUNCTION         PASSWORD
 CUSTOM_PASSWORD_FUNCTION
```

The following example gets all profiles and the password verification functions that they are associated with.

```

select * from DBA_PROFILES where RESOURCE_NAME = 'PASSWORD_VERIFY_FUNCTION';


PROFILE                    RESOURCE_NAME                    RESOURCE  LIMIT
-------------------------  -------------------------------- --------
 ------------------------
DEFAULT                    PASSWORD_VERIFY_FUNCTION         PASSWORD
 CUSTOM_PASSWORD_FUNCTION
RDSADMIN                   PASSWORD_VERIFY_FUNCTION         PASSWORD  NULL
```

The create_passthrough_verify_fcn Procedure

The `create_passthrough_verify_fcn` procedure is supported for Oracle version 11.2.0.4.v11 and later, Oracle version 12.1.0.2.v7 and later, all 12.2.0.1 versions, all 18.0.0.0 versions, and all 19.0.0 versions.

You can create a custom function to verify passwords by using the Amazon RDS procedure `rdsadmin.rdsadmin_password_verify.create_passthrough_verify_fcn`. The `create_passthrough_verify_fcn` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_verify_function_name`	varchar2	—	Yes	The name for your custom verification function. This is a wrapper function that is created for you in the

Parameter Name	Data Type	Default	Required	Description
				SYS schema, and it doesn't contain any verification logic. You assign this function to user profiles.
`p_target_owner`	varchar2	—	Yes	The schema owner for your custom verification function.
`p_target_function_name`	varchar2	—	Yes	The name of your existing custom function that contains the verification logic. Your custom function must return a boolean. Your function should return `true` if the password is valid and `false` if the password is invalid.

The following example creates a password verification function that uses the logic from the function named `PASSWORD_LOGIC_EXTRA_STRONG`.

```
begin
    rdsadmin.rdsadmin_password_verify.create_passthrough_verify_fcn(
        p_verify_function_name => 'CUSTOM_PASSWORD_FUNCTION',
        p_target_owner         => 'TEST_USER',
        p_target_function_name => 'PASSWORD_LOGIC_EXTRA_STRONG');
end;
/
```

To associate the verification function with a user profile, use `alter profile`. The following example associates the verification function with the `DEFAULT` user profile.

```
alter profile DEFAULT limit PASSWORD_VERIFY_FUNCTION CUSTOM_PASSWORD_FUNCTION;
```

Setting Up a Custom DNS Server

Amazon RDS supports outbound network access on your DB instances running Oracle. For more information about outbound network access, including prerequisites, see Using utl_http, utl_tcp, and utl_smtp with an Oracle DB Instance (p. 870).

Amazon RDS Oracle allows Domain Name Service (DNS) resolution from a custom DNS server owned by the customer. You can resolve only fully qualified domain names from your Amazon RDS DB instance through your custom DNS server.

After you set up your custom DNS name server, it takes up to 30 minutes to propagate the changes to your DB instance. After the changes are propagated to your DB instance, all outbound network traffic requiring a DNS lookup queries your DNS server over port 53.

To set up a custom DNS server for your Amazon RDS for Oracle DB instance, do the following:

- From the DHCP options set attached to your virtual private cloud (VPC), set the `domain-name-servers` option to the IP address of your DNS name server. For more information, see DHCP Options Sets.

> **Note**
> The `domain-name-servers` option accepts up to four values, but your Amazon RDS DB instance uses only the first value.

- Ensure that your DNS server can resolve all lookup queries, including public DNS names, Amazon EC2 private DNS names, and customer-specific DNS names. If the outbound network traffic contains any DNS lookups that your DNS server can't handle, your DNS server must have appropriate upstream DNS providers configured.
- Configure your DNS server to produce User Datagram Protocol (UDP) responses of 512 bytes or less.
- Configure your DNS server to produce Transmission Control Protocol (TCP) responses of 1024 bytes or less.
- Configure your DNS server to allow inbound traffic from your Amazon RDS DB instances over port 53. If your DNS server is in an Amazon VPC, the VPC must have a security group that contains inbound rules that allow UDP and TCP traffic on port 53. If your DNS server is not in an Amazon VPC, it must have appropriate firewall whitelisting to allow UDP and TCP inbound traffic on port 53.

  For more information, see Security Groups for Your VPC and Adding and Removing Rules.
- Configure the VPC of your Amazon RDS DB instance to allow outbound traffic over port 53. Your VPC must have a security group that contains outbound rules that allow UDP and TCP traffic on port 53.

  For more information, see Security Groups for Your VPC and Adding and Removing Rules.
- The routing path between the Amazon RDS DB instance and the DNS server has to be configured correctly to allow DNS traffic.
  - If the Amazon RDS DB instance and the DNS server are not in the same VPC, a peering connection has to be set up between them. For more information, see What is VPC Peering?

Common DBA Database Tasks for Oracle DB Instances

Following, you can find how to perform certain common DBA tasks related to databases on your Amazon RDS DB instances running Oracle. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances. Amazon RDS also restricts access to some system procedures and tables that require advanced privileges.

Topics

Changing the Global Name of a Database

To change the global name of a database, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.rename_global_name`. The `rename_global_name` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_new_global_name`	varchar2	—	Yes	The new global name for the database.

The database must be open for the name change to occur. For more information about changing the global name of a database, see ALTER DATABASE in the Oracle documentation.

The following example changes the global name of a database to `new_global_name`.

```
exec rdsadmin.rdsadmin_util.rename_global_name(p_new_global_name => 'new_global_name');
```

Creating and Sizing Tablespaces

Amazon RDS only supports Oracle Managed Files (OMF) for data files, log files, and control files. When you create data files and log files, you can't specify the physical file names.

By default, tablespaces are created with auto-extend enabled, and no maximum size. Because of these default settings, tablespaces can grow to consume all allocated storage. We recommend that you specify an appropriate maximum size on permanent and temporary tablespaces, and that you carefully monitor space usage.

The following example creates a tablespace named `users2` with a starting size of 1 gigabyte and a maximum size of 10 gigabytes:

```
create tablespace users2 datafile size 1G autoextend on maxsize 10G;
```

The following example creates temporary tablespace named `temp01`:

```
create temporary tablespace temp01;
```

We recommend that you don't use smallfile tablespaces because you can't resize smallfile tablespaces with Amazon RDS for Oracle. However, you can add a datafile to a smallfile tablespace.

You can resize a bigfile tablespace by using `ALTER TABLESPACE`. You can specify the size in kilobytes (K), megabytes (M), gigabytes (G), or terabytes (T).

The following example resizes a bigfile tablespace named `users2` to 200 MB.

```
alter tablespace users2 resize 200M;
```

The following example adds an additional datafile to a smallfile tablespace named **`users2`**.

```
alter tablespace users2 add datafile size 100000M autoextend on next 250m
 maxsize UNLIMITED;
```

Setting the Default Tablespace

To set the default tablespace, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.alter_default_tablespace`. The `alter_default_tablespace` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`tablespace_name`	varchar	—	Yes	The name of the default tablespace.

The following example sets the default tablespace to *users2*:

```
exec rdsadmin.rdsadmin_util.alter_default_tablespace(tablespace_name => 'users2');
```

Setting the Default Temporary Tablespace

To set the default temporary tablespace, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.alter_default_temp_tablespace`. The `alter_default_temp_tablespace` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`tablespace_name`	varchar	—	Yes	The name of the default temporary tablespace.

The following example sets the default temporary tablespace to *temp01*.

```
exec rdsadmin.rdsadmin_util.alter_default_temp_tablespace(tablespace_name => 'temp01');
```

Checkpointing a Database

To checkpoint the database, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.checkpoint`. The `checkpoint` procedure has no parameters.

The following example checkpoints the database.

```
exec rdsadmin.rdsadmin_util.checkpoint;
```

Setting Distributed Recovery

To set distributed recovery, use the Amazon RDS procedures `rdsadmin.rdsadmin_util.enable_distr_recovery` and `disable_distr_recovery`. The procedures have no parameters.

The following example enables distributed recovery.

```
exec rdsadmin.rdsadmin_util.enable_distr_recovery;
```

The following example disables distributed recovery.

```
exec rdsadmin.rdsadmin_util.disable_distr_recovery;
```

Setting the Database Time Zone

There are two different ways that you can set the time zone of your Amazon RDS Oracle database:

- You can use the `Timezone` option.

  The `Timezone` option changes the time zone at the host level and impacts all date columns and values such as `SYSDATE`. For more information about the `Timezone` option, see Oracle Time Zone (p. 987).

- You can use the Amazon RDS procedure `rdsadmin.rdsadmin_util.alter_db_time_zone`.

  The `alter_db_time_zone` procedure changes the time zone for only certain data types, and doesn't change `SYSDATE`. There are additional restrictions on setting the time zone listed in the Oracle documentation.

The `alter_db_time_zone` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_new_tz`	varchar2	—	Yes	The new time zone as a named region or an absolute offset from Coordinated Universal Time (UTC). Valid offsets range from -12:00 to +14:00.

The following example changes the time zone to UTC plus 3 hours.

```
exec rdsadmin.rdsadmin_util.alter_db_time_zone(p_new_tz => '+3:00');
```

The following example changes the time zone to the time zone of the Africa/Algiers region.

```
exec rdsadmin.rdsadmin_util.alter_db_time_zone(p_new_tz => 'Africa/Algiers');
```

After you alter the time zone by using the `alter_db_time_zone` procedure, you must reboot the DB instance for the change to take effect. For more information, see Rebooting a DB Instance (p. 247).

Working with Oracle External Tables

Oracle external tables are tables with data that is not in the database. Instead, the data is in external files that the database can access. By using external tables, you can access data without loading it into the database. For more information about external tables, see Managing External Tables in the Oracle documentation.

With Amazon RDS, you can store external table files in directory objects. You can create a directory object, or you can use one that is predefined in the Oracle database, such as the DATA_PUMP_DIR directory. For information about creating directory objects, see Creating New Directories in the Main Data Storage Space (p. 1051). You can query the ALL_DIRECTORIES view to list the directory objects for your Amazon RDS Oracle DB instance.

Note
Directory objects point to the main data storage space (Amazon EBS volume) used by your instance. The space used—along with data files, redo logs, audit, trace, and other files—counts against allocated storage.

You can move an external data file from one Oracle database to another by using the DBMS_FILE_TRANSFER package or the UTL_FILE package. The external data file is moved from a directory on the source database to the specified directory on the destination database. For information about using DBMS_FILE_TRANSFER, see Importing Using Oracle Data Pump (p. 896).

After you move the external data file, you can create an external table with it. The following example creates an external table that uses the `emp_xt_file1.txt` file in the USER_DIR1 directory.

```
CREATE TABLE emp_xt (
  emp_id      NUMBER,
  first_name  VARCHAR2(50),
  last_name   VARCHAR2(50),
  user_name   VARCHAR2(20)
)
ORGANIZATION EXTERNAL (
  TYPE ORACLE_LOADER
  DEFAULT DIRECTORY USER_DIR1
  ACCESS PARAMETERS (
    RECORDS DELIMITED BY NEWLINE
    FIELDS TERMINATED BY ','
    MISSING FIELD VALUES ARE NULL
    (emp_id,first_name,last_name,user_name)
  )
  LOCATION ('emp_xt_file1.txt')
)
PARALLEL
REJECT LIMIT UNLIMITED;
```

Suppose that you want to move data that is in an Amazon RDS Oracle DB instance into an external data file. In this case, you can populate the external data file by creating an external table and selecting the data from the table in the database. For example, the following SQL statement creates the `orders_xt` external table by querying the `orders` table in the database.

```
CREATE TABLE orders_xt
  ORGANIZATION EXTERNAL
   (
     TYPE ORACLE_DATAPUMP
     DEFAULT DIRECTORY DATA_PUMP_DIR
     LOCATION ('orders_xt.dmp')
   )
   AS SELECT * FROM orders;
```

In this example, the data is populated in the `orders_xt.dmp` file in the DATA_PUMP_DIR directory.

Generating Performance Reports with Automatic Workload Repository (AWR)

To gather performance data and generate reports, Oracle recommends Automatic Workload Repository (AWR). AWR requires Oracle Database Enterprise Edition and a license for the Diagnostics and Tuning packs. To enable AWR, set the `CONTROL_MANAGEMENT_PACK_ACCESS` initialization parameter to either `DIAGNOSTIC` or `DIAGNOSTIC+TUNING`.

Working with AWR Reports in RDS

To generate AWR reports, you can run scripts such as `awrrpt.sql`. These scripts are installed on the database host server. In Amazon RDS, you don't have direct access to the host. However, you can get copies of SQL scripts from another installation of Oracle Database.

You can also use AWR by running procedures in the `SYS.DBMS_WORKLOAD_REPOSITORY` PL/SQL package. You can use this package to manage baselines and snapshots, and also to display ASH and AWR reports. For example, to generate an AWR report in text format run the `DBMS_WORKLOAD_REPOSITORY.AWR_REPORT_TEXT` procedure. However, you can't reach these AWR reports from the AWS Management Console.

When working with AWR, we recommend using the `rdsadmin.rdsadmin_diagnostic_util` procedures. You can use these procedures to generate the following:

- AWR reports
- Active Session History (ASH) reports
- Automatic Database Diagnostic Monitor (ADDM) reports
- Oracle Data Pump Export dump files of AWR data

The `rdsadmin_diagnostic_util` procedures save the reports to the DB instance file system. You can access these reports from the console. You can also access reports using the `rdsadmin.rds_file_util` procedures, and you can access reports that are copied to Amazon S3 using the S3 Integration option. For more information, see Reading Files in a DB Instance Directory (p. 1052) and Amazon S3 Integration (p. 915).

You can use the `rdsadmin_diagnostic_util` procedures in the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v24 or higher 11.2 versions
- 12.1.0.2.v20 or higher 12.1 versions
- 12.2.0.2.ru-2020-04.rur-2020-04.r1 or higher 12.2 versions
- 18.0.0.0.ru-2020-04.rur-2020-04.r1 or higher 18c versions
- 19.0.0.0.ru-2020-04.rur-2020-04.r1 or higher 19c versions

Common Parameters for the Diagnostic Utility Package

You typically use the following parameters when managing AWR and ADDM with the rdsadmin_diagnostic_util package.

Parameter	Data Type	Defaul	Requir	Description
`begin_snap_id`	`NUMBER`	—	Yes	The ID of the beginning snapshot.
`end_snap_id`	`NUMBER`	—	Yes	The ID of the ending snapshot.
`dump_directory`	`VARCHAR2`	`BDUMP`	No	The directory to write the report or export file to. If you specify a nondefault directory, the user that runs the `rdsadmin_diagnostic_util` procedures must have write permissions for the directory.
`report_type`	`VARCHAR2`	`HTML`	No	The format of the report. Valid values are `TEXT` and `HTML`.
`dbid`	`NUMBER`	—	No	A valid database identifier (DBID) shown in the `DBA_HIST_DATABASE_INSTANCE` view for Oracle. If this

Parameter	Data Type	Defaul	Requir	Description
				parameter is not specified, RDS uses the current DBID, which is shown in the `V$DATABASE.DBID` view.

You typically use the following parameters when managing ASH with the rdsadmin_diagnostic_util package.

Parameter	Data Type	Default	Require	Description
`begin_time`	`DATE`	—	Yes	The beginning time of the ASH analysis.
`end_time`	`DATE`	—	Yes	The ending time of the ASH analysis.
`slot_width`	`NUMBER`	0	No	The duration of the slots (in seconds) used in the "Top Activity" section of the ASH report. If this parameter isn't specified, the time interval between `begin_time` and `end_time` uses no more than 10 slots.
`sid`	`NUMBER`	Null	No	The session ID.
`sql_id`	`VARCHAR2`	Null	No	The SQL ID.
`wait_class`	`VARCHAR2`	Null	No	The wait class name.
`service_hash`	`NUMBER`	Null	No	The service name hash.
`module_name`	`VARCHAR2`	Null	No	The module name.
`action_name`	`VARCHAR2`	Null	No	The action name.
`client_id`	`VARCHAR2`	Null	No	The application-specific ID of the database session.
`plsql_entry`	`VARCHAR2`	Null	No	The PL/SQL entry point.

Generating an AWR Report

To generate an AWR report, use the `rdsadmin.rdsadmin_diagnostic_util.awr_report` procedure.

The following example generates a AWR report for the snapshot range 101–106. The output text file is named `awrrpt_101_106.txt`. You can access this report from the AWS Management Console.

```
exec rdsadmin.rdsadmin_diagnostic_util.awr_report(101,106,'TEXT');
```

The following example generates an HTML report for the snapshot range 63–65. The output HTML file is named `awrrpt_63_65.html`. The procedure writes the report to the nondefault database directory named `AWR_RPT_DUMP`.

```
exec rdsadmin.rdsadmin_diagnostic_util.awr_report(63,65,'HTML','AWR_RPT_DUMP');
```

Extracting AWR Data into a Dump File

To extract AWR data into a dump file, use the `rdsadmin.rdsadmin_diagnostic_util.awr_extract` procedure.

The following example extracts the snapshot range 101–106. The output dump file is named awrextract_101_106.dmp. You can access this file through the console.

```
exec rdsadmin.rdsadmin_diagnotic_util.awr_extract(101,106);
```

The following example extracts the snapshot range 63–65. The output dump file is named awrextract_63_65.dmp. The file is stored in the nondefault database directory named AWR_RPT_DUMP.

```
exec rdsadmin.rdsadmin_diagnostic_util.awr_extract(63,65,'AWR_RPT_DUMP');
```

Generating an ADDM Report

To generate an ADDM report, use the rdsadmin.rdsadmin_diagnostic_util.addm_report procedure.

The following example generates an ADDM report for the snapshot range 101–106. The output text file is named addmrpt_101_106.txt. You can access the report through the console.

```
exec rdsadmin.rdsadmin_diagnostic_util.addm_report(101,106);
```

The following example generates an ADDM report for the snapshot range 63–65. The output text file is named addmrpt_63_65.txt. The file is stored in the nondefault database directory named ADDM_RPT_DUMP.

```
exec rdsadmin.rdsadmin_diagnostic_util.addm_report(63,65,'ADDM_RPT_DUMP');
```

Generating an ASH Report

To generate an ASH report, use the rdsadmin.rdsadmin_diagnostic_util.ash_report procedure.

The following example generates an ASH report that includes the data from 14 minutes ago until the current time. The name of the output file uses the format ashrpt*begin_timeend_time*.txt, where *begin_time* and *end_time* use the format YYYYMMDDHH24MISS. You can access the file through the console.

```
BEGIN
    rdsadmin.rdsadmin_diagnostic_util.ash_report(
        begin_time     =>     SYSDATE-14/1440,
        end_time       =>     SYSDATE,
        report_type    =>     'TEXT');
END;
/
```

The following example generates an ASH report that includes the data from November 18, 2019, at 6:07 PM through November 18, 2019, at 6:15 PM. The name of the output HTML report is ashrpt_20190918180700_20190918181500.html. The report is stored in the nondefault database directory named AWR_RPT_DUMP.

```
BEGIN
    rdsadmin.rdsadmin_diagnostic_util.ash_report(
        begin_time     =>    TO_DATE('2019-09-18 18:07:00', 'YYYY-MM-DD HH24:MI:SS'),
        end_time       =>    TO_DATE('2019-09-18 18:15:00', 'YYYY-MM-DD HH24:MI:SS'),
        report_type    =>    'html',
        dump_directory =>    'AWR_RPT_DUMP');
END;
/
```

Accessing AWR Reports from the Console or CLI

To access AWR reports or export dump files, you can use the AWS Management Console or AWS CLI. For more information, see Downloading a Database Log File (p. 453).

Adjusting Database Links for Use with DB Instances in a VPC

To use Oracle database links with Amazon RDS DB instances inside the same virtual private cloud (VPC) or peered VPCs, the two DB instances should have a valid route between them. Verify the valid route between the DB instances by using your VPC routing tables and network access control list (ACL).

The security group of each DB instance must allow ingress to and egress from the other DB instance. The inbound and outbound rules can refer to security groups from the same VPC or a peered VPC. For more information, see Updating Your Security Groups to Reference Peered VPC Security Groups.

If you have configured a custom DNS server using the DHCP Option Sets in your VPC, your custom DNS server must be able to resolve the name of the database link target. For more information, see Setting Up a Custom DNS Server (p. 1010).

For more information about using database links with Oracle Data Pump, see Importing Using Oracle Data Pump (p. 896).

Setting the Default Edition for a DB Instance

You can redefine database objects in a private environment called an edition. You can use edition-based redefinition to upgrade an application's database objects with minimal downtime.

You can set the default edition of an Amazon RDS Oracle DB instance using the Amazon RDS procedure `rdsadmin.rdsadmin_util.alter_default_edition`.

The following example sets the default edition for the Amazon RDS Oracle DB instance to `RELEASE_V1`.

```
exec rdsadmin.rdsadmin_util.alter_default_edition('RELEASE_V1');
```

The following example sets the default edition for the Amazon RDS Oracle DB instance back to the Oracle default.

```
exec rdsadmin.rdsadmin_util.alter_default_edition('ORA$BASE');
```

For more information about Oracle edition-based redefinition, see About Editions and Edition-Based Redefinition in the Oracle documentation.

Enabling Auditing for the SYS.AUD$ Table

To enable auditing on the database audit trail table `SYS.AUD$`, use the Amazon RDS procedure `rdsadmin.rdsadmin_master_util.audit_all_sys_aud_table`. The only supported audit property is `ALL`. You can't audit or not audit individual statements or operations.

Enabling auditing is supported for Oracle DB instances running the following versions:

- 11.2.0.4.v18 and later 11.2 versions
- 12.1.0.2.v14 and later 12.1 versions
- All 12.2.0.1 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

The `audit_all_sys_aud_table` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_by_access`	boolean	true	No	Set to `true` to audit `BY ACCESS`. Set to `false` to audit `BY SESSION`.

The following query returns the current audit configuration for `SYS.AUD$` for a database.

```
select * from dba_obj_audit_opts where owner='SYS' and object_name='AUD$';
```

The following commands enable audit of `ALL` on `SYS.AUD$` `BY ACCESS`.

```
exec rdsadmin.rdsadmin_master_util.audit_all_sys_aud_table;

exec rdsadmin.rdsadmin_master_util.audit_all_sys_aud_table(p_by_access => true);
```

The following command enables audit of `ALL` on `SYS.AUD$` `BY SESSION`.

```
exec rdsadmin.rdsadmin_master_util.audit_all_sys_aud_table(p_by_access => false);
```

For more information, see AUDIT (Traditional Auditing) in the Oracle documentation.

Disabling Auditing for the SYS.AUD$ Table

To disable auditing on the database audit trail table `SYS.AUD$`, use the Amazon RDS procedure `rdsadmin.rdsadmin_master_util.noaudit_all_sys_aud_table`. This procedure takes no parameters.

The following query returns the current audit configuration for `SYS.AUD$` for a database:

```
select * from dba_obj_audit_opts where owner='SYS' and object_name='AUD$';
```

The following command disables audit of `ALL` on `SYS.AUD$`.

```
exec rdsadmin.rdsadmin_master_util.noaudit_all_sys_aud_table;
```

For more information, see NOAUDIT (Traditional Auditing) in the Oracle documentation.

Cleaning Up Interrupted Online Index Builds

To clean up failed online index builds, use the Amazon RDS procedure `rdsadmin.rdsadmin_dbms_repair.online_index_clean`.

The `online_index_clean` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`object_id`	binary_integer	`ALL_INDEX_ID`	No	The object ID of the index. Typically, you can use the object ID from the ORA-08104 error text.
`wait_for_lock`	binary_integer	`rdsadmin.rdsadmin_dbms_repair.lock_wait`	No	Specify `rdsadmin.rdsadmin_dbms_repair.lo`, the default, to try to get a lock on the underlying object and retry until an internal limit is reached if the lock fails. Specify `rdsadmin.rdsadmin_dbms_repair.lo` to try to get a lock on the underlying object but not retry if the lock fails.

The following example cleans up a failed online index build:

```
declare
  is_clean boolean;
begin
  is_clean := rdsadmin.rdsadmin_dbms_repair.online_index_clean(
    object_id     => 1234567890,
    wait_for_lock => rdsadmin.rdsadmin_dbms_repair.lock_nowait
  );
end;
 /
```

For more information, see ONLINE_INDEX_CLEAN Function in the Oracle documentation.

Skipping Corrupt Blocks

To skip corrupt blocks during index and tables scans, use the `rdsadmin.rdsadmin_dbms_repair` package.

The following procedures wrap the functionality of the `sys.dbms_repair.admin_table` procedure and take no parameters:

- `rdsadmin.rdsadmin_dbms_repair.create_repair_table`
- `rdsadmin.rdsadmin_dbms_repair.create_orphan_keys_table`
- `rdsadmin.rdsadmin_dbms_repair.drop_repair_table`
- `rdsadmin.rdsadmin_dbms_repair.drop_orphan_keys_table`
- `rdsadmin.rdsadmin_dbms_repair.purge_repair_table`
- `rdsadmin.rdsadmin_dbms_repair.purge_orphan_keys_table`

These procedures take no parameters.

The following procedures take the same parameters as their counterparts in the `DBMS_REPAIR` package for Oracle databases:

- `rdsadmin.rdsadmin_dbms_repair.check_object`
- `rdsadmin.rdsadmin_dbms_repair.dump_orphan_keys`
- `rdsadmin.rdsadmin_dbms_repair.fix_corrupt_blocks`
- `rdsadmin.rdsadmin_dbms_repair.rebuild_freelists`
- `rdsadmin.rdsadmin_dbms_repair.segment_fix_status`
- `rdsadmin.rdsadmin_dbms_repair.skip_corrupt_blocks`

Each procedure takes the same parameters as the corresponding procedure in the `DBMS_REPAIR` package for Oracle databases. For more information about the parameters for these procedures, see DBMS_REPAIR in the Oracle documentation.

Complete the following steps to skip corrupt blocks during index and table scans.

1. Run the following procedures to create repair tables if they don't already exist.

```
exec rdsadmin.rdsadmin_dbms_repair.create_repair_table;
exec rdsadmin.rdsadmin_dbms_repair.create_orphan_keys_table;
```

2. Run the following procedures to check for existing records and purge them if appropriate.

```
select count(*) from SYS.REPAIR_TABLE;
select count(*) from SYS.ORPHAN_KEY_TABLE;
select count(*) from SYS.DBA_REPAIR_TABLE;
select count(*) from SYS.DBA_ORPHAN_KEY_TABLE;

exec rdsadmin.rdsadmin_dbms_repair.purge_repair_table;
exec rdsadmin.rdsadmin_dbms_repair.purge_orphan_keys_table;
```

3. Run the following procedure to check for corrupt blocks.

```
set serveroutput on
declare v_num_corrupt int;
begin
  v_num_corrupt := 0;
  rdsadmin.rdsadmin_dbms_repair.check_object (
    schema_name => '&corruptionOwner',
    object_name => '&corruptionTable',
    corrupt_count =>  v_num_corrupt
  );
dbms_output.put_line('number corrupt: '||to_char(v_num_corrupt));
end;
/

col corrupt_description format a30
col repair_description format a30
select object_name, block_id, corrupt_type, marked_corrupt, corrupt_description,
 repair_description from sys.repair_table;

select skip_corrupt from dba_tables where owner = '&corruptionOwner' and table_name =
 '&corruptionTable';
```

4. Run the following procedure to enable corruption skipping for affected tables.

```
begin
  rdsadmin.rdsadmin_dbms_repair.skip_corrupt_blocks (
    schema_name => '&corruptionOwner',
    object_name => '&corruptionTable',
    object_type => rdsadmin.rdsadmin_dbms_repair.table_object,
    flags => rdsadmin.rdsadmin_dbms_repair.skip_flag);
end;
/
select skip_corrupt from dba_tables where owner = '&corruptionOwner' and table_name =
 '&corruptionTable';
```

5. Run the following procedure to disable corruption skipping.

```
begin
  rdsadmin.rdsadmin_dbms_repair.skip_corrupt_blocks (
    schema_name => '&corruptionOwner',
    object_name => '&corruptionTable',
    object_type => rdsadmin.rdsadmin_dbms_repair.table_object,
    flags => rdsadmin.rdsadmin_dbms_repair.noskip_flag);
end;
/

select skip_corrupt from dba_tables where owner = '&corruptionOwner' and table_name =
 '&corruptionTable';
```

6. Run the following procedures to drop the repair tables.

```
exec rdsadmin.rdsadmin_dbms_repair.drop_repair_table;
exec rdsadmin.rdsadmin_dbms_repair.drop_orphan_keys_table;
```

Resizing the Temporary Tablespace in a Read Replica

By default, Oracle tablespaces are created with auto-extend enabled and no maximum size. Because of these default settings, tablespaces can grow too large in some cases. We recommend that you specify an appropriate maximum size on permanent and temporary tablespaces, and that you carefully monitor space usage.

To resize the temporary space in a read replica for an Oracle DB instance, use either the `rdsadmin.rdsadmin_util.resize_temp_tablespace` or the `rdsadmin.rdsadmin_util.resize_tempfile` Amazon RDS procedure.

The `resize_temp_tablespace` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`temp_tbs`	varchar2	—	Yes	The name of the temporary tablespace to resize.
`size`	varchar2	—	Yes	You can specify the size in bytes (the default),

Parameter Name	Data Type	Default	Required	Description
				kilobytes (K), megabytes (M), or gigabytes (G).

The `resize_tempfile` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`file_id`	binary_integer	—	Yes	The file identifier of the temporary tablespace to resize.
`size`	varchar2	—	Yes	You can specify the size in bytes (the default), kilobytes (K), megabytes (M), or gigabytes (G).

The following examples resize a temporary tablespace named `TEMP` to the size of 4 gigabytes on a read replica.

```
exec rdsadmin.rdsadmin_util.resize_temp_tablespace('TEMP','4G');
```

```
exec rdsadmin.rdsadmin_util.resize_temp_tablespace('TEMP','4096000000');
```

The following example resizes a temporary tablespace based on the tempfile with the file identifier `1` to the size of 2 megabytes on a read replica.

```
exec rdsadmin.rdsadmin_util.resize_tempfile(1,'2M');
```

For more information about read replicas for Oracle DB instances, see Working with Oracle Read Replicas for Amazon RDS (p. 908).

Purging the Recycle Bin

When you drop a table, your Oracle database doesn't immediately remove its storage space. The database renames the table and places it and any associated objects in a recycle bin. Purging the recycle bin removes these items and releases their storage space.

To purge the entire recycle bin, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.purge_dba_recyclebin`. However, this procedure can't purge the recycle bin of `SYS` and `RDSADMIN` objects. If you need to purge these objects, contact AWS Support.

The following example purges the entire recycle bin.

```
exec rdsadmin.rdsadmin_util.purge_dba_recyclebin;
```

Common DBA Log Tasks for Oracle DB Instances

Following, you can find how to perform certain common DBA tasks related to logging on your Amazon RDS DB instances running Oracle. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and restricts access to certain system procedures and tables that require advanced privileges.

For more information, see Oracle Database Log Files (p. 476).

Topics

Setting Force Logging

In force logging mode, Oracle logs all changes to the database except changes in temporary tablespaces and temporary segments (`NOLOGGING` clauses are ignored). For more information, see Specifying FORCE LOGGING Mode in the Oracle documentation.

To set force logging, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.force_logging`. The `force_logging` procedure has the following parameters.

Parameter Name	Data Type	Default	Yes	Description
`p_enable`	boolean	true	No	Set to `true` to put the database in force logging mode, `false` to remove the database from force logging mode.

The following example puts the database in force logging mode.

```
exec rdsadmin.rdsadmin_util.force_logging(p_enable => true);
```

Setting Supplemental Logging

Supplemental logging ensures that LogMiner and products that use LogMiner technology have sufficient information to support chained rows and storage arrangements such as cluster tables. For more information, see Supplemental Logging in the Oracle documentation.

Oracle Database doesn't enable supplemental logging by default. To enable and disable supplemental logging, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.alter_supplemental_logging`. For more information about how Amazon RDS manages the retention of archived redo logs for Oracle DB instances, see Retaining Archived Redo Logs (p. 1029).

The `alter_supplemental_logging` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_action`	varchar2	—	Yes	`'ADD'` to add supplemental logging, `'DROP'` to drop supplemental logging.
`p_type`	varchar2	null	No	The type of supplemental logging. Valid values are `'ALL'`, `'FOREIGN KEY'`, `'PRIMARY KEY'`, or `'UNIQUE'`.

The following example enables supplemental logging.

```
begin
    rdsadmin.rdsadmin_util.alter_supplemental_logging(
        p_action => 'ADD');
end;
/
```

The following example enables supplemental logging for all fixed-length maximum size columns.

```
begin
    rdsadmin.rdsadmin_util.alter_supplemental_logging(
        p_action => 'ADD',
        p_type   => 'ALL');
end;
/
```

The following example enables supplemental logging for primary key columns.

```
begin
    rdsadmin.rdsadmin_util.alter_supplemental_logging(
        p_action => 'ADD',
        p_type   => 'PRIMARY KEY');
end;
/
```

Switching Online Log Files

To switch log files, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.switch_logfile`. The `switch_logfile` procedure has no parameters.

The following example switches log files.

```
exec rdsadmin.rdsadmin_util.switch_logfile;
```

Adding Online Redo Logs

An Amazon RDS DB instance running Oracle starts with four online redo logs, 128 MB each. To add additional redo logs, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.add_logfile`.

The `add_logfile` procedure has the following parameters.

> **Note**
> The parameters are mutually exclusive.

Parameter Name	Data Type	Default	Required	Description
`bytes`	positive	null	No	The size of the log file in bytes.
`p_size`	varchar2	—	Yes	The size of the log file. You can specify the size in kilobytes (K), megabytes (M), or gigabytes (G).

The following command adds a 100 MB log file.

```
exec rdsadmin.rdsadmin_util.add_logfile(p_size => '100M');
```

Dropping Online Redo Logs

To drop redo logs, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.drop_logfile`. The `drop_logfile` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`grp`	positive	—	Yes	The group number of the log.

The following example drops the log with group number 3.

```
exec rdsadmin.rdsadmin_util.drop_logfile(grp => 3);
```

You can only drop logs that have a status of unused or inactive. The following example gets the statuses of the logs.

```
select GROUP#, STATUS from V$LOG;

GROUP#     STATUS
---------- ----------------
1          CURRENT
2          INACTIVE
3          INACTIVE
4          UNUSED
```

Resizing Online Redo Logs

An Amazon RDS DB instance running Oracle starts with four online redo logs, 128 MB each. The following example shows how you can use Amazon RDS procedures to resize your logs from 128 MB each to 512 MB each.

```
/* Query V$LOG to see the logs.          */
/* You start with 4 logs of 128 MB each. */

select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
```

```
1          134217728  INACTIVE
2          134217728  CURRENT
3          134217728  INACTIVE
4          134217728  INACTIVE


/* Add four new logs that are each 512 MB */

exec rdsadmin.rdsadmin_util.add_logfile(bytes => 536870912);
exec rdsadmin.rdsadmin_util.add_logfile(bytes => 536870912);
exec rdsadmin.rdsadmin_util.add_logfile(bytes => 536870912);
exec rdsadmin.rdsadmin_util.add_logfile(bytes => 536870912);


/* Query V$LOG to see the logs. */
/* Now there are 8 logs.        */

select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
1          134217728  INACTIVE
2          134217728  CURRENT
3          134217728  INACTIVE
4          134217728  INACTIVE
5          536870912  UNUSED
6          536870912  UNUSED
7          536870912  UNUSED
8          536870912  UNUSED


/* Drop each inactive log using the group number. */

exec rdsadmin.rdsadmin_util.drop_logfile(grp => 1);
exec rdsadmin.rdsadmin_util.drop_logfile(grp => 3);
exec rdsadmin.rdsadmin_util.drop_logfile(grp => 4);


/* Query V$LOG to see the logs. */
/* Now there are 5 logs.        */

select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
2          134217728  CURRENT
5          536870912  UNUSED
6          536870912  UNUSED
7          536870912  UNUSED
8          536870912  UNUSED


/* Switch logs so that group 2 is no longer current. */

exec rdsadmin.rdsadmin_util.switch_logfile;


/* Query V$LOG to see the logs.        */
/* Now one of the new logs is current. */

SQL>select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
2          134217728  ACTIVE
5          536870912  CURRENT
```

```
6          536870912  UNUSED
7          536870912  UNUSED
8          536870912  UNUSED


/* If the status of log 2 is still "ACTIVE", issue a checkpoint to clear it to "INACTIVE".
 */

exec rdsadmin.rdsadmin_util.checkpoint;


/* Query V$LOG to see the logs.          */
/* Now the final original log is inactive. */

select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
2          134217728  INACTIVE
5          536870912  CURRENT
6          536870912  UNUSED
7          536870912  UNUSED
8          536870912  UNUSED


# Drop the final inactive log.

exec rdsadmin.rdsadmin_util.drop_logfile(grp => 2);


/* Query V$LOG to see the logs.    */
/* Now there are four 512 MB logs. */

select GROUP#, BYTES, STATUS from V$LOG;

GROUP#     BYTES      STATUS
---------- ---------- ----------------
5          536870912  CURRENT
6          536870912  UNUSED
7          536870912  UNUSED
8          536870912  UNUSED
```

Retaining Archived Redo Logs

You can retain archived redo logs locally on your DB instance for use with products like Oracle LogMiner (DBMS_LOGMNR). After you have retained the redo logs, you can use LogMiner to analyze the logs. For more information, see Using LogMiner to Analyze Redo Log Files in the Oracle documentation.

To retain archived redo logs, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.set_configuration`. The `set_configuration` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`name`	varchar	—	Yes	The name of the configuration to update.
`value`	varchar	—	Yes	The value for the configuration.

The following example retains 24 hours of redo logs.

```
begin
    rdsadmin.rdsadmin_util.set_configuration(
        name  => 'archivelog retention hours',
        value => '24');
end;
/
commit;
```

Note
The commit is required for the change to take effect.

To view how long archived redo logs are kept for your DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.show_configuration`.

The following example shows the log retention time.

```
set serveroutput on
exec rdsadmin.rdsadmin_util.show_configuration;
```

The output shows the current setting for `archivelog retention hours`. The following output shows that archived redo logs are kept for 48 hours.

```
NAME:archivelog retention hours
VALUE:48
DESCRIPTION:ArchiveLog expiration specifies the duration in hours before archive/redo log
 files are automatically deleted.
```

Because the archived redo logs are retained on your DB instance, ensure that your DB instance has enough allocated storage for the retained logs. To determine how much space your DB instance has used in the last X hours, you can run the following query, replacing X with the number of hours.

```
select sum(BLOCKS * BLOCK_SIZE) bytes
  from V$ARCHIVED_LOG
 where FIRST_TIME >= SYSDATE-(X/24) and DEST_ID=1;
```

Archived redo logs are only generated if the backup retention period of your DB instance is greater than zero. By default the backup retention period is greater than zero, so unless you explicitly set yours to zero, archived redo logs are generated for your DB instance.

After the archived redo logs are removed from your DB instance, you can't download them again to your DB instance. Amazon RDS retains the archived redo logs outside of your DB instance to support restoring your DB instance to a point in time. Amazon RDS retains the archived redo logs outside of your DB instance based on the backup retention period configured for your DB instance. To modify the backup retention period for your DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Note
In some cases, you might be using JDBC on Linux to download archived redo logs and experience long latency times and connection resets. In such cases, the issues might be caused by the default random number generator setting on your Java client. We recommend setting your JDBC drivers to use a nonblocking random number generator.

Accessing Transaction Logs

Accessing transaction logs is supported for Oracle version 11.2.0.4.v11 and later, Oracle version 12.1.0.2.v7 and later, all 12.2.0.1 versions, all 18.0.0.0 versions, and all 19.0.0 versions.

You might want to access your online and archived redo log files for mining with external tools such as GoldenGate, Attunity, Informatica, and others. If you want to access your online and archived redo log files, you must first create directory objects that provide read-only access to the physical file paths.

The following code creates directories that provide read-only access to your online and archived redo log files:

> **Important**
> This code also revokes the `DROP ANY DIRECTORY` privilege.

```
exec rdsadmin.rdsadmin_master_util.create_archivelog_dir;
exec rdsadmin.rdsadmin_master_util.create_onlinelog_dir;
```

After you create directory objects for your online and archived redo log files, you can read the files by using PL/SQL. For more information about reading files from directory objects, see Listing Files in a DB Instance Directory (p. 1052) and Reading Files in a DB Instance Directory (p. 1052).

The following code drops the directories for your online and archived redo log files.

```
exec rdsadmin.rdsadmin_master_util.drop_archivelog_dir;
exec rdsadmin.rdsadmin_master_util.drop_onlinelog_dir;
```

The following code grants and revokes the `DROP ANY DIRECTORY` privilege.

```
exec rdsadmin.rdsadmin_master_util.revoke_drop_any_directory;
exec rdsadmin.rdsadmin_master_util.grant_drop_any_directory;
```

Common DBA Recovery Manager (RMAN) Tasks for Oracle DB Instances

In the following section, you can find how you can perform Oracle Recovery Manager (RMAN) DBA tasks on your Amazon RDS DB instances running Oracle. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances. It also restricts access to certain system procedures and tables that require advanced privileges.

You can use the Amazon RDS package `rdsadmin.rdsadmin_rman_util` to perform RMAN backups of your Amazon RDS for Oracle database to disk. The `rdsadmin.rdsadmin_rman_util` package supports full and incremental database file backups, tablespace backups, and archive log backups.

RMAN backups consume storage space on the Amazon RDS DB instance host. When you perform a backup, you specify an Oracle directory object as a parameter in the procedure call. The backup files are placed in the specified directory. You can use default directories, such as `DATA_PUMP_DIR`, or create a new directory. For more information, see Creating New Directories in the Main Data Storage Space (p. 1051).

After an RMAN backup has finished, you can copy the backup files off the Amazon RDS for Oracle DB instance host. You might do this for the purpose of restoring to a non-RDS host or for long-term storage of backups. For example, you can copy the backup files to an Amazon S3 bucket. For more information, see using Amazon S3 Integration (p. 915).

The backup files for RMAN backups remain on the Amazon RDS DB instance host until you remove them manually. You can use the `UTL_FILE.FREMOVE` Oracle procedure to remove files from a directory. For more information, see FREMOVE Procedure in the Oracle documentation.

When backing up archived redo logs or performing a full or incremental backup that includes archived redo logs, redo log retention must be set to a nonzero value. For more information, see Retaining Archived Redo Logs (p. 1029).

Note
For backing up and restoring to another Amazon RDS for Oracle DB instance, you can continue to use the Amazon RDS backup and restore features. For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290)
Currently, RMAN restore isn't supported for Amazon RDS for Oracle DB instances.

Topics

Common Parameters for RMAN Procedures

You can use procedures in the Amazon RDS package `rdsadmin.rdsadmin_rman_util` to perform tasks with RMAN. Several parameters are common to the procedures in the package. The package has the following common parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_owner`	varchar2	A valid owner of the directory specified in `p_directory_name`.	—	Yes	The owner of the directory to contain the backup files.
`p_directory_name`	varchar2	A valid database directory name.	–	Yes	The name of the directory to contain the backup files.
`p_label`	varchar2	`a-z`, `A-Z`, `0-9`, `'_'`, `'-'`, `'.'`	—	No	A unique string that is included in the backup file names. **Note** The limit is 30 characters.
`p_compress`	boolean	`TRUE`, `FALSE`	`FALSE`	No	Specify `TRUE` to enable BASIC backup compression. Specify `FALSE` to disable BASIC backup compression.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_include_archive_logs`	boolean	`TRUE`, `FALSE`	`FALSE`	No	Specify `TRUE` to include archived redo logs in the backup. Specify `FALSE` to exclude archived redo logs from the backup. If you include archived redo logs in the backup, set retention to one hour or greater using the `rdsadmin.rdsadmin_util.set_co` procedure. Also, call the `rdsadmin.rdsadmin_rman_util.c` procedure immediately before executing the backup. Otherwise, the backup might fail due to missing archived redo logs that have been deleted by Amazon RDS management procedures.
`p_include_controlfile`	boolean	`TRUE`, `FALSE`	`FALSE`	No	Specify `TRUE` to include the control file in the backup. Specify `FALSE` to exclude the control file from the backup.
`p_optimize`	boolean	`TRUE`, `FALSE`	`TRUE`	No	Specify `TRUE` to enable backup optimization, if archived redo logs are included, to reduce backup size. Specify `FALSE` to disable backup optimization.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_parallel`	number	A valid integer between `1` and `254` for Oracle Database Enterprise Edition (EE) `1` for other Oracle Database editions	`1`	No	Number of channels.
`p_rman_to_dbms_output`	boolean	`TRUE`, `FALSE`	`FALSE`	No	When `TRUE`, the RMAN output is sent to the `DBMS_OUTPUT` package in addition to a file in the `BDUMP` directory. When using SQL*Plus, execute `SET SERVEROUTPUT ON` to see the output. When `FALSE`, the RMAN output is only sent to a file in the `BDUMP` directory.
`p_section_size_mb`	number	A valid integer	`NULL`	No	The section size in megabytes (MB). Validates in parallel by dividing each file into the specified section size. When `NULL`, the parameter is ignored.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_validation_type`	varchar2	`'PHYSICAL'`, `'PHYSICAL+LOGICAL'`	`'PHYSICAL'`	No	The level of corruption detection. Specify `'PHYSICAL'` to check for physical corruption. An example of physical corruption is a block with a mismatch in the header and footer. Specify `'PHYSICAL+LOGICAL'` to check for logical inconsistencies in addition to physical corruption. An example of logical corruption is a corrupt block.

Validating DB Instance Files

You can use the Amazon RDS package `rdsadmin.rdsadmin_rman_util` to validate Amazon RDS for Oracle DB instance files, such as data files, tablespaces, control files, or server parameter files (SPFILEs).

For more information about RMAN validation, see Validating Database Files and Backups and VALIDATE in the Oracle documentation.

Topics

Validating a DB Instance

To validate all of the relevant files used by an Amazon RDS Oracle DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.validate_database`.

This procedure uses the following common parameters for RMAN tasks:

- `p_validation_type`
- `p_parallel`
- `p_section_size_mb`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

The following example validates the DB instance using the default values for the parameters.

```
exec rdsadmin.rdsadmin_rman_util.validate_database;
```

The following example validates the DB instance using the specified values for the parameters.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.validate_database(
        p_validation_type      => 'PHYSICAL+LOGICAL',
        p_parallel             => 4,
        p_section_size_mb      => 10,
        p_rman_to_dbms_output => FALSE);
END;
/
```

When the `p_rman_to_dbms_output` parameter is set to `FALSE`, the RMAN output is written to a file in the `BDUMP` directory.

To view the files in the `BDUMP` directory, run the following `SELECT` statement.

```
SELECT * FROM table(rdsadmin.rds_file_util.listdir('BDUMP')) order by mtime;
```

To view the contents of a file in the `BDUMP` directory, run the following `SELECT` statement.

```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','rds-rman-validate-nnn.txt'));
```

Replace the file name with the name of the file you want to view.

Validating a Tablespace

To validate the files associated with a tablespace, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.validate_tablespace`.

This procedure uses the following common parameters for RMAN tasks:

- `p_validation_type`
- `p_parallel`
- `p_section_size_mb`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameter.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_tablespace_name`	varchar2	A valid tablespace name	—	Yes	The name of the tablespace.

Validating a Control File

To validate only the control file used by an Amazon RDS Oracle DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.validate_current_controlfile`.

This procedure uses the following common parameter for RMAN tasks:

- `p_validation_type`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

Validating an SPFILE

To validate only the server parameter file (SPFILE) used by an Amazon RDS Oracle DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.validate_spfile`.

This procedure uses the following common parameter for RMAN tasks:

- `p_validation_type`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

Validating a Data File

To validate a data file, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.validate_datafile`.

This procedure uses the following common parameters for RMAN tasks:

- `p_validation_type`
- `p_parallel`
- `p_section_size_mb`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_datafile`	varchar2	A valid datafile ID number or a valid datafile name including complete path	—	Yes	The datafile ID number (from `v$datafile.file#`) or the full datafile name including the path (from `v$datafile.name`).

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_from_block`	number	A valid integer	`NULL`	No	The number of the block where the validation starts within the data file. When this is `NULL`, `1` is used.
`p_to_block`	number	A valid integer	`NULL`	No	The number of the block where the validation ends within the data file. When this is `NULL`, the maximum block in the data file is used.

Enabling and Disabling Block Change Tracking

You can enable block change tracking for a DB instance using the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.enable_block_change_tracking`.

You can disable block change tracking for a DB instance using the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.disable_block_change_tracking`.

These procedures take no parameters. Enabling block change tracking can improve the performance of incremental backups.

These procedures are supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

To determine whether block change tracking is enabled for your DB instance, run the following query.

```
SELECT status, filename FROM V$BLOCK_CHANGE_TRACKING;
```

The following example enables block change tracking for a DB instance.

```
exec rdsadmin.rdsadmin_rman_util.enable_block_change_tracking;
```

The following example disables block change tracking for a DB instance.

```
exec rdsadmin.rdsadmin_rman_util.disable_block_change_tracking;
```

Crosschecking Archived Redo Logs

You can crosscheck archived redo logs using the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.crosscheck_archivelog`.

You can use this procedure to crosscheck the archived redo logs registered in the control file and optionally delete the expired logs. Each time an RMAN backup is performed, a record is made in the control file. Over time, these records increase the size of the control file. It is best practice to flush old, expired records periodically.

> **Note**
> Standard Amazon RDS backups don't use RMAN and therefore don't create records in the control file.

This procedure uses the common parameter `p_rman_to_dbms_output` for RMAN tasks.

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameter.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_delete_expired`	boolean	`TRUE`, `FALSE`	`TRUE`	No	When `TRUE`, delete expired archived redo logs from the control file. When `FALSE`, retain the expired archived redo logs in the control file.

This procedure is supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

The following example deletes the expired archived redo logs from the control file.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.crosscheck_archivelog(
        p_delete_expired      => FALSE,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Backing Up Archived Redo Logs

You can use the Amazon RDS package `rdsadmin.rdsadmin_rman_util` to back up archived redo logs for an Amazon RDS Oracle DB instance.

The procedures for backing up archived redo logs are supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

Topics

Backing Up All Archived Redo Logs

To back up all of the archived redo logs for an Amazon RDS Oracle DB instance, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_archivelog_all`.

This procedure uses the following common parameters for RMAN tasks:

- `p_owner`
- `p_directory_name`
- `p_label`
- `p_parallel`
- `p_compress`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

The following example backs up all archived redo logs for the DB instance.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_archivelog_all(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_parallel            => 4,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Backing Up an Archived Redo Log from a Date Range

To back up specific archived redo logs for an Amazon RDS Oracle DB instance by specifying a date range, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_archivelog_date`. The date range specifies which archived redo logs to back up.

This procedure uses the following common parameters for RMAN tasks:

- `p_owner`

- `p_directory_name`
- `p_label`
- `p_parallel`
- `p_compress`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_from_date`	date	A date that is between the `start_date` and `next_date` of an archived redo log that exists on disk. The value must be less than or equal to the value specified for `p_to_date`.	—	Yes	The starting date for the archived log backups.
`p_to_date`	date	A date that is between the `start_date` and `next_date` of an archived redo log that exists on disk. The value must be greater than or equal to the value specified for `p_from_date`.	—	Yes	The ending date for the archived log backups.

The following example backs up archived redo logs in the date range for the DB instance.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_archivelog_date(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_from_date           => '03/01/2019 00:00:00',
        p_to_date             => '03/02/2019 00:00:00',
        p_parallel            => 4,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Backing Up an Archived Redo Log from an SCN Range

To back up specific archived redo logs for an Amazon RDS Oracle DB instance by specifying a system change number (SCN) range, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_archivelog_scn`. The SCN range specifies which archived redo logs to back up.

This procedure uses the following common parameters for RMAN tasks:

- `p_owner`
- `p_directory_name`
- `p_label`
- `p_parallel`
- `p_compress`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_from_scn`	number	An SCN of an archived redo log that exists on disk. The value must be less than or equal to the value specified for `p_to_scn`.	—	Yes	The starting SCN for the archived log backups.
`p_to_scn`	number	An SCN of an archived redo log	—	Yes	The ending SCN for the archived log backups.

Parameter Name	Data Type	Valid Values	Default	Required	Description
		that exists on disk. The value must be greater than or equal to the value specified for `p_from_scn`.			

The following example backs up archived redo logs in the SCN range for the DB instance.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_archivelog_scn(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_from_scn            => 1533835,
        p_to_scn              => 1892447,
        p_parallel            => 4,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Backing Up an Archived Redo Log from a Sequence Number Range

To back up specific archived redo logs for an Amazon RDS Oracle DB instance by specifying a sequence number range, use the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_archivelog_sequence`. The sequence number range specifies which archived redo logs to back up.

This procedure uses the following common parameters for RMAN tasks:

- `p_owner`
- `p_directory_name`
- `p_label`
- `p_parallel`
- `p_compress`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_from_sequence`	number	A sequence number an	—	Yes	The starting sequence number for the archived log backups.

Parameter Name	Data Type	Valid Values	Default	Required	Description
		archived redo log that exists on disk. The value must be less than or equal to the value specified for `p_to_sequence`.			
`p_to_sequence`	number	A sequence number of an archived redo log that exists on disk. The value must be greater than or equal to the value specified for `p_from_sequence`.	—	Yes	The ending sequence number for the archived log backups.

The following example backs up archived redo logs in the sequence number range for the DB instance.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_archivelog_sequence(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_from_sequence       => 11160,
        p_to_sequence         => 11160,
        p_parallel            => 4,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Performing a Full Database Backup

You can perform a backup of all blocks of data files included in the backup using Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_database_full`.

This procedure uses the following common parameters for RMAN tasks:

- `p_owner`

- p_directory_name
- p_label
- p_parallel
- p_section_size_mb
- p_include_archive_logs
- p_optimize
- p_compress
- p_rman_to_dbms_output

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure is supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

The following example performs a full backup of the DB instance using the specified values for the parameters.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_database_full(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_parallel            => 4,
        p_section_size_mb     => 10,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Performing an Incremental Database Backup

You can perform an incremental backup of your DB instance using the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_database_incremental`.

For more information about incremental backups, see Incremental Backups in the Oracle documentation.

This procedure uses the following common parameters for RMAN tasks:

- p_owner
- p_directory_name
- p_label
- p_parallel
- p_section_size_mb
- p_include_archive_logs
- p_include_controlfile
- p_optimize

- p_compress
- p_rman_to_dbms_output

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure is supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

This procedure also uses the following additional parameter.

Parameter Name	Data Type	Valid Values	Default	Required	Description
p_level	number	0, 1	0	No	Specify 0 to enable a full incremental backup. Specify 1 to enable a non-cumulative incremental backup.

The following example performs an incremental backup of the DB instance using the specified values for the parameters.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_database_incremental(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_level               => 1,
        p_parallel            => 4,
        p_section_size_mb     => 10,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Performing a Tablespace Backup

You can perform a DB instance tablespace using the Amazon RDS procedure `rdsadmin.rdsadmin_rman_util.backup_tablespace`.

This procedure uses the following common parameters for RMAN tasks:

- p_owner
- p_directory_name
- p_label
- p_parallel

- `p_section_size_mb`
- `p_include_archive_logs`
- `p_include_controlfile`
- `p_optimize`
- `p_compress`
- `p_rman_to_dbms_output`

For more information, see Common Parameters for RMAN Procedures (p. 1032).

This procedure also uses the following additional parameter.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`p_tablespace_name`	varchar2	A valid tablespace name.	—	Yes	The name of the tablespace to back up.

This procedure is supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v19 or higher 11.2 versions
- 12.1.0.2.v15 or higher 12.1 versions
- 12.2.0.1.ru-2019-01.rur-2019-01.r1 or higher 12.2 versions
- All 18.0.0.0 versions
- All 19.0.0.0 versions

The following example performs a tablespace backup using the specified values for the parameters.

```
BEGIN
    rdsadmin.rdsadmin_rman_util.backup_tablespace(
        p_owner               => 'SYS',
        p_directory_name      => 'MYDIRECTORY',
        p_tablespace_name     => MYTABLESPACE,
        p_parallel            => 4,
        p_section_size_mb     => 10,
        p_rman_to_dbms_output => FALSE);
END;
/
```

Common DBA Oracle Scheduler Tasks for Oracle DB Instances

Some SYS-owned scheduler jobs can interfere with normal database operations, and Oracle Support recommends they be disabled or the job schedule be modified. You can use the Amazon RDS package `rdsadmin.rdsadmin_dbms_scheduler` to perform tasks for SYS-owned Oracle Scheduler jobs.

These procedures are supported for the following Amazon RDS for Oracle DB engine versions:

- 11.2.0.4.v21 or higher 11.2 versions

- 12.1.0.2.v17 or higher 12.1 versions
- 12.2.0.2.ru-2019-07.rur-2019-07.r1 or higher 12.2 versions

Topics

Common Parameters for Oracle Scheduler Procedures

To perform tasks with Oracle Scheduler, use procedures in the Amazon RDS package `rdsadmin.rdsadmin_dbms_scheduler`. Several parameters are common to the procedures in the package. The package has the following common parameters.

Parameter Name	Data Type	Valid Values	Default	Required	Description
`name`	varchar2	`'SYS.BSLN_MAINTAIN_STATS_JOB','SYS.CLEANUP_ONLINE_IND_BUILD`	–	Yes	The name of the job to modify. **Note** Currently, you can only modify `SYS.CLEANUP_ONLINE_IND_BUI` and `SYS.BSLN_MAINTAIN_STATS_JO` jobs.
`attribute`	varchar2	`'REPEAT_INTERVAL','SCHEDULE_NAME'`	–	Yes	Attribute to modify. To modify the repeat interval for the job, specify `'REPEAT_INTERVAL'`. To modify the schedule name for the job, specify `'SCHEDULE_NAME'`.
`value`	varchar2	A valid schedule interval or schedule name, depending on attribute used.	–	Yes	The new value of the attribute.

Modifying DBMS_SCHEDULER Jobs

You can still use the Oracle procedure `dbms_scheduler.set_attribute` to modify certain components of the scheduler. For more information, see DBMS_SCHEDULER and SET_ATTRIBUTE Procedure in the Oracle documentation.

When working with Amazon RDS DB instances, prepend the schema name `SYS` to the object name. The following example sets the resource plan attribute for the Monday window object.

```
begin
    dbms_scheduler.set_attribute(
        name      => 'SYS.MONDAY_WINDOW',
        attribute => 'RESOURCE_PLAN',
        value     => 'resource_plan_1');
end;
/
```

> **Note**
> Some SYS-owned Oracle Scheduler jobs can interfere with normal database operations. Oracle Support recommends that they be disabled or that the job schedule be modified. Amazon RDS for Oracle doesn't provide the required privileges to modify SYS-owned Oracle Scheduler jobs using the `DBMS_SCHEDULER` package. Instead, you can use the procedures in the Amazon RDS package `rdsadmin.rdsadmin_dbms_scheduler` to perform tasks for SYS-owned Oracle Scheduler jobs. For information about using these procedures, see Common DBA Oracle Scheduler Tasks for Oracle DB Instances (p. 1047).

Disabling SYS-Owned Oracle Scheduler Jobs

To disable a SYS-owned Oracle Scheduler job, use the `rdsadmin.rdsadmin_dbms_scheduler.disable` procedure.

This procedure uses the `name` common parameter for Oracle Scheduler tasks. For more information, see Common Parameters for Oracle Scheduler Procedures (p. 1048).

The following example disables the `SYS.CLEANUP_ONLINE_IND_BUILD` Oracle Scheduler job.

```
BEGIN
   rdsadmin.rdsadmin_dbms_scheduler.disable('SYS.CLEANUP_ONLINE_IND_BUILD');
END;
/
```

Enabling SYS-Owned Oracle Scheduler Jobs

To enable a SYS-owned Oracle Scheduler job, use the `rdsadmin.rdsadmin_dbms_scheduler.disable` procedure.

This procedure uses the `name` common parameter for Oracle Scheduler tasks. For more information, see Common Parameters for Oracle Scheduler Procedures (p. 1048).

The following example enables the `SYS.CLEANUP_ONLINE_IND_BUILD` Oracle Scheduler job.

```
BEGIN
   rdsadmin.rdsadmin_dbms_scheduler.enable('SYS.CLEANUP_ONLINE_IND_BUILD');
```

```
END;
/
```

Modifying the Repeat Interval for Jobs of CALENDAR Type

To modify the repeat interval to modify a SYS-owned Oracle Scheduler job of `CALENDAR` type, use the `rdsadmin.rdsadmin_dbms_scheduler.disable` procedure.

This procedure uses the following common parameters for Oracle Scheduler tasks:

- `name`
- `attribute`
- `value`

For more information, see Common Parameters for Oracle Scheduler Procedures (p. 1048).

The following example modifies the repeat interval of the `SYS.CLEANUP_ONLINE_IND_BUILD` Oracle Scheduler job.

```
BEGIN
     rdsadmin.rdsadmin_dbms_scheduler.set_attribute(
          name      => 'SYS.CLEANUP_ONLINE_IND_BUILD',
          attribute => 'repeat_interval',
          value     => 'freq=daily;byday=FRI,SAT;byhour=20;byminute=0;bysecond=0');
END;
/
```

Modifying the Repeat Interval for Jobs of NAMED Type

Some Oracle Scheduler jobs use a schedule name instead of an interval. For this type of jobs, you must create a new named schedule in the master user schema. Use the standard Oracle `sys.dbms_scheduler.create_schedule` procedure to do this. Also, use the `rdsadmin.rdsadmin_dbms_scheduler.set_attribute procedure` to assign the new named schedule to the job.

This procedure uses the following common parameter for Oracle Scheduler tasks:

- `name`
- `attribute`
- `value`

For more information, see Common Parameters for Oracle Scheduler Procedures (p. 1048).

The following example modifies the repeat interval of the `SYS.BSLN_MAINTAIN_STATS_JOB` Oracle Scheduler job.

```
BEGIN
     dbms_scheduler.create_schedule (
          schedule_name   => 'rds_master_user.new_schedule',
          start_date      => SYSTIMESTAMP,
          repeat_interval =>
 'freq=daily;byday=MON,TUE,WED,THU,FRI;byhour=0;byminute=0;bysecond=0',
```

```
        end_date         => NULL,
        comments         => 'Repeats daily forever');
END;
/

BEGIN
     rdsadmin.rdsadmin_dbms_scheduler.set_attribute (
          name      => 'SYS.BSLN_MAINTAIN_STATS_JOB',
          attribute => 'schedule_name',
          value     => 'rds_master_user.new_schedule');
END;
/
```

Common DBA Miscellaneous Tasks for Oracle DB Instances

Following, you can find how to perform miscellaneous DBA tasks on your Amazon RDS DB instances running Oracle. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and restricts access to certain system procedures and tables that require advanced privileges.

Topics

Creating New Directories in the Main Data Storage Space

To create directories, use the Amazon RDS procedure `rdsadmin.rdsadmin_util.create_directory`. You can create up to 10,000 directories, all located in your main data storage space.

The `create_directory` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_directory_name`	varchar2	—	Yes	The name of the new directory.

The following example creates a new directory named **`product_descriptions`**.

```
exec rdsadmin.rdsadmin_util.create_directory(p_directory_name => 'product_descriptions');
```

You can list the directories by querying `DBA_DIRECTORIES`. The system chooses the actual host pathname automatically. The following example gets the directory path for the directory named `product_descriptions`:

```
select DIRECTORY_PATH
  from DBA_DIRECTORIES
 where DIRECTORY_NAME='product_descriptions';

DIRECTORY_PATH
----------------------------------------
```

```
/rdsdbdata/userdirs/01
```

The master user name for the DB instance has read and write privileges in the new directory, and can grant access to other users. Execute privileges are not available for directories on a DB instance. Directories are created in your main data storage space and will consume space and I/O bandwidth.

You can drop a directory that you created by using the Oracle `drop directory` command. Dropping a directory doesn't remove its contents. Because the `create_directory()` method can reuse pathnames, files in dropped directories can appear in a newly created directory. Before you drop a directory, you should use `UTL_FILE.FREMOVE` to remove files from the directory. For more information, see FREMOVE Procedure in the Oracle documentation.

Listing Files in a DB Instance Directory

To list the files in a directory, use the Amazon RDS procedure `rdsadmin.rds_file_util.listdir`. The `listdir` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_directory`	varchar2	—	Yes	The name of the directory to list.

The following example lists the files in the directory named `product_descriptions`.

```
select * from table
    (rdsadmin.rds_file_util.listdir(p_directory => 'product_descriptions'));
```

Reading Files in a DB Instance Directory

To read a text file, use the Amazon RDS procedure `rdsadmin.rds_file_util.read_text_file`. The `read_text_file` procedure has the following parameters.

Parameter Name	Data Type	Default	Required	Description
`p_directory`	varchar2	—	Yes	The name of the directory that contains the file.
`p_filename`	varchar2	—	Yes	The name of the file to read.

The following example reads the file `rice.txt` from the directory `product_descriptions`.

```
select * from table
    (rdsadmin.rds_file_util.read_text_file(
        p_directory => 'product_descriptions',
        p_filename  => 'rice.txt'));
```

Using Kerberos Authentication with Amazon RDS for Oracle

You can use Kerberos authentication to authenticate users when they connect to your Amazon RDS DB instance running Oracle. In this case, your DB instance works with AWS Directory Service for Microsoft Active Directory, also called AWS Managed Microsoft AD, to enable Kerberos authentication. When users authenticate with an Oracle DB instance joined to the trusting domain, authentication requests are forwarded to the directory that you create with AWS Directory Service.

Keeping all of your credentials in the same directory can save you time and effort. You have a centralized place for storing and managing credentials for multiple database instances. Using a directory can also improve your overall security profile.

Amazon RDS supports Kerberos authentication for Oracle DB instances in the following AWS Regions:

- US East (Ohio)
- US East (N. Virginia)
- US West (N. California)
- US West (Oregon)
- Asia Pacific (Mumbai)
- Asia Pacific (Seoul)
- Asia Pacific (Singapore)
- Asia Pacific (Sydney)
- Asia Pacific (Tokyo)
- Canada (Central)
- Europe (Frankfurt)
- Europe (Ireland)
- Europe (London)
- Europe (Stockholm)
- South America (São Paulo)

> **Note**
> Kerberos authentication isn't supported for DB instance classes that are deprecated for Oracle DB instances. For more information, see DB Instance Class Support for Oracle (p. 850).

To set up Kerberos authentication for an Oracle DB instance, complete the following general steps, described in more detail later:

1. Use AWS Managed Microsoft AD to create an AWS Managed Microsoft AD directory. You can use the AWS Management Console, the AWS CLI, or the AWS Directory Service API to create the directory.
2. Create an AWS Identity and Access Management (IAM) role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`. The role allows Amazon RDS to make calls to your directory.

   For the role to allow access, the AWS Security Token Service (AWS STS) endpoint must be activated in the correct AWS Region for your AWS account. AWS STS endpoints are active by default in all AWS Regions, and you can use them without any further actions. For more information, see Activating and Deactivating AWS STS in an AWS Region in the *IAM User Guide*.
3. Create and configure users in the AWS Managed Microsoft AD directory using the Microsoft Active Directory tools. For more information about creating users in your Microsoft Active Directory, see Manage Users and Groups in AWS Managed Microsoft AD in the *AWS Directory Service Administration Guide*.

4. Create or modify an Oracle DB instance either from the console, CLI, or RDS API using one of the following methods:
   - Creating an Amazon RDS DB Instance (p. 136)
   - Modifying an Amazon RDS DB Instance (p. 220)
   - Restoring from a DB Snapshot (p. 303)
   - Restoring a DB Instance to a Specified Time (p. 336)

   When you create or modify the DB instance, provide the domain identifier (`d-*` identifier) that was generated when you created your directory and the name of the role you created. You can locate the DB instance in the same Amazon Virtual Private Cloud (VPC) as the directory or in a different VPC.
5. Use the Amazon RDS master user credentials to connect to the Oracle DB instance. Create the user in Oracle to be identified externally. Externally identified users can log in to the Oracle DB instance using Kerberos authentication.

To get Kerberos authentication using an on-premises or self-hosted Microsoft Active Directory, create a forest trust or external trust. The trust can be one-way or two-way. For more information on setting up forest trusts using AWS Directory Service, see When to Create a Trust Relationship in the *AWS Directory Service Administration Guide*.

Topics

Setting Up Kerberos Authentication for Oracle DB Instances

You use AWS Directory Service for Microsoft Active Directory, also called AWS Managed Microsoft AD, to set up Kerberos authentication for an Oracle DB instance. To set up Kerberos authentication, complete the following steps:

- Step 1: Create a Directory Using the AWS Managed Microsoft AD (p. 1054)
- Step 2: Create a Trust (p. 1058)
- Step 3: Create an IAM Role for Use by Amazon RDS (p. 1058)
- Step 4: Create and Configure Users (p. 1059)
- Step 5: Configure VPC Peering (p. 1059)
- Step 6: Create or Modify an Oracle DB Instance (p. 1060)
- Step 7: Create Kerberos Authentication Oracle Logins (p. 1062)
- Step 8: Configure an Oracle Client (p. 1062)

Step 1: Create a Directory Using the AWS Managed Microsoft AD

AWS Directory Service creates a fully managed Active Directory in the AWS Cloud. When you create an AWS Managed Microsoft AD directory, AWS Directory Service creates two domain controllers and Domain Name System (DNS) servers on your behalf. The directory servers are created in different subnets in a VPC. This redundancy helps make sure that your directory remains accessible even if a failure occurs.

When you create an AWS Managed Microsoft AD directory, AWS Directory Service performs the following tasks on your behalf:

- Sets up an Active Directory within the VPC.
- Creates a directory administrator account with the user name Admin and the specified password. You use this account to manage your directory.

  Note
  Be sure to save this password. AWS Directory Service doesn't store it. You can reset it, but you can't retrieve it.
- Creates a security group for the directory controllers.

When you launch an AWS Managed Microsoft AD, AWS creates an Organizational Unit (OU) that contains all of your directory's objects. This OU has the NetBIOS name that you typed when you created your directory and is located in the domain root. The domain root is owned and managed by AWS.

The Admin account that was created with your AWS Managed Microsoft AD directory has permissions for the most common administrative activities for your OU:

- Create, update, or delete users
- Add resources to your domain such as file or print servers, and then assign permissions for those resources to users in your OU
- Create additional OUs and containers
- Delegate authority
- Restore deleted objects from the Active Directory Recycle Bin
- Run AD and DNS Windows PowerShell modules on the Active Directory Web Service

The Admin account also has rights to perform the following domain-wide activities:

- Manage DNS configurations (add, remove, or update records, zones, and forwarders)
- View DNS event logs
- View security event logs

To create a directory with AWS Managed Microsoft AD

1. Sign in to the AWS Management Console and open the AWS Directory Service console at https://console.aws.amazon.com/directoryservicev2/.
2. In the navigation pane, choose **Directories** and choose **Set up Directory**.
3. Choose **AWS Managed Microsoft AD**. AWS Managed Microsoft AD is the only option that you can currently use with Amazon RDS.
4. Enter the following information:

   Directory DNS name

      The fully qualified name for the directory, such as **`corp.example.com`**.

   Directory NetBIOS name

      The short name for the directory, such as **`CORP`**.

   Directory description

      (Optional) A description for the directory.

   Admin password

      The password for the directory administrator. The directory creation process creates an administrator account with the user name Admin and this password.

The directory administrator password and can't include the word "admin." The password is case-sensitive and must be 8–64 characters in length. It must also contain at least one character from three of the following four categories:

- Lowercase letters (a–z)
- Uppercase letters (A–Z)
- Numbers (0–9)
- Non-alphanumeric characters (~!@#$%^&*_-+=`|\(){}[]:;"'<>,.?/)

Confirm password

The administrator password retyped.

5. Choose **Next**.
6. Enter the following information in the **Networking** section and then choose **Next**:

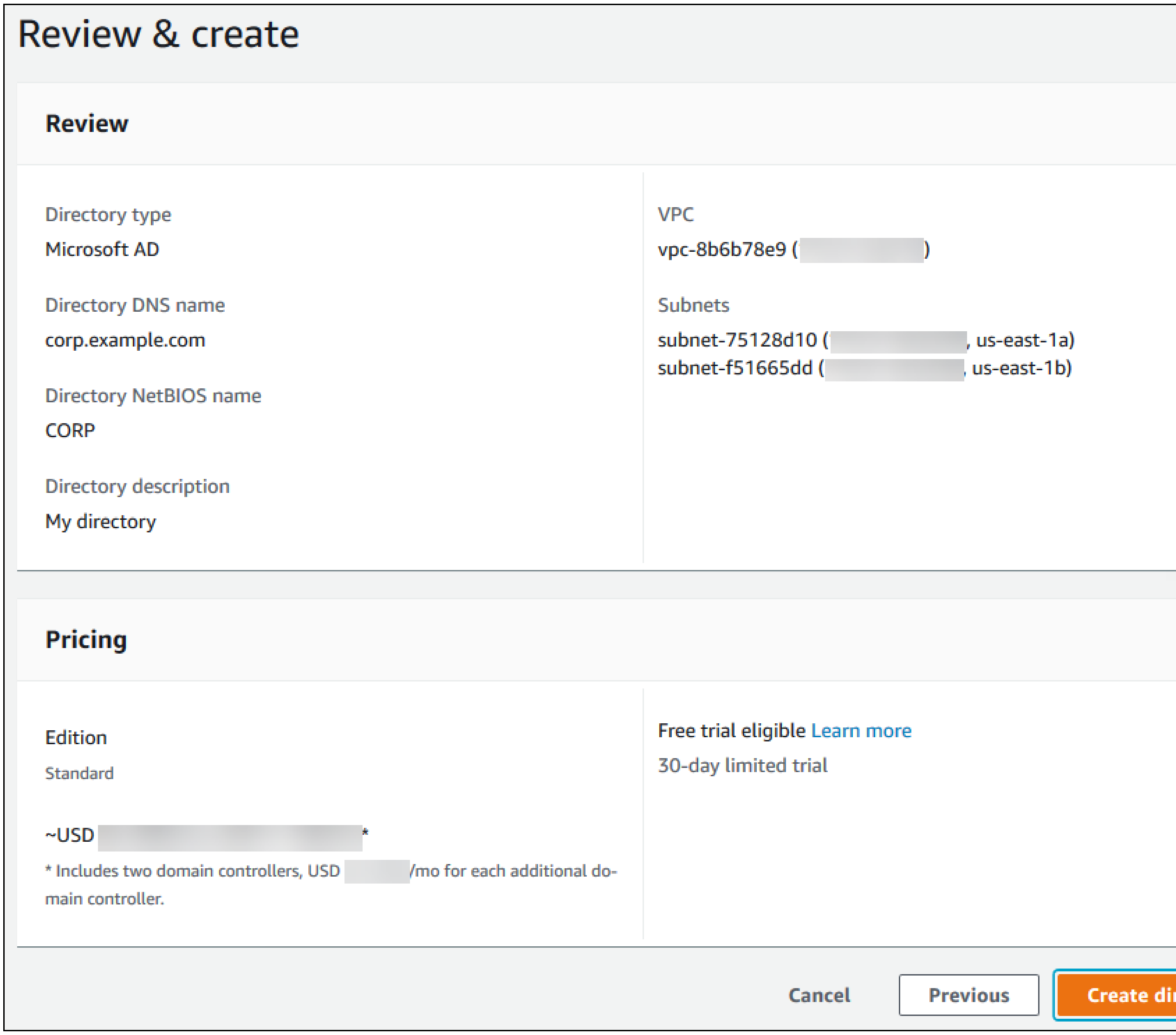
VPC

The VPC for the directory. Create the Oracle DB instance in this same VPC.

Subnets

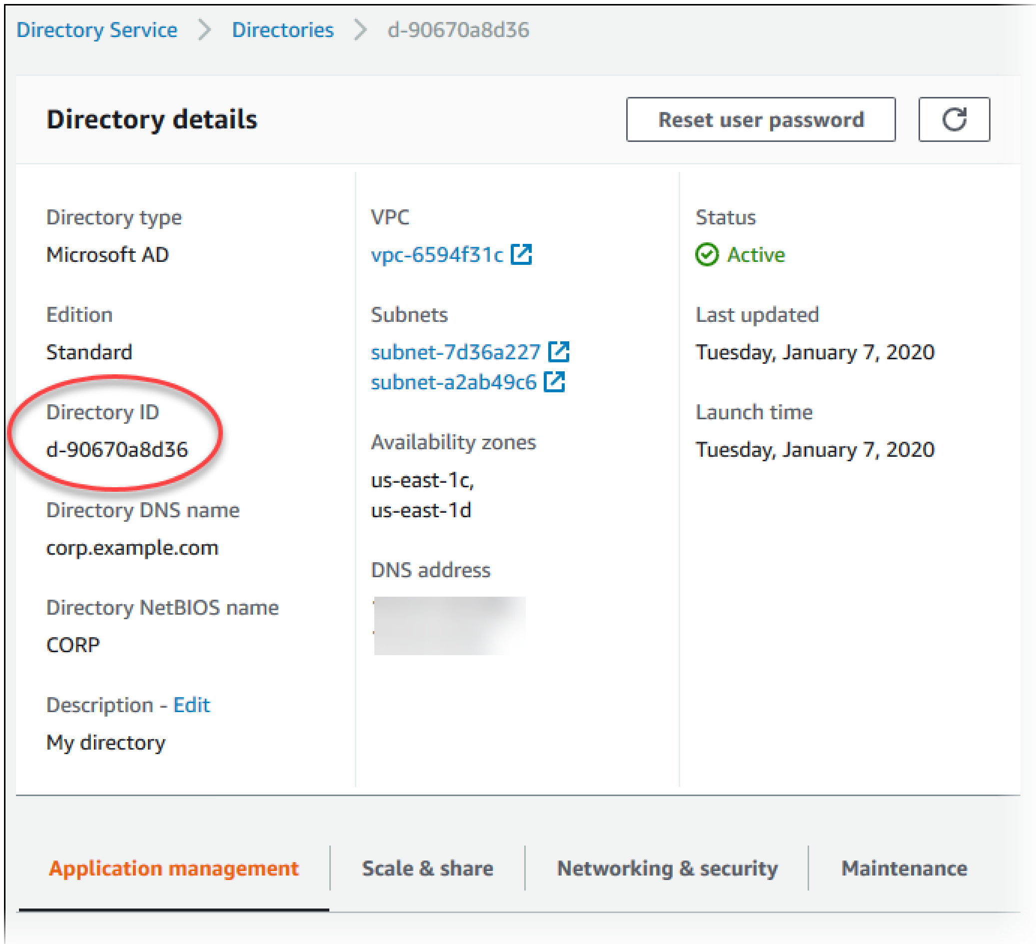
Subnets for the directory servers. The two subnets must be in different Availability Zones.

7. Review the directory information and make any necessary changes. When the information is correct, choose **Create directory**.



It takes several minutes for the directory to be created. When it has been successfully created, the **Status** value changes to **Active**.

To see information about your directory, choose the directory name in the directory listing. Note the **Directory ID** value because you need this value when you create or modify your Oracle DB instance.



Step 2: Create a Trust

If you plan to use AWS Managed Microsoft AD only, move on to Step 3: Create an IAM Role for Use by Amazon RDS (p. 1058).

To get Kerberos authentication using an on-premises or self-hosted Microsoft Active Directory, create a forest trust or external trust. The trust can be one-way or two-way. For more information about setting up forest trusts using AWS Directory Service, see When to Create a Trust Relationship in the *AWS Directory Service Administration Guide*.

Step 3: Create an IAM Role for Use by Amazon RDS

For Amazon RDS to call AWS Directory Service for you, an IAM role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess` is required. This role allows Amazon RDS to make calls to the AWS Directory Service.

When a DB instance is created using the AWS Management Console and the console user has the `iam:CreateRole` permission, the console creates this role automatically. In this case, the role name is `rds-directoryservice-kerberos-access-role`. Otherwise, you must create the IAM role manually. When you create this IAM role, choose `Directory Service`, and attach the AWS managed policy `AmazonRDSDirectoryServiceAccess` to it.

For more information about creating IAM roles for a service, see Creating a Role to Delegate Permissions to an AWS Service in the *IAM User Guide*.

Note
The IAM role used for Windows Authentication for RDS for Microsoft SQL Server can't be used for RDS for Oracle.

Optionally, you can create policies with the required permissions instead of using the managed IAM policy `AmazonRDSDirectoryServiceAccess`. In this case, the IAM role must have the following IAM trust policy.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": [
          "directoryservice.rds.amazonaws.com",
          "rds.amazonaws.com"
        ]
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

The role must also have the following IAM role policy.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "ds:DescribeDirectories",
        "ds:AuthorizeApplication",
        "ds:UnauthorizeApplication",
        "ds:GetAuthorizedApplicationDetails"
      ],
    "Effect": "Allow",
    "Resource": "*"
    }
  ]
}
```

Step 4: Create and Configure Users

You can create users with the Active Directory Users and Computers tool, which is one of the Active Directory Domain Services and Active Directory Lightweight Directory Services tools. In this case, *users* are individual people or entities that have access to your directory.

To create users in an AWS Directory Service directory, you must be connected to a Windows-based Amazon EC2 instance that is a member of the AWS Directory Service directory. At the same time, you must be logged in as a user that has privileges to create users. For more information, see Create a User in the *AWS Directory Service Administration Guide*.

Step 5: Configure VPC Peering

If you plan to locate the directory and the DB instance in different VPCs, configure VPC peering by following the instructions in this step. If you plan to locate the directory and the DB instance in the same VPC, skip this step and move on to Step 6: Create or Modify an Oracle DB Instance (p. 1060).

If the same AWS account owns both VPCs, follow the instructions in What is VPC Peering?. Specifically, complete the following steps:

1. Set up appropriate VPC routing rules to ensure the network traffic can flow both ways.
2. Ensure the DB instance's security group can receive ingress traffic from this security group.
3. Ensure that there is no network access control list (ACL) rule to block traffic.

If different AWS accounts own the VPCs, complete the following steps:

1. Configure VPC peering by following the instructions in What is VPC Peering? in *Amazon Virtual Private Cloud VPC Peering*. Specifically, complete the following steps:
   a. Set up appropriate VPC routing rules to ensure the network traffic can flow both ways.
   b. Ensure that there is no ACL rule to block traffic.
2. Initiate sharing of the directory with the AWS account that the DB instance will be created in by following the instructions in Tutorial: Sharing Your AWS Managed Microsoft AD Directory for Seamless EC2 Domain-Join in the *AWS Directory Service Administration Guide*.
3. Log in to the AWS Directory Service console using the account for the DB instance, and ensure that the domain has the `SHARED` status before proceeding.
4. While logged into the AWS Directory Service console using the account for the DB instance, make a note of the **Directory ID** value for the directory.

Step 6: Create or Modify an Oracle DB Instance

Create or modify an Oracle DB instance for use with your directory. You can use the console, CLI, or RDS API to associate a DB instance with a directory. You can do this in one of the following ways:

- Create a new Oracle DB instance using the console, the create-db-instance CLI command, or the CreateDBInstance RDS API operation.

  For instructions, see Creating an Amazon RDS DB Instance (p. 136).
- Modify an existing Oracle DB instance using the console, the modify-db-instance CLI command, or the ModifyDBInstance RDS API operation.

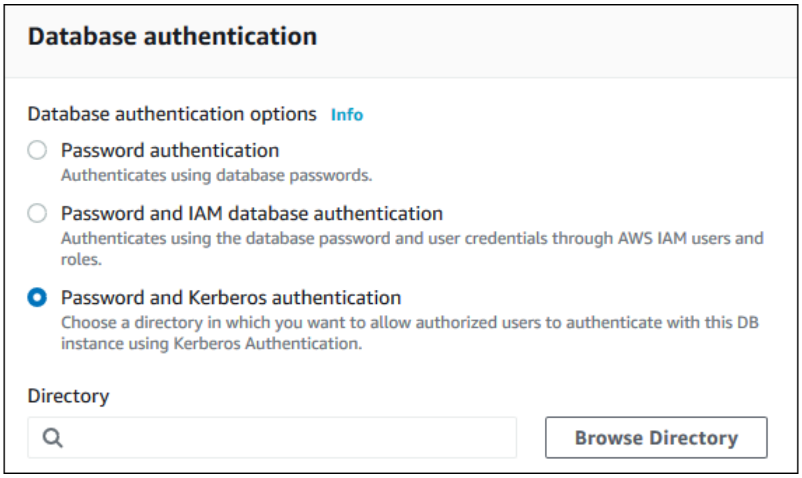
  For instructions, see Modifying an Amazon RDS DB Instance (p. 220).
- Restore an Oracle DB instance from a DB snapshot using the console, the restore-db-instance-from-db-snapshot CLI command, or the RestoreDBInstanceFromDBSnapshot RDS API operation.

  For instructions, see Restoring from a DB Snapshot (p. 303).
- Restore an Oracle DB instance to a point-in-time using the console, the restore-db-instance-to-point-in-time CLI command, or the RestoreDBInstanceToPointInTime RDS API operation.

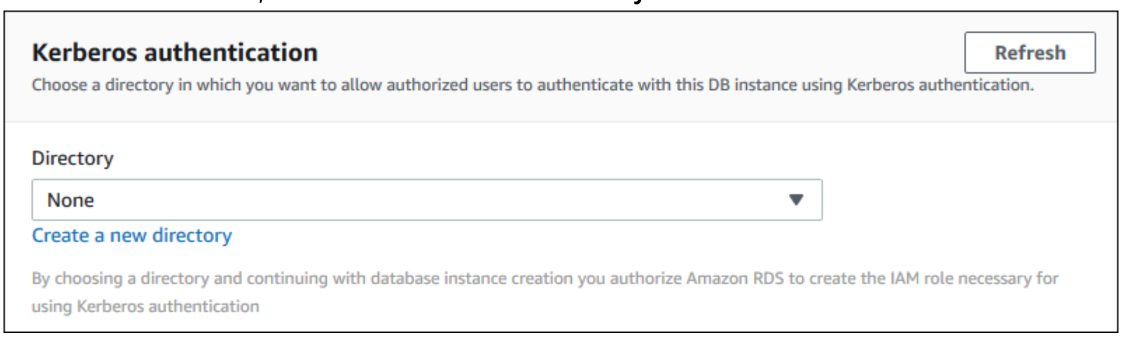
  For instructions, see Restoring a DB Instance to a Specified Time (p. 336).

Kerberos authentication is only supported for Oracle DB instances in a VPC. The DB instance can be in the same VPC as the directory, or in a different VPC. The DB instance must use a security group that allows egress within the directory's VPC so the DB instance can communicate with the directory.

When you use the console to create a DB instance, choose **Password and Kerberos authentication** in the **Database authentication** section. Choose **Browse Directory** and then select the directory, or choose **Create a new directory**.



When you use the console to modify or restore a DB instance, choose the directory in the **Kerberos authentication** section, or choose **Create a new directory**.



When you use the AWS CLI, the following parameters are required for the DB instance to be able to use the directory that you created:

- For the `--domain` parameter, use the domain identifier ("d-*" identifier) generated when you created the directory.
- For the `--domain-iam-role-name` parameter, use the role you created that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`.

For example, the following CLI command modifies a DB instance to use a directory.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --domain d-ID \
    --domain-iam-role-name role-name
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --domain d-ID ^
    --domain-iam-role-name role-name
```

Important
If you modify a DB instance to enable Kerberos authentication, reboot the DB instance after making the change.

Step 7: Create Kerberos Authentication Oracle Logins

Use the Amazon RDS master user credentials to connect to the Oracle DB instance as you do any other DB instance. The DB instance is joined to the AWS Managed Microsoft AD domain. Thus, you can provision Oracle logins and users from the Microsoft Active Directory users and groups in your domain. To manage database permissions, you grant and revoke standard Oracle permissions to these logins.

To allow a Microsoft Active Directory user to authenticate with Oracle, use the Amazon RDS master user credentials. You use these credentials to connect to the Oracle DB instance as you do any other DB instance. After you're logged in, create an externally authenticated user in Oracle.

```
CREATE USER "KRBUSER@CORP.EXAMPLE.COM" IDENTIFIED EXTERNALLY;
GRANT CREATE SESSION TO "KRBUSER@CORP.EXAMPLE.COM";
```

Replace *KRBUSER@CORP.EXAMPLE.COM* with the user name and domain name. Users (both humans and applications) from your domain can now connect to the RDS Oracle instance from a domain joined client machine using Kerberos authentication.

Step 8: Configure an Oracle Client

To configure an Oracle client, meet the following requirements:

- Create a krb5.conf file (or equivalent) to point to the domain. Configure the Oracle client to use this krb5.conf file.
- Verify that traffic can flow between the client host and AWS Directory Service over DNS port 53 and Kerberos ports (88 and 464 for managed AWS Directory Service) over TCP/UDP.
- Verify that traffic can flow between the client host and the DB instance over the database port.

The following is sample krb5.conf content for AWS Managed Microsoft AD:

```
[libdefaults]
 default_realm = EXAMPLE.COM
 default_ccache_name = /tmp/kerbcache
[realms]
 EXAMPLE.COM = {
  kdc = example.com
  admin_server = example.com
 }
[domain_realm]
 .example.com = EXAMPLE.COM
 example.com = EXAMPLE.COM
```

The following is sample krb5.conf content for on-premise Microsoft AD:

```
[libdefaults]
 default_realm = EXAMPLE.COM
 default_ccache_name = /tmp/kerbcache
[realms]
```

```
 EXAMPLE.COM = {
  kdc = example.com
  admin_server = example.com
 }
 ONPREM.COM = {
  kdc = onprem.com
  admin_server = onprem.com
 }
[domain_realm]
 .example.com = EXAMPLE.COM
 example.com = EXAMPLE.COM
 .onprem.com = ONPREM.COM
 onprem.com = ONPREM.COM
```

The following is sample sqlnet.ora content for a SQL*Plus configuration:

```
SQLNET.AUTHENTICATION_SERVICES=(KERBEROS5PRE,KERBEROS5)
SQLNET.KERBEROS5_CONF=path_to_krb5.conf_file
```

For an example of a SQL Developer configuration, see Document 1609359.1 from Oracle Support.

Managing a DB Instance in a Domain

You can use the console, the CLI, or the RDS API to manage your DB instance and its relationship with your Microsoft Active Directory. For example, you can associate a Microsoft Active Directory to enable Kerberos authentication. You can also disassociate a Microsoft Active Directory to disable Kerberos authentication. You can also move a DB instance to be externally authenticated by one Microsoft Active Directory to another.

For example, using the CLI, you can do the following:

- To reattempt enabling Kerberos authentication for a failed membership, use the modify-db-instance CLI command and specify the current membership's directory ID for the `--domain` option.
- To disable Kerberos authentication on a DB instance, use the modify-db-instance CLI command and specify `none` for the `--domain` option.
- To move a DB instance from one domain to another, use the modify-db-instance CLI command and specify the domain identifier of the new domain for the `--domain` option.

Understanding Domain Membership

After you create or modify your DB instance, the DB instance becomes a member of the domain. You can view the status of the domain membership for the DB instance in the console or by running the describe-db-instances CLI command. The status of the DB instance can be one of the following:

- `kerberos-enabled` – The DB instance has Kerberos authentication enabled.
- `enabling-kerberos` – AWS is in the process of enabling Kerberos authentication on this DB instance.
- `pending-enable-kerberos` – Enabling Kerberos authentication is pending on this DB instance.
- `pending-maintenance-enable-kerberos` – AWS will attempt to enable Kerberos authentication on the DB instance during the next scheduled maintenance window.
- `pending-disable-kerberos` – Disabling Kerberos authentication is pending on this DB instance.
- `pending-maintenance-disable-kerberos` – AWS will attempt to disable Kerberos authentication on the DB instance during the next scheduled maintenance window.

- `enable-kerberos-failed` – A configuration problem has prevented AWS from enabling Kerberos authentication on the DB instance. Correct the configuration problem before reissuing the command to modify the DB instance.
- `disabling-kerberos` – AWS is in the process of disabling Kerberos authentication on this DB instance.

A request to enable Kerberos authentication can fail because of a network connectivity issue or an incorrect IAM role. If the attempt to enable Kerberos authentication fails when you create or modify a DB instance, first make sure that you are using the correct IAM role. Then modify the DB instance to join the domain.

> **Note**
> Only Kerberos authentication with Amazon RDS for Oracle sends traffic to the domain's DNS servers. All other DNS requests are treated as outbound network access on your DB instances running Oracle. For more information about outbound network access with Amazon RDS for Oracle, see Setting Up a Custom DNS Server (p. 1010).

Force-Rotating Kerberos Keys

A secret key is shared between AWS Managed Microsoft AD and Amazon RDS for Oracle DB instance. This key is rotated automatically every 45 days. You can use the following Amazon RDS procedure to force the rotation of this key.

```
SELECT rdsadmin.rdsadmin_kerberos_auth_tasks.rotate_kerberos_keytab AS TASK_ID FROM DUAL;
```

> **Note**
> In a read replica configuration, this procedure is available only on the source DB instance and not on the read replica.

The `SELECT` statement returns the ID of the task in a `VARCHAR2` data type. You can view the status of an ongoing task in a bdump file. The bdump files are located in the `/rdsdbdata/log/trace` directory. Each bdump file name is in the following format.

```
dbtask-task-id.log
```

You can view the result by displaying the task's output file.

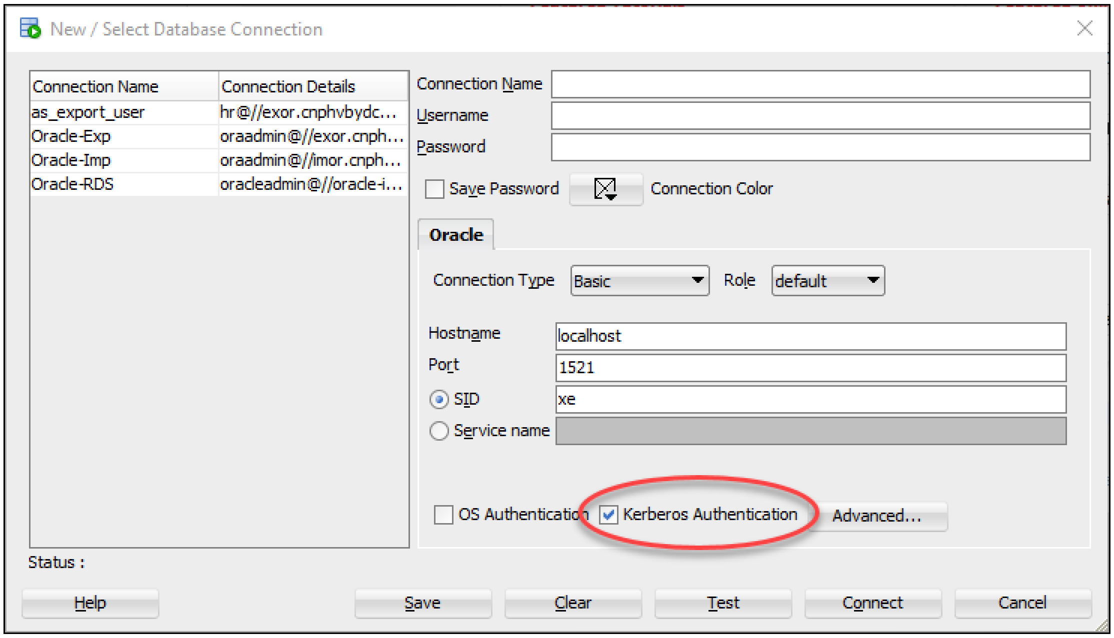
```
SELECT text FROM table(rdsadmin.rds_file_util.read_text_file('BDUMP','dbtask-task-
id.log'));
```

Replace *`task-id`* with the task ID returned by the procedure.

> **Note**
> Tasks are executed asynchronously.

Connecting to Oracle with Kerberos Authentication

To connect to Oracle with Kerberos authentication, log in using the Kerberos authentication type. For example, after launching Oracle SQL Developer, choose **Kerberos Authentication** as the authentication type, as shown following.



To connect to Oracle with Kerberos authentication with SQL*Plus, take the following steps:

1. At a command prompt, run the following command:

```
kinit username
```

   Replace *username* with the user name and, at the prompt, enter the password stored in the Microsoft Active Directory for the user.
2. Open SQL*Plus and connect using the DNS name and port number for the Oracle DB instance.

   For more information about connecting to an Oracle DB instance in SQL*Plus, see Connecting to Your DB Instance Using SQL*Plus (p. 878).

Tools and Third-Party Software for Oracle DB Instances

This section provides information about tools and third-party software for Oracle DB instances on Amazon RDS.

Topics

Setting Up Amazon RDS to Host Tools and Third-Party Software for Oracle

You can use Amazon RDS to host an Oracle DB instance that supports software and components such as the following:

- Siebel Customer Relationship Management (CRM)
- Oracle Fusion Middleware Metadata — installed by the Repository Creation Utility (RCU)

The following procedures help you create an Oracle DB instance on Amazon RDS that you can use to host additional software and components for Oracle.

Creating a VPC for Use with an Oracle Database

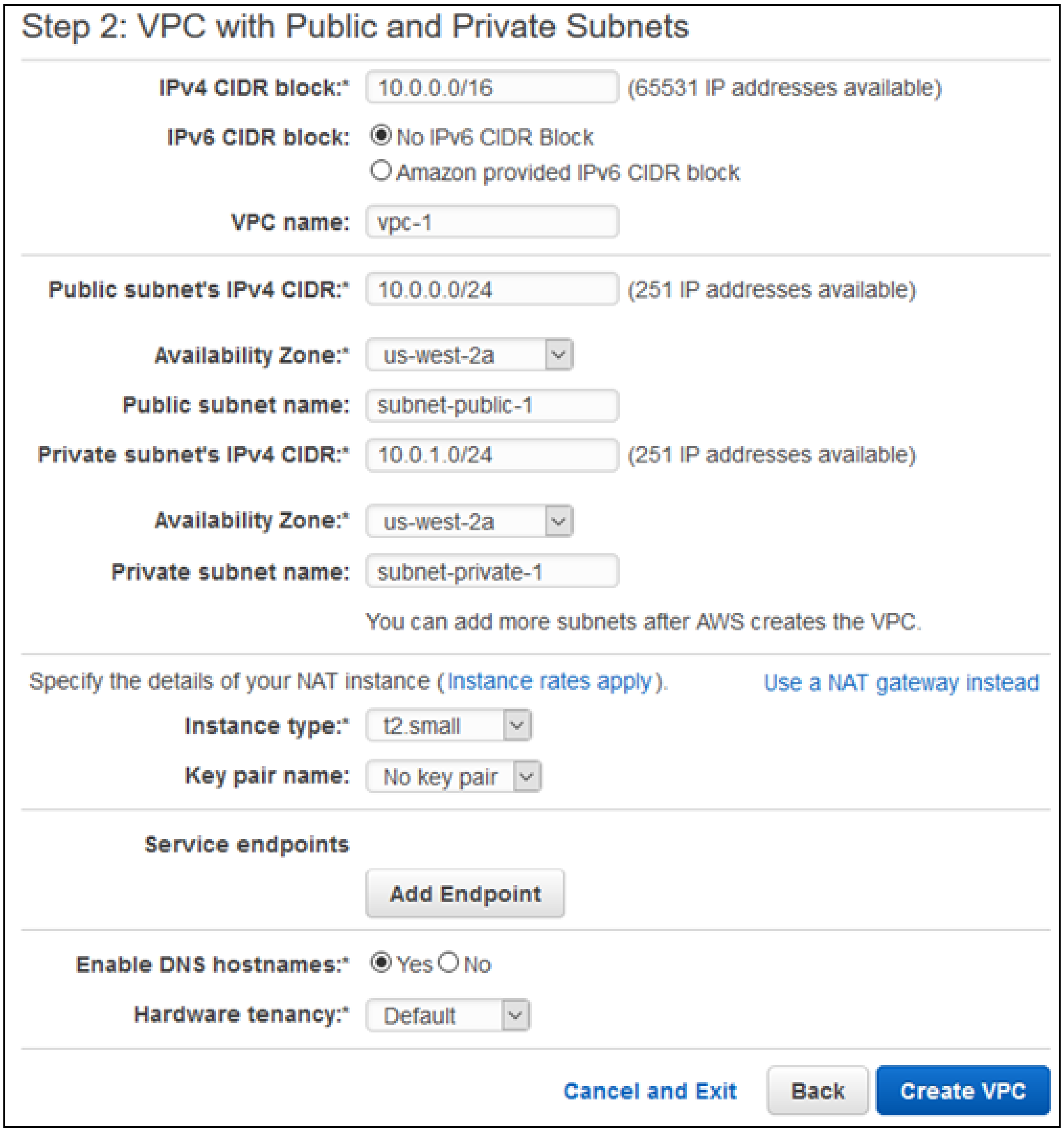
In the following procedure, you create a virtual private cloud (VPC) based on the Amazon VPC service, a private subnet, and a security group. Your Amazon RDS DB instance needs to be available only to your middle-tier components, and not to the public internet. Thus, your Amazon RDS DB instance is hosted in a private subnet, providing greater security.

To create a VPC based on Amazon VPC

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the upper-right corner of the AWS Management Console, choose the AWS Region for your VPC. This example uses the US West (Oregon) region.
3. In the upper-left corner, choose **VPC Dashboard**, and then choose **Start VPC Wizard**.
4. On the page **Step 1: Select a VPC Configuration**, choose **VPC with Public and Private Subnets**, and then choose **Select**.
5. On the page **Step 2: VPC with Public and Private Subnets**, shown following, set the following values.

Option	Value
IPv4 CIDR block	`10.0.0.0/16` For more information about selecting CIDR blocks for your VPC, see VPC Sizing.

Option	Value
IPv6 CIDR block	**No IPv6 CIDR Block**
VPC name	The name for your VPC, for example **`vpc-1`**.
Public subnet's IPv4 CIDR	`10.0.0.0/24` For more information about subnet sizing, see Subnet Sizing.
Availability Zone	An Availability Zone for your AWS Region.
Public subnet name	The name for your public subnet, for example **`subnet-public-1`**.
Private subnet's IPv4 CIDR	`10.0.1.0/24` For more information about subnet sizing, see Subnet Sizing.
Availability Zone	An Availability Zone for your AWS Region.
Private subnet name	The name for your private subnet, for example **`subnet-private-1`**.
Instance type	An instance type for your NAT instance, for example `t2.small`. **Note** If you don't see **Instance type** in the console, choose **Use a NAT instance instead**.
Key pair name	`No key pair`
Service endpoints	`None`
Enable DNS hostnames	`Yes`
Hardware tenancy	`Default`



6. Choose **Create VPC**.

An Amazon RDS DB instance in a VPC requires at least two private subnets or at least two public subnets, to support Multi-AZ deployment. For more information about working with multiple Availability Zones, see Regions, Availability Zones, and Local Zones (p. 37). Because your database is private, add a second private subnet to your VPC.

To create an additional subnet

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the upper-right corner of the AWS Management Console, confirm that you are in the correct AWS Region for your VPC.
3. In the upper-left corner, choose **VPC Dashboard**, choose **Subnets**, and then choose **Create Subnet**.

4. On the **Create Subnet** page, set the following values.

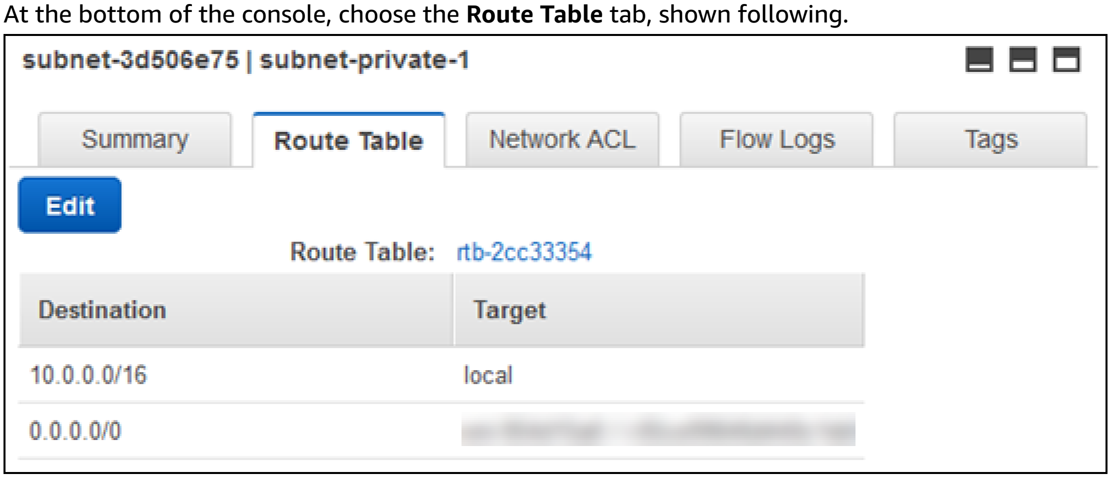
Option	Value
Name tag	The name for your second private subnet, for example **`subnet-private-2`**.
VPC	Your VPC, for example **`vpc-1`**.
Availability Zone	An Availability Zone for your AWS Region. **Note** Choose an Availability Zone different from the one that you chose for the first private subnet.
CIDR block	`10.0.2.0/24`

5. Choose **Yes, Create**.

Both private subnets must use the same route table. In the following procedure, you check to make sure the route tables match, and if not you edit one of them.

To ensure the subnets use the same route table.

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the upper-right corner of the AWS Management Console, confirm that you are in the correct AWS Region for your VPC.
3. In the upper-left corner, choose **VPC Dashboard**, choose **Subnets**, and then choose your first private subnet, for example **`subnet-private-1`**.
4. At the bottom of the console, choose the **Route Table** tab, shown following.



5. Make a note of the route table, for example `rtb-0d9fc668`.
6. In the list of subnets, choose the second private subnet, for example **`subnet-private-2`**.
7. At the bottom of the console, choose the **Route Table** tab.
8. If the route table for the second subnet is not the same as the route table for the first subnet, edit it to match:

   a. Choose **Edit**.

   b. For **Change to**, choose the route table that matches your first subnet.

   c. Choose **Save**.

A security group acts as a virtual firewall for your DB instance to control inbound and outbound traffic. In the following procedure, you create a security group for your DB instance. For more information about security groups, see Security Groups for Your VPC.

To create a VPC security group for a Private Amazon RDS DB Instance

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the upper-right corner of the AWS Management Console, confirm that you are in the correct AWS Region for your VPC.
3. In the upper-left corner, choose **VPC Dashboard**, choose **Security Groups**, and then choose **Create Security Group**.
4. On the page **Create Security Group**, set the following values.

Option	Value
Name tag	The name for your security group, for example **`sgdb-1`**.
Group name	The name for your security group, for example **`sgdb-1`**.
Description	A description for your security group.
VPC	Your VPC, for example **`vpc-1`**.

5. Choose **Yes, Create**.

In the following procedure, you add rules to your security group to control inbound traffic to your DB instance. For more information about inbound rules, see Security Group Rules.

To add inbound rules to the security group

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the upper-right corner of the AWS Management Console, confirm that you are in the correct AWS Region for your VPC.
3. In the upper-left corner, choose **VPC Dashboard**, choose **Security Groups**, and then choose your security group, for example **`sgdb-1`**.
4. At the bottom of the console, choose the **Inbound Rules** tab, and then choose **Edit**.
5. Set these values, as shown following.

Option	Value
Type	`Oracle (1521)`
Protocol	`TCP (6)`
Port Range	1521
Source	The identifier of your security group. When you choose the box, you see the name of your security group, for example **`sgdb-1`**.

6. Choose **Save**.

Creating an Oracle DB Instance

You can use Amazon RDS to host an Oracle DB instance. When you create the new DB instance, specify the VPC and security group you created previously using the instructions in Creating a VPC for Use with an Oracle Database (p. 1066). Also, choose **No** for **Publicly accessible**.

For information about creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

Additional Amazon RDS Interfaces

In the preceding procedures, we use the AWS Management Console to perform tasks. Amazon Web Services also provides the AWS Command Line Interface (AWS CLI), and an application programming interface (API). You can use the AWS CLI or the API to automate many of the tasks for managing Amazon RDS, including tasks to manage an Oracle DB instance with Amazon RDS.

For more information, see AWS Command Line Interface Reference for Amazon RDS and Amazon RDS API Reference.

Related Topics

- Setting Up for Amazon RDS (p. 58)
- Using the Oracle Repository Creation Utility on Amazon RDS for Oracle (p. 1084)
- Installing a Siebel Database on Oracle on Amazon RDS (p. 1089)
- Scenarios for Accessing a DB Instance in a VPC (p. 1435)
- Connecting to a DB Instance Running the Oracle Database Engine (p. 874)

Using Oracle GoldenGate with Amazon RDS

Oracle GoldenGate (GoldenGate) is used to collect, replicate, and manage transactional data between databases. It is a log-based change data capture (CDC) and replication software package used with Oracle databases for online transaction processing (OLTP) systems. GoldenGate creates trail files that contain the most recent changed data from the source database and then pushes these files to the target database. You can use GoldenGate with Amazon RDS for Active-Active database replication, zero-downtime migration and upgrades, disaster recovery, data protection, and in-region and cross-region replication.

The following are important points to know when working with GoldenGate on Amazon RDS:

- You are responsible for setting up and managing GoldenGate for use with Amazon RDS.
- You are responsible for managing GoldenGate licensing (bring-your-own-license) for use with Amazon RDS in all AWS regions. For more information, see Oracle Licensing (p. 847).
- Amazon RDS supports GoldenGate for Oracle Database Standard Edition Two (SE2), Standard Edition One (SE1), Standard Edition (SE), and Enterprise Edition (EE).
- Amazon RDS supports GoldenGate for database version 11.2.0.4, 12.1.0.2, 12.2.0.1, 18.0.0.0, and 19.0.0.
- Amazon RDS supports GoldenGate version 11.2.1 and later, including 12.1, 12.2, and 12.3.
- Amazon RDS supports migration and replication across Oracle databases using GoldenGate. We do not support nor prevent customers from migrating or replicating across heterogeneous databases.
- You can use GoldenGate on Amazon RDS Oracle DB instances that use Oracle Transparent Data Encryption (TDE). To maintain the integrity of replicated data, you should configure encryption on the GoldenGate hub using EBS encrypted volumes or trail file encryption. You should also configure encryption for data sent between the GoldenGate hub and the source and target database instances. Amazon RDS Oracle DB instances support encryption with Oracle Secure Sockets Layer (p. 967) or Oracle Native Network Encryption (p. 963).
- GoldenGate DDL is supported with GoldenGate version 12.1 and later when using Integrated capture mode.

Overview

The GoldenGate architecture for use with Amazon RDS consists of three decoupled modules. The source database can be either an on-premises Oracle database, an Oracle database on an Amazon EC2 instance, or an Oracle database on an Amazon RDS DB instance. You also work with a GoldenGate hub, which moves transaction information from the source database to the target database. Your hub can be either of these:

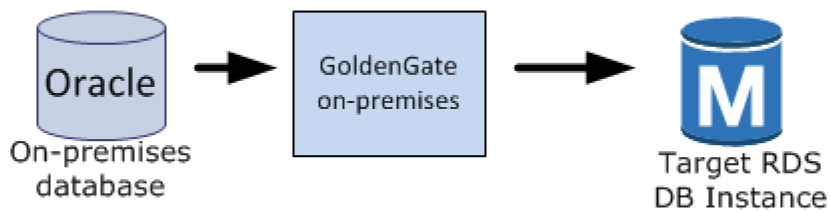
- An Amazon EC2 instance with Oracle Database and GoldenGate installed
- An on-premises Oracle installation.

You can have more than one Amazon EC2 hub, and we recommend that you use two hubs if you are using GoldenGate for cross-region replication.

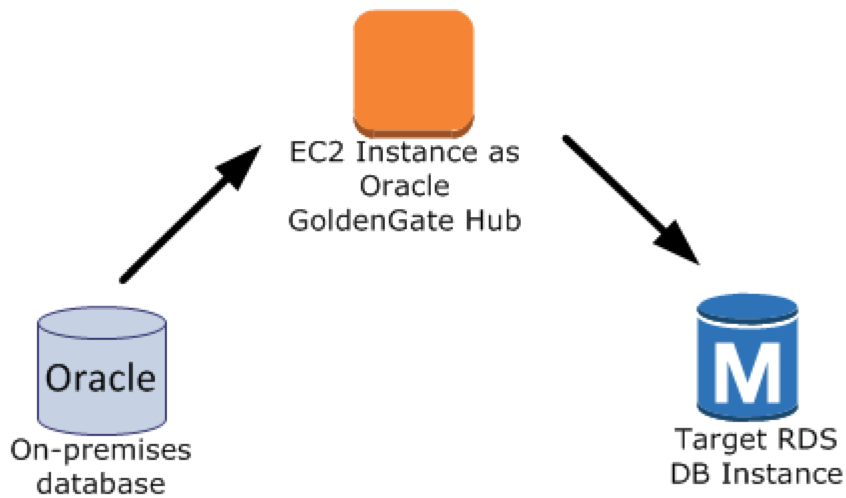
Your target database can be on either an Amazon RDS DB instance, an Amazon EC2 instance, or an on-premises location.

GoldenGate on Amazon RDS supports the following common scenarios:

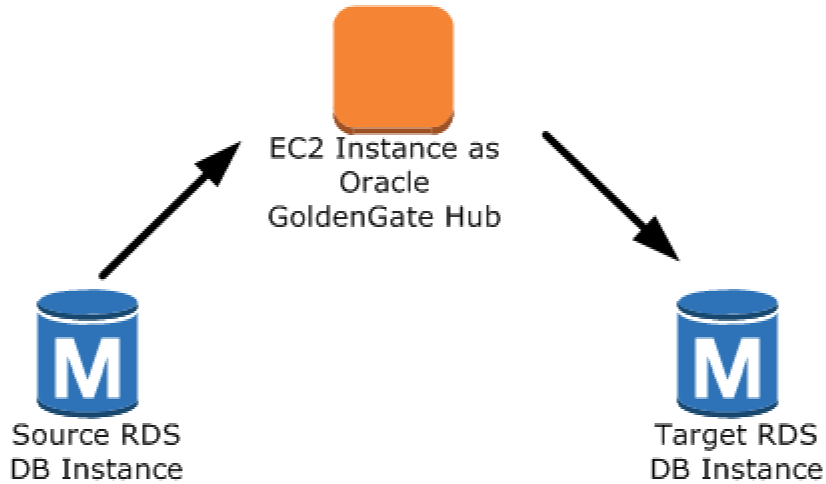
Scenario 1: An on-premises Oracle source database and on-premises GoldenGate hub, that provides data to a target Amazon RDS DB instance.



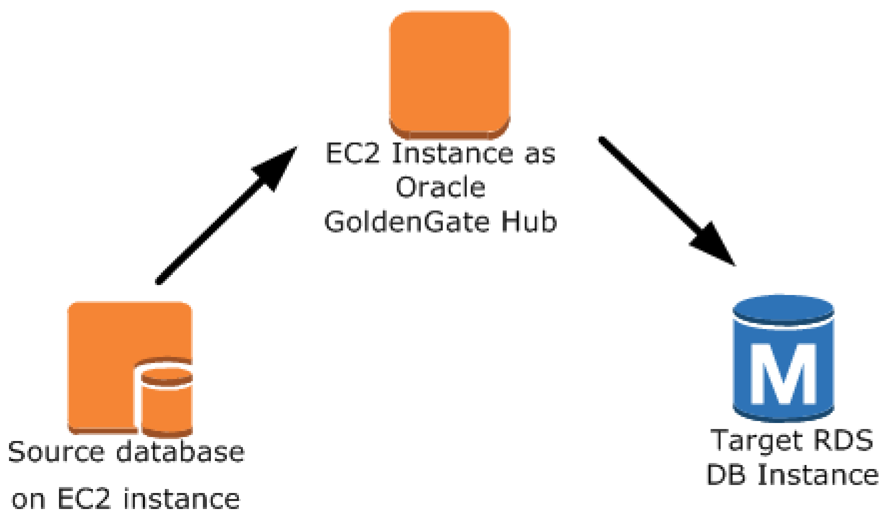
Scenario 2: An on-premises Oracle database that acts as the source database, connected to an Amazon EC2 instance hub that provides data to a target Amazon RDS DB instance.



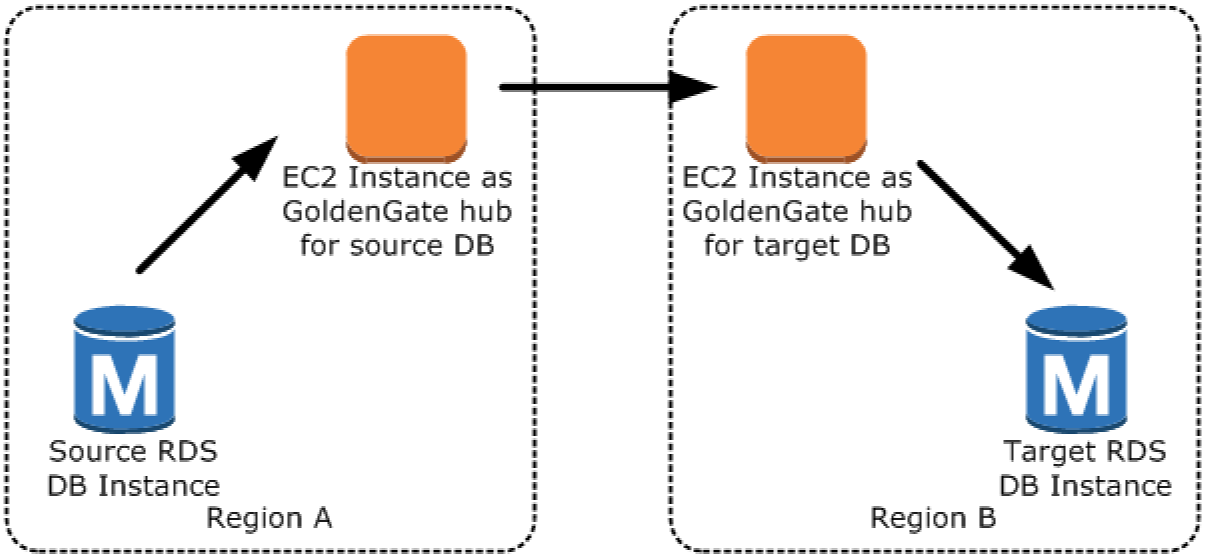
Scenario 3: An Oracle database on an Amazon RDS DB instance that acts as the source database, connected to an Amazon EC2 instance hub that provides data to a target Amazon RDS DB instance.



Scenario 4: An Oracle database on an Amazon EC2 instance that acts as the source database, connected to an Amazon EC2 instance hub that provides data to a target Amazon RDS DB instance.



Scenario 5: An Oracle database on an Amazon RDS DB instance connected to an Amazon EC2 instance hub in the same AWS Region. In this scenario, the hub is connected to an Amazon EC2 instance hub in a different AWS Region. This second hub provides data to the target Amazon RDS DB instance in the same AWS Region as the second Amazon EC2 instance hub.



Note
Any issues that affect running GoldenGate on an on-premises environment also affect running GoldenGate on AWS. We strongly recommend that you monitor the GoldenGate hub to ensure that `EXTRACT` and `REPLICAT` are resumed if a failover occurs. Because the GoldenGate hub is run on an Amazon EC2 instance, Amazon RDS does not manage the GoldenGate hub and cannot ensure that it is running.

You can use GoldenGate using Amazon RDS to upgrade to major versions of Oracle. For example, you can use GoldenGate with Amazon RDS to upgrade from an Oracle version 8 on-premises database to an Oracle database running version 11.2.0.4 on an Amazon RDS DB instance.

To set up GoldenGate using Amazon RDS, you configure the hub on the Amazon EC2 instance, and then configure the source and target databases. The following steps show how to set up GoldenGate for use with Amazon RDS. Each step is explained in detail in the following sections:

- Setting Up a GoldenGate Hub on Amazon EC2 (p. 1075)
- Setting Up a Source Database for Use with GoldenGate on Amazon RDS (p. 1076)
- Setting Up a Target Database for Use with GoldenGate on Amazon RDS (p. 1079)
- Working with the EXTRACT and REPLICAT Utilities of GoldenGate (p. 1080)

Setting Up a GoldenGate Hub on Amazon EC2

To create a GoldenGate hub on an Amazon EC2 instance, you complete several steps. First, you create an Amazon EC2 instance with a full client installation of Oracle RDBMS. For Oracle version 11.2.0.4, you install patch 13328193. The Amazon EC2 instance must also have Oracle GoldenGate software installed. The exact software versions depend on the source and target database versions. For more information about installing GoldenGate, see the Oracle documentation

The Amazon EC2 instance that serves as the GoldenGate hub stores and processes the transaction information from the source database into trail files. To support this process, make sure that you have enough allocated storage to store the trail files. Also, make sure that the Amazon EC2 instance has enough processing power to manage the amount of data being processed. In addition, make sure that the EC2 instance has enough memory to store the transaction information before it's written to the trail file.

The following tasks set up a GoldenGate hub on an Amazon EC2 instance; each task is explained in detail in this section:

1. Create the GoldenGate subdirectories.
2. Update the GLOBALS parameter file.
3. Configure the mgr.prm file and start the manager.

Create subdirectories in the GoldenGate directory using the Amazon EC2 command line shell and *ggsci*, the GoldenGate command interpreter. The subdirectories are created under the gg directory and include directories for parameter, report, and checkpoint files.

```
prompt$ cd /gg
prompt$ ./ggsci
  GGSCI> CREATE SUBDIRS
```

Create a GLOBALS parameter file using the Amazon EC2 command line shell. Parameters that affect all GoldenGate processes are defined in the GLOBALS parameter file. The following example creates the necessary file:

```
$ cd $GGHOME
$ vi GLOBALS
CheckpointTable oggadm1.oggchkpt
```

The last step in setting up and configuring the GoldenGate hub is to configure the *manager*. Add the following lines to the *mgr.prm* file, then start the *manager* using *ggsci*:

```
PORT 8199
PurgeOldExtracts ./dirdat/*, UseCheckpoints, MINKEEPDAYS 5
```

```
GGSCI>  start mgr
```

Once you have completed these steps, the GoldenGate hub is ready for use. Next, you set up the source and target databases.

Setting Up a Source Database for Use with GoldenGate on Amazon RDS

When your source database is running version 11.2.0.4 or later, complete the following tasks to set up a source database for use with GoldenGate:

1. Set the `compatible` parameter to 11.2.0.4 or later.
2. Set the `ENABLE_GOLDENGATE_REPLICATION` parameter to *True*. This parameter turns on supplemental logging for the source database. If your source database is on an Amazon RDS DB instance, make sure that you have a parameter group assigned to the DB instance with the `ENABLE_GOLDENGATE_REPLICATION` parameter set to *true*. For more information about the `ENABLE_GOLDENGATE_REPLICATION` parameter, see the Oracle documentation.
3. Set the retention period for archived redo logs for the GoldenGate source database.
4. Create a GoldenGate user account on the source database.
5. Grant the necessary privileges to the GoldenGate user.
6. Add a TNS alias for the source database to the `tnsnames.ora` file on the GoldenGate hub.

Make sure that the source database has the `compatible` parameter set to 11.2.0.4 or later. If you use an Oracle database on an Amazon RDS DB instance as the source, make sure that you have a parameter group with `compatible` set to 11.2.0.4 or later associated with the DB instance. If you change the `compatible` parameter in a parameter group associated with the DB instance, the change requires an instance reboot.

You can use the following Amazon RDS CLI commands to create a new parameter group and set the `compatible` parameter. Make sure that you associate the new parameter group with the source DB instance.

For Linux, macOS, or Unix:

```
aws rds create-db-parameter-group \
    --db-parameter-group-name example-goldengate \
    --description "Parameters to allow GoldenGate" \
    --db-parameter-group-family oracle-ee-11.2

aws rds modify-db-parameter-group \
    --db-parameter-group-name example-goldengate \
    --parameters "ParameterName=compatible, ParameterValue=11.2.0.4, ApplyMethod=pending-reboot"

aws rds modify-db-instance \
    --db-instance-identifier example-test \
    --db-parameter-group-name example-goldengate \
    --apply-immediately

aws rds reboot-db-instance \
    --db-instance-identifier example-test
```

For Windows:

```
aws rds create-db-parameter-group ^
    --db-parameter-group-name example-goldengate ^
    --description "Parameters to allow GoldenGate" ^
    --db-parameter-group-family oracle-ee-11.2

aws rds modify-db-parameter-group ^
    --db-parameter-group-name example-goldengate ^
    --parameters "ParameterName=compatible, ParameterValue=11.2.0.4, ApplyMethod=pending-reboot"

aws rds modify-db-instance ^
    --db-instance-identifier example-test ^
    --db-parameter-group-name example-goldengate ^
    --apply-immediately

aws rds reboot-db-instance ^
    --db-instance-identifier example-test
```

Always retain the parameter group with the `compatible` parameter. If you restore an instance from a DB snapshot, make sure to modify the restored instance to use the parameter group that has a matching or greater `compatible` parameter value. Do this modification as soon as possible after the restore action. It requires a reboot of the instance.

The `ENABLE_GOLDENGATE_REPLICATION` parameter, when set to *True*, turns on supplemental logging for the source database and configures the required GoldenGate permissions. If your source database is on an Amazon RDS DB instance, make sure that you have a parameter group assigned to the DB instance with `ENABLE_GOLDENGATE_REPLICATION` set to *true*. For more information about `ENABLE_GOLDENGATE_REPLICATION`, see the Oracle documentation.

The source database must also retain archived redo logs. For example, the following command sets the retention period for archived redo logs to 24 hours.

```
exec rdsadmin.rdsadmin_util.set_configuration('archivelog retention hours',24);
```

Specify the duration for log retention in hours. The duration should exceed any potential downtime of the source instance, any potential period of communication, and any potential period of networking issues for the source instance. Such a duration lets Oracle GoldenGate recover logs from the source instance as needed.

The absolute minimum value required is one hour of logs retained. If you don't have log retention enabled, or if the retention value is too small, you receive the following message.

```
2014-03-06 06:17:27  ERROR   OGG-00446  error 2 (No such file or directory)
opening redo log /rdsdbdata/db/GGTEST3_A/onlinelog/o1_mf_2_9k4bp1n6_.log
for sequence 1306Not able to establish initial position for begin time 2014-03-06
 06:16:55.
```

Because these logs are retained on your DB instance, you need to ensure that you have enough storage available on your instance to accommodate the log files. To see how much space you have used in the last "X" hours, use the following query, replacing "X" with the number of hours.

```
select sum(blocks * block_size) bytes from v$archived_log
   where next_time>=sysdate-X/24 and dest_id=1;
```

GoldenGate runs as a database user and requires the appropriate database privileges to access the redo and archive logs for the source database. To provide these, create a GoldenGate user account on the source database. For more information about the permissions for a GoldenGate user account, see the sections 4, section 4.4, and table 4.1 in the Oracle documentation.

The following statements create a user account named *oggadm1*.

```
CREATE tablespace administrator;
CREATE USER oggadm1  IDENTIFIED BY "XXXXXX"
   default tablespace ADMINISTRATOR temporary tablespace TEMP;
```

Finally, grant the necessary privileges to the GoldenGate user account. The following statements grant privileges to a user named *oggadm1*.

```
grant create session, alter session to oggadm1;
grant resource to oggadm1;
grant select any dictionary to oggadm1;
grant flashback any table to oggadm1;
grant select any table to oggadm1;
grant select_catalog_role to <RDS instance master username> with admin option;
exec RDSADMIN.RDSADMIN_UTIL.GRANT_SYS_OBJECT ('DBA_CLUSTERS', 'OGGADM1');
grant execute on dbms_flashback to oggadm1;
grant select on SYS.v_$database to oggadm1;
grant alter any table to oggadm1;

EXEC DBMS_GOLDENGATE_AUTH.GRANT_ADMIN_PRIVILEGE (grantee=>'OGGADM1',
   privilege_type=>'capture',
   grant_select_privileges=>true,
   do_grants=>TRUE);
```

Add the following entry to `$ORACLE_HOME/network/admin/tnsnames.ora` in the Oracle Home to be used by the `EXTRACT` process. For more information on the `tnsname.ora` file, see the Oracle documentation.

```
OGGSOURCE=
(DESCRIPTION=
 (ENABLE=BROKEN)
(ADDRESS_LIST=
   (ADDRESS=(PROTOCOL=TCP)(HOST=goldengate-source.abcdef12345.us-west-2.rds.amazonaws.com)
(PORT=8200))
)
(CONNECT_DATA=
   (SID=ORCL)
)
)
```

Setting Up a Target Database for Use with GoldenGate on Amazon RDS

The following tasks set up a target DB instance for use with GoldenGate:

1. Set the `compatible` parameter to 11.2.0.4 or later
2. Set the `ENABLE_GOLDENGATE_REPLICATION` parameter to *True*. If your target database is on an Amazon RDS DB instance, make sure that you have a parameter group assigned to the DB instance with the `ENABLE_GOLDENGATE_REPLICATION` parameter set to *true*. For more information about the ENABLE_GOLDENGATE_REPLICATION parameter, see the Oracle documentation .
3. Create and manage a GoldenGate user account on the target database
4. Grant the necessary privileges to the GoldenGate user
5. Add a TNS alias for the target database to tnsnames.ora on the GoldenGate hub.

GoldenGate runs as a database user and requires the appropriate database privileges. To make sure it has these, create a GoldenGate user account on the target database.

The following statements create a user named *oggadm1*:

```
create tablespace administrator;
create tablespace administrator_idx;
CREATE USER oggadm1  IDENTIFIED BY "XXXXXX"
   default tablespace ADMINISTRATOR
   temporary tablespace TEMP;
alter user oggadm1 quota unlimited on ADMINISTRATOR;
alter user oggadm1 quota unlimited on ADMINISTRATOR_IDX;
```

Finally, grant the necessary privileges to the GoldenGate user account. The following statements grant privileges to a user named *oggadm1*:

```
grant create session        to oggadm1;
grant alter session         to oggadm1;
grant CREATE CLUSTER        to oggadm1;
grant CREATE INDEXTYPE      to oggadm1;
grant CREATE OPERATOR       to oggadm1;
grant CREATE PROCEDURE      to oggadm1;
grant CREATE SEQUENCE       to oggadm1;
grant CREATE TABLE          to oggadm1;
grant CREATE TRIGGER        to oggadm1;
grant CREATE TYPE           to oggadm1;
grant select any dictionary to oggadm1;
grant create any table      to oggadm1;
grant alter any table       to oggadm1;
grant lock any table        to oggadm1;
grant select any table      to oggadm1;
grant insert any table      to oggadm1;
```

```
grant update any table      to oggadm1;
grant delete any table      to oggadm1;

EXEC DBMS_GOLDENGATE_AUTH.GRANT_ADMIN_PRIVILEGE
   (grantee=>'OGGADM1',privilege_type=>'apply',
   grant_select_privileges=>true, do_grants=>TRUE);
```

Add the following entry to `$ORACLE_HOME/network/admin/tnsnames.ora` in the Oracle Home to be used by the `REPLICAT` process. For more information on the `tnsname.ora` file, see the Oracle documentation.

```


OGGTARGET=
(DESCRIPTION=
 (ENABLE=BROKEN)
(ADDRESS_LIST=
   (ADDRESS=(PROTOCOL=TCP)(HOST=goldengate-target.abcdef12345.us-west-2.rds.amazonaws.com)
(PORT=8200))
)
(CONNECT_DATA=
   (SID=ORCL)
)
)
```

Working with the EXTRACT and REPLICAT Utilities of GoldenGate

The GoldenGate utilities `EXTRACT` and `REPLICAT` work together to keep the source and target databases in sync via incremental transaction replication using trail files. All changes that occur on the source database are automatically detected by `EXTRACT`, then formatted and transferred to trail files on the GoldenGate on-premises or EC2-instance hub. After initial load is completed, the data is read from these files and replicated to the target database by the `REPLICAT` utility.

Running the GoldenGate EXTRACT Utility

The `EXTRACT` utility retrieves, converts, and outputs data from the source database to trail files. `EXTRACT` queues transaction details to memory or to temporary disk storage. When the transaction is committed to the source database, `EXTRACT` flushes all of the transaction details to a trail file. The trail file routes these details to the GoldenGate on-premises or the EC2 instance hub and then to the target database.

The following tasks enable and start the `EXTRACT` utility:

1. Configure the `EXTRACT` parameter file on the GoldenGate hub (on-premises or EC2 instance). The following listing shows an example `EXTRACT` parameter file.

```
EXTRACT EABC
SETENV (ORACLE_SID=ORCL)
SETENV (NLSLANG=AL32UTF8)

USERID oggadm1@OGGSOURCE, PASSWORD XXXXXX
EXTTRAIL /path/to/goldengate/dirdat/ab

IGNOREREPLICATES
GETAPPLOPS
TRANLOGOPTIONS EXCLUDEUSER OGGADM1

TABLE EXAMPLE.TABLE;
```

2. On the GoldenGate hub, launch the GoldenGate command line interface (*ggsci*). Log into the source database. The following example shows the format for logging in:

```
dblogin userid <user>@<db tnsname>
```

3. Add a checkpoint table for the database:

```
add checkpointtable
```

4. Add transdata to turn on supplemental logging for the database table:

```
add trandata <user>.<table>
```

   Alternatively, you can add transdata to turn on supplemental logging for all tables in the database:

```
add trandata <user>.*
```

5. Using the `ggsci` command line, enable the `EXTRACT` utility using the following commands:

```
add extract <extract name> tranlog, INTEGRATED tranlog, begin now
add exttrail <path-to-trail-from-the param-file>
   extract <extractname-from-paramfile>,
   MEGABYTES Xm
```

6. Register the `EXTRACT` utility with the database so that the archive logs are not deleted. This allows you to recover old, uncommitted transactions if necessary. To register the `EXTRACT` utility with the database, use the following command:

```
register EXTRACT <extract process name>, DATABASE
```

7. To start the `EXTRACT` utility, use the following command:

```
start <extract process name>
```

Running the GoldenGate REPLICAT Utility

The `REPLICAT` utility is used to "push" transaction information in the trail files to the target database.

The following tasks enable and start the `REPLICAT` utility:

1. Configure the `REPLICAT` parameter file on the GoldenGate hub (on-premises or EC2 instance). The following listing shows an example `REPLICAT` parameter file.

```
REPLICAT RABC
SETENV (ORACLE_SID=ORCL)
SETENV (NLSLANG=AL32UTF8)

USERID oggadm1@OGGTARGET, password XXXXXX

ASSUMETARGETDEFS
MAP EXAMPLE.TABLE, TARGET EXAMPLE.TABLE;
```

2. Launch the GoldenGate command line interface (ggsci). Log into the target database. The following example shows the format for logging in.

```
dblogin userid <user>@<db tnsname>
```

3. Using the *ggsci* command line, add a checkpoint table. The user indicated should be the GoldenGate user account, not the target table schema owner. The following example creates a checkpoint table named *gg_checkpoint*.

```
add checkpointtable <user>.gg_checkpoint
```

4. To enable the `REPLICAT` utility, use the following command.

```
add replicat <replicat name> EXTTRAIL <extract trail file> CHECKPOINTTABLE
 <user>.gg_checkpoint
```

5. To start the `REPLICAT` utility, use the following command.

```
start <replicat name>
```

Troubleshooting Issues When Using GoldenGate with Amazon RDS

This section explains the most common issues when using Oracle GoldenGate with Amazon RDS.

Topics

Log Retention

To work with Oracle GoldenGate with Amazon RDS, make sure that you have log retention enabled.

Specify the duration for log retention in hours. The duration should exceed any potential downtime of the source instance, any potential period of communication, and any potential period of networking issues for the source instance. Such a duration lets Oracle GoldenGate recover logs from the source instance as needed.

The absolute minimum value required is one hour of logs retained. If you don't have log retention enabled, or if the retention value is too small, you receive the following message.

```
2014-03-06 06:17:27  ERROR   OGG-00446  error 2 (No such file or directory)
opening redo log /rdsdbdata/db/GGTEST3_A/onlinelog/o1_mf_2_9k4bp1n6_.log
for sequence 1306Not able to establish initial position for begin time 2014-03-06
 06:16:55.
```

GoldenGate Appears to Be Properly Configured but Replication Is Not Working

For pre-existing tables, GoldenGate must be told which SCN it should work from. Take the following steps to fix this issue:

1. Launch the GoldenGate command line interface (ggsci). Log into the source database. The following example shows the format for logging.

```
dblogin userid <user>@<db tnsname>
```

2. Using the ggsci command line, set up the start SCN for the `EXTRACT` process. The following example sets the SCN to 223274 for the extract.

```
ALTER EXTRACT <extract process name> SCN 223274
start <extract process name>
```

3. Log in to the target database. The following example shows the format for logging in.

```
dblogin userid <user>@<db tnsname>
```

4. Using the ggsci command line, set up the start SCN for the `REPLICAT` process. The following example sets the SCN to 223274 for the `REPLICAT`.

```
start <replicat process name> atcsn 223274
```

Using the Oracle Repository Creation Utility on Amazon RDS for Oracle

You can use Amazon RDS to host an Oracle DB instance that holds the schemas to support your Fusion Middleware components. Before you can use Fusion Middleware components, you must create and populate schemas for them in your database. You create and populate the schemas by using the Oracle Repository Creation Utility (RCU).

You can store the schemas for any Fusion Middleware components in your Amazon RDS DB instance. The following is a list of schemas that have been verified to install correctly:

- Analytics (ACTIVITIES)
- Audit Services (IAU)
- Audit Services Append (IAU_APPEND)
- Audit Services Viewer (IAU_VIEWER)
- Discussions (DISCUSSIONS)
- Metadata Services (MDS)
- Oracle Business Intelligence (BIPLATFORM)
- Oracle Platform Security Services (OPSS)
- Portal and Services (WEBCENTER)
- Portlet Producers (PORTLET)
- Service Table (STB)
- SOA Infrastructure (SOAINFRA)
- User Messaging Service (UCSUMS)
- WebLogic Services (WLS)

Licensing and Versions

Amazon RDS supports Oracle Repository Creation Utility (RCU) version 12c only. You can use the RCU in the following configurations:

- RCU 12c with Oracle database 12.2.0.1
- RCU 12c with Oracle database 12.1.0.2.v4 or later
- RCU 12c with Oracle database 11.2.0.4.v8 or later

Before you can use RCU, you need a license for Oracle Fusion Middleware. You also need to follow the Oracle licensing guidelines for the Oracle database that hosts the repository. For more information, see Oracle Fusion Middleware Licensing Information User Manual in the Oracle documentation.

Fusion MiddleWare supports repositories on Oracle Database Enterprise Edition and Standard Editions (SE, SE One, or SE Two). Oracle recommends Enterprise Edition for production installations that require partitioning and installations that require online index rebuild.

Before you create your Oracle DB instance, confirm the Oracle database version that you need to support the components that you want to deploy. You can use the Certification Matrix to find the requirements for the Fusion Middleware components and versions you want to deploy. For more information, see Oracle Fusion Middleware Supported System Configurations in the Oracle documentation.

Amazon RDS supports Oracle database version upgrades as needed. For more information, see Upgrading a DB Instance Engine Version (p. 241).

Before You Begin

Before you begin, you need an Amazon VPC. Because your Amazon RDS DB instance needs to be available only to your Fusion Middleware components, and not to the public Internet, your Amazon RDS DB instance is hosted in a private subnet, providing greater security. For information about how to create an Amazon VPC for use with an Oracle DB instance, see Creating a VPC for Use with an Oracle Database (p. 1066).

Before you begin, you also need an Oracle DB instance. For information about how to create an Oracle DB instance for use with Fusion Middleware metadata, see Creating an Oracle DB Instance (p. 1071).

Recommendations

The following are some recommendations for working with your DB instance in this scenario:

- We recommend that you use Multi-AZ for production workloads. For more information about working with multiple Availability Zones, see Regions, Availability Zones, and Local Zones (p. 37).
- For additional security, Oracle recommends that you use Transparent Data Encryption (TDE) to encrypt your data at rest. If you have an Enterprise Edition license that includes the Advanced Security Option, you can enable encryption at rest by using the TDE option. For more information, see Oracle Transparent Data Encryption (p. 990).

  Amazon RDS also provides an encryption at rest option for all database editions. For more information, see Encrypting Amazon RDS Resources (p. 1358).
- Configure your VPC Security Groups to allow communication between your application servers and your Amazon RDS DB instance. The application servers that host the Fusion Middleware components can be on Amazon EC2 or on-premises.

Using the Oracle Repository Creation Utility

You use the Oracle Repository Creation Utility (RCU) to create and populate the schemas to support your Fusion Middleware components.

Running RCU Using the Command Line in One Step

If you don't need to edit any of your schemas before populating them, you can run RCU in a single step. Otherwise, see the following section for running RCU in multiple steps.

You can run the RCU in silent mode by using the command-line parameter `-silent`. When you run RCU in silent mode, you can avoid typing passwords on the command line by creating a text file containing the passwords. Create a text file with the password for `dbUser` on the first line, and the password for each component on subsequent lines. You specify the name of the password file as the last parameter to the RCU command.

Example

The following example creates and populates schemas for the SOA Infrastructure component (and its dependencies) in a single step.

For Linux, macOS, or Unix:

```
export ORACLE_HOME=/u01/app/oracle/product/12.2.1.0/fmw
export JAVA_HOME=/usr/java/jdk1.8.0_65
${ORACLE_HOME}/oracle_common/bin/rcu \
-silent \
-createRepository \
-connectString ${dbhost}:${dbport}:${dbname} \
```

```
-dbUser ${dbuser} \
-dbRole Normal \
-honorOMF \
-schemaPrefix ${SCHEMA_PREFIX} \
-component MDS \
-component STB \
-component OPSS \
-component IAU \
-component IAU_APPEND \
-component IAU_VIEWER \
-component UCSUMS \
-component WLS \
-component SOAINFRA \
-f < /tmp/passwordfile.txt
```

For more information, see Running Repository Creation Utility from the Command Line in the Oracle documentation.

Running RCU Using the Command Line in Multiple Steps

If you need to manually edit your schema scripts, you can run the RCU in multiple steps:

1. Run RCU in **Prepare Scripts for System Load** mode by using the `-generateScript` command-line parameter to create the scripts for your schemas.
2. Manually edit and run the generated script `script_systemLoad.sql`.
3. Run RCU again in **Perform Product Load** mode by using the `-dataLoad` command-line parameter to populate the schemas.
4. Run the generated clean-up script `script_postDataLoad.sql`.

You can run the RCU in silent mode by using the command-line parameter `-silent`. When you run RCU in silent mode, you can avoid typing passwords on the command line by creating a text file containing the passwords. Create a text file with the password for `dbUser` on the first line, and the password for each component on subsequent lines. You specify the name of the password file as the last parameter to the RCU command.

Example

The following example creates schema scripts for the SOA Infrastructure component (and its dependencies).

For Linux, macOS, or Unix:

```
export ORACLE_HOME=/u01/app/oracle/product/12.2.1.0/fmw
export JAVA_HOME=/usr/java/jdk1.8.0_65
${ORACLE_HOME}/oracle_common/bin/rcu \
-silent \
-generateScript \
-connectString ${dbhost}:${dbport}:${dbname} \
-dbUser ${dbuser} \
-dbRole Normal \
-honorOMF \
[-encryptTablespace true] \
-schemaPrefix ${SCHEMA_PREFIX} \
-component MDS \
-component STB \
-component OPSS \
-component IAU \
-component IAU_APPEND \
-component IAU_VIEWER \
-component UCSUMS \
```

```
-component WLS \
-component SOAINFRA \
-scriptLocation /tmp/rcuscripts \
-f < /tmp/passwordfile.txt
```

Now you can edit the generated script, connect to your Oracle DB instance, and run the script. The generated script is named `script_systemLoad.sql`. For information about connecting to your Oracle DB instance, see Connecting to Your Sample Oracle DB Instance (p. 89).

The following example populates the schemas for the SOA Infrastructure component (and its dependencies).

For Linux, macOS, or Unix:

```
export JAVA_HOME=/usr/java/jdk1.8.0_65
${ORACLE_HOME}/oracle_common/bin/rcu \
-silent \
-dataLoad \
-connectString ${dbhost}:${dbport}:${dbname} \
-dbUser ${dbuser} \
-dbRole Normal \
-honorOMF \
-schemaPrefix ${SCHEMA_PREFIX} \
-component MDS \
-component STB \
-component OPSS \
-component IAU \
-component IAU_APPEND \
-component IAU_VIEWER \
-component UCSUMS \
-component WLS \
-component SOAINFRA \
-f < /tmp/passwordfile.txt
```

To finish, you connect to your Oracle DB instance, and run the clean-up script. The script is named `script_postDataLoad.sql`.

For more information, see Running Repository Creation Utility from the Command Line in the Oracle documentation.

Running RCU in Interactive Mode

To use the RCU graphical user interface, you can run RCU in interactive mode. To run RCU in interactive mode, include the `-interactive` parameter and omit the `-silent` parameter. For more information, see Understanding Repository Creation Utility Screens in the Oracle documentation.

Example

The following example starts RCU in interactive mode and pre-populates the connection information.

For Linux, macOS, or Unix:

```
export ORACLE_HOME=/u01/app/oracle/product/12.2.1.0/fmw
export JAVA_HOME=/usr/java/jdk1.8.0_65
${ORACLE_HOME}/oracle_common/bin/rcu \
-interactive \
-createRepository \
-connectString ${dbhost}:${dbport}:${dbname} \
-dbUser ${dbuser} \
-dbRole Normal
```

Known Issues

The following are some known issues for working with RCU, with some troubleshooting suggestions:

- Oracle Managed Files (OMF) — Amazon RDS uses OMF data files to simplify storage management. You can customize tablespace attributes, such as size and extent management. However, specifying a data file name when you run RCU causes tablespace code to fail with `ORA-20900`. The RCU can be used with OMF in the following ways:
  - In RCU 12.2.1.0 and later, use the `-honorOMF` command-line parameter.
  - In RCU 12.1.0.3 and later, use multiple steps and edit the generated script. For more information, see Running RCU Using the Command Line in Multiple Steps (p. 1086).
- SYSDBA — Because Amazon RDS is a managed service, you don't have full SYSDBA access to your Oracle DB instance. However, RCU 12c supports users with lower privileges. In most cases, the master user privilege is sufficient to create repositories. In some cases, the RCU might fail with `ORA-01031` when attempting to grant SYS object privileges. You can retry and run the RDSADMIN_UTIL.GRANT_SYS_OBJECT() stored procedure, or contact AWS Support.
- Dropping Enterprise Scheduler Service — When you use the RCU to drop an Enterprise Scheduler Service repository, the RCU might fail with `Error: Component drop check failed`.

Related Topics

- Oracle Licensing (p. 847)

Installing a Siebel Database on Oracle on Amazon RDS

You can use Amazon RDS to host a Siebel Database on an Oracle DB instance. The Siebel Database is part of the Siebel Customer Relationship Management (CRM) application architecture. For an illustration, see Generic Architecture of Siebel Business Application.

Use the following topic to help set up a Siebel Database on an Oracle DB instance on Amazon RDS. You can also find out how to use Amazon Web Services to support the other components required by the Siebel CRM application architecture.

> **Note**
> To install a Siebel Database on Oracle on Amazon RDS, you need to use the master user account. You don't need `SYSDBA` privilege; master user privilege is sufficient. For more information, see Master User Account Privileges (p. 1427).

Licensing and Versions

To install a Siebel Database on Amazon RDS, you must use your own Oracle Database license, and your own Siebel license. You must have the appropriate Oracle Database license (with Software Update License and Support) for the DB instance class and Oracle Database edition. For more information, see Oracle Licensing (p. 847).

Oracle Database Enterprise Edition is the only edition certified by Siebel for this scenario. Amazon RDS supports Siebel CRM version 15.0 or 16.0. Use Oracle 12c, version 12.1.0.2.0. For the procedures following, we use Siebel CRM version 15.0 and Oracle 12.1.0.2 or 12.2.0.1. For more information, see Oracle 12c with Amazon RDS (p. 855).

Amazon RDS supports database version upgrades. For more information, see Upgrading a DB Instance Engine Version (p. 241).

Before You Begin

Before you begin, you need an Amazon VPC. Because your Amazon RDS DB instance needs to be available only to your Siebel Enterprise Server, and not to the public Internet, your Amazon RDS DB instance is hosted in a private subnet, providing greater security. For information about how to create an Amazon VPC for use with Siebel CRM, see Creating a VPC for Use with an Oracle Database (p. 1066).

Before you begin, you also need an Oracle DB instance. For information about how to create an Oracle DB instance for use with Siebel CRM, see Creating an Oracle DB Instance (p. 1071).

Installing and Configuring a Siebel Database

After you create your Oracle DB instance, you can install your Siebel Database. You install the database by creating table owner and administrator accounts, installing stored procedures and functions, and then running the Siebel Database Configuration Wizard. For more information, see Installing the Siebel Database on the RDBMS.

To run the Siebel Database Configuration Wizard, you need to use the master user account. You don't need `SYSDBA` privilege; master user privilege is sufficient. For more information, see Master User Account Privileges (p. 1427).

Using Other Amazon RDS Features with a Siebel Database

After you create your Oracle DB instance, you can use additional Amazon RDS features to help you customize your Siebel Database.

Collecting Statistics with the Oracle Statspack Option

You can add features to your DB instance through the use of options in DB option groups. When you created your Oracle DB instance, you used the default DB option group. If you want to add features to your database, you can create a new option group for your DB instance.

If you want to collect performance statistics on your Siebel Database, you can add the Oracle Statspack feature. For more information, see Oracle Statspack (p. 984).

Some option changes are applied immediately, and some option changes are applied during the next maintenance window for the DB instance. For more information, see Working with Option Groups (p. 186). After you create a customized option group, modify your DB instance to attach it. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

Performance Tuning with Parameters

You manage your DB engine configuration through the use of parameters in a DB parameter group. When you created your Oracle DB instance, you used the default DB parameter group. If you want to customize your database configuration, you can create a new parameter group for your DB instance.

When you change a parameter, depending on the type of the parameter, the changes are applied either immediately or after you manually reboot the DB instance. For more information, see Working with DB Parameter Groups (p. 202). After you create a customized parameter group, modify your DB instance to attach it. For more information, see Modifying an Amazon RDS DB Instance (p. 220).

To optimize your Oracle DB instance for Siebel CRM, you can customize certain parameters. The following table shows some recommended parameter settings. For more information about performance tuning Siebel CRM, see Siebel CRM Performance Tuning Guide.

Parameter Name	Default Value	Guidance for Optimal Siebel CRM Performance
`_always_semi_join`	`CHOOSE`	`OFF`
`_b_tree_bitmap_plans`	`TRUE`	`FALSE`
`_like_with_bind_as_equality`	`FALSE`	`TRUE`
`_no_or_expansion`	`FALSE`	`FALSE`
`_optimizer_join_sel_sanity_check`	`TRUE`	`TRUE`
`_optimizer_max_permutations`	`2000`	100
`_optimizer_sortmerge_join_enabled`	`TRUE`	`FALSE`
`_partition_view_enabled`	`TRUE`	`FALSE`
`open_cursors`	`300`	At least **`2000`**.

Creating Snapshots

After you create your Siebel Database, you can copy the database by using the snapshot features of Amazon RDS. For more information, see Creating a DB Snapshot (p. 301) and Restoring from a DB Snapshot (p. 303).

Support for Other Siebel CRM Components

In addition to your Siebel Database, you can also use Amazon Web Services to support the other components of your Siebel CRM application architecture. You can find more information about the support provided by Amazon AWS for additional Siebel CRM components in the following table.

Siebel CRM Component	Amazon AWS Support
Siebel Enterprise (with one or more Siebel Servers)	You can host your Siebel Servers on Amazon Elastic Compute Cloud (Amazon EC2) instances. You can use Amazon EC2 to launch as many or as few virtual servers as you need. Using Amazon EC2, you can scale up or down easily to handle changes in requirements. For more information, see What Is Amazon EC2? You can put your servers in the same VPC with your DB instance and use the VPC security group to access the database. For more information, see Working with a DB Instance in a VPC (p. 1442).
Web Servers (with Siebel Web Server Extensions)	You can install multiple Web Servers on multiple EC2 instances. You can then use Elastic Load Balancing to distribute incoming traffic among the instances. For more information, see What Is Elastic Load Balancing?
Siebel Gateway Name Server	You can host your Siebel Gateway Name Server on an EC2 instance. You can then put your server in the same VPC with the DB instance and use the VPC security group to access the database. For more information, see Working with a DB Instance in a VPC (p. 1442).

Related Topics

- Connecting to a DB Instance Running the Oracle Database Engine (p. 874)

Oracle Database Engine Release Notes

Updates to your Amazon RDS for Oracle DB instances keep them current. If you apply updates, you can be confident that your DB instance is running a version of the database software that has been tested by both Oracle and Amazon. We don't support applying one-off patches to individual DB instances.

You can specify any currently supported Oracle version when creating a new DB instance. You can specify the major version (such as Oracle 12.1), and any supported minor version for the specified major version. If no version is specified, Amazon RDS defaults to a supported version, typically the most recent version. If a major version is specified but a minor version is not, Amazon RDS defaults to a recent release of the major version that you have specified. To see a list of supported versions and defaults for newly created DB instances, use the `describe-db-engine-versions` AWS CLI command.

Oracle Versions 19.0.0, 18.0.0, and 12.2.0.1

For Amazon RDS for Oracle versions 19.0.0.0, 18.0.0.0, and 12.2.0.1, Amazon RDS incorporates bug fixes from Oracle by using Release Updates (RUs) and Release Updates Revisions (RURs). We don't support applying one-off patches to individual DB instances.

To find what RUs and RURs are applied to Amazon RDS for Oracle versions 19.0.0, 18.0.0.0, and 12.2.0.1, see the following table.

RU and RUR	Version 19.0.0.0	Version 18.0.0.0	Version 12.2.0.1
2020 April	19.0.0.0.ru-2020-04.rur-2020-04.r1 (p. 1093)	18.0.0.0.ru-2020-04.rur-2020-04.r1 (p. 1108)	12.2.0.1.ru-2020-04.rur-2020-04
2020 January	19.0.0.0.ru-2020-01.rur-2020-01.r1 (p. 1098)	18.0.0.0.ru-2020-01.rur-2020-01.r1 (p. 1112)	12.2.0.1.ru-2020-01.rur-2020-01
2019 October	19.0.0.0.ru-2019-10.rur-2019-10.r1 (p. 1102)	18.0.0.0.ru-2019-10.rur-2019-10.r1 (p. 1115)	12.2.0.1.ru-2019-10.rur-2019-10
2019 July	19.0.0.0.ru-2019-07.rur-2019-07.r1 (p. 1106)	18.0.0.0.ru-2019-07.rur-2019-07.r1 (p. 1118)	12.2.0.1.ru-2019-07.rur-2019-07
2019 April	—	—	12.2.0.1.ru-2019-04.rur-2019-04
2019 January	—	—	12.2.0.1.ru-2019-01.rur-2019-01
2018 October	—	—	12.2.0.1.ru-2018-10.rur-2018-10

Oracle Versions 12.1.0.2 and 11.2.0.4

For Amazon RDS for Oracle versions 12.1.0.2 and 11.2.0.4, Amazon RDS incorporates bug fixes from Oracle by using their quarterly Database Patch Set Updates (PSUs). If you apply updates, you can be confident that your DB instance is running a version of the database software that has been tested by both Oracle and Amazon. We don't support applying one-off patches to individual DB instances.

To find what Oracle Patch Set Updates (PSUs) are applied to Amazon RDS for Oracle versions 12.1.0.2 and 11.2.0.4, see the following table.

PSU	Version 12.1.0.2	Version 11.2.0.4
2020 April	12.1.0.2.v20 (p. 1145)	11.2.0.4.v24 (p. 1185)
2020 January	12.1.0.2.v19 (p. 1149)	11.2.0.4.v23 (p. 1188)
2019 October	12.1.0.2.v18 (p. 1152)	11.2.0.4.v22 (p. 1190)

PSU	Version 12.1.0.2	Version 11.2.0.4
2019 July	12.1.0.2.v17 (p. 1155)	11.2.0.4.v21 (p. 1193)
2019 April	12.1.0.2.v16 (p. 1158)	11.2.0.4.v20 (p. 1195)
2019 January	12.1.0.2.v15 (p. 1161)	11.2.0.4.v19 (p. 1196)
2018 October	12.1.0.2.v14 (p. 1163)	11.2.0.4.v18 (p. 1198)
2018 July	12.1.0.2.v13 (p. 1165)	11.2.0.4.v17 (p. 1200)
2018 April	12.1.0.2.v12 (p. 1168)	11.2.0.4.v16 (p. 1202)
2018 January	12.1.0.2.v11 (p. 1170)	11.2.0.4.v15 (p. 1203)
2017 October	12.1.0.2.v10 (p. 1172)	11.2.0.4.v14 (p. 1205)
2017 July	12.1.0.2.v9 (p. 1173)	11.2.0.4.v13 (p. 1206)
2017 April	12.1.0.2.v8 (p. 1175)	11.2.0.4.v12 (p. 1208)
2017 January	12.1.0.2.v7 (p. 1177)	11.2.0.4.v11 (p. 1209)
2016 October	12.1.0.2.v6 (p. 1178)	11.2.0.4.v10 (p. 1211)
2016 July	12.1.0.2.v5 (p. 1180)	11.2.0.4.v9 (p. 1212)
2016 April	12.1.0.2.v4 (p. 1181)	11.2.0.4.v8 (p. 1213)
2016 January	12.1.0.2.v3 (p. 1182)	11.2.0.4.v7 (p. 1215)
2015 October	12.1.0.2.v2 (p. 1183)	11.2.0.4.v6 (p. 1216) 11.2.0.4.v5 (p. 1216)
2015 April	12.1.0.2.v1 (p. 1184)	11.2.0.4.v4 (p. 1217)
2014 October	—	11.2.0.4.v3 (p. 1219)
2014 July	—	11.2.0.4.v2 (p. 1219) (Deprecated)
2014 January	—	11.2.0.4.v1 (p. 1220)

Database Engine: 19.0.0.0

The following versions are available for Oracle database engine 19.0.0.0:

Version 19.0.0.0.ru-2020-04.rur-2020-04.r1

Version 19.0.0.0.ru-2020-04.rur-2020-04.r1 adds support for the following:

- Patch 30869156: Database Release Update 19.7.0.0.200414
- Patch 30805684: Oracle JVM Release Update 19.7.0.0.200414
- Patch 29997937: DSTv34 UPDATE for RDBMS (TZDATA2019B)
- Patch 29997959: DSTV34 UPDATE for OJVM (TZDATA2019B)
- PreUpgrade Jar: preupgrade_19_cbuild_5_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Patch 30528704: 19C RMAN RECOVER DATABASE USE REDO LOG INSTEAD OF ARCHIVELOG AFTER APPLYING OCT DATABASE RU
- Adds support for Purging the Recycle Bin (p. 1024).
- Adds support for Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015) using the `rdsadmin.rdsadmin_diagnostic_util` package.

Combined Patches for Version 19.0.0.0.ru-2020-04.rur-2020-04.r1, Released April 2020

Bugs fixed:

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Version 19.0.0.0.ru-2020-01.rur-2020-01.r1

Version 19.0.0.0.ru-2020-01.rur-2020-01.r1 adds support for the following:

- Patch 30557433: Database Release Update: 19.6.0.0.200114
- Patch 30484981: OJVM RELEASE UPDATE: 19.6.0.0.200114
- Patch 29997937: DSTv34 UPDATE for RDBMS (TZDATA2019B)
- Patch 29997959: DSTV34 UPDATE for OJVM (TZDATA2019B)
- PreUpgrade Jar: preupgrade_19_cbuild_5_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Patch 30528704: 19C RMAN RECOVER DATABASE USE REDO LOG INSTEAD OF ARCHIVELOG AFTER APPLYING OCT DATABASE RU

Oracle Release Update 19.6.0.0.200114, Released January 2020

Bugs fixed:

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Version 19.0.0.0.ru-2019-10.rur-2019-10.r1

Version 19.0.0.0.ru-2019-10.rur-2019-10.r1 adds support for the following:

- Patch 30125133: DATABASE RELEASE UPDATE 19.5.0.0.0
- Patch 30128191: OJVM RELEASE UPDATE 19.5.0.0.0
- Patch 29997937: DSTv34 UPDATE for RDBMS (TZDATA2019B)
- Patch 29997959: DSTV34 UPDATE for OJVM (TZDATA2019B)
- PreUpgrade Jar: preupgrade_19_cbuild_4_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Patch 30528704: 19C RMAN RECOVER DATABASE USE REDO LOG INSTEAD OF ARCHIVELOG AFTER APPLYING OCT DATABASE RU
- Adds support for Resizing the Temporary Tablespace in a Read Replica (p. 1023).

Oracle Release Update 19.5.0.0.0, Released October 2019

Bugs fixed:

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Version 19.0.0.0.ru-2019-07.rur-2019-07.r1

Version 19.0.0.0.ru-2019-07.rur-2019-07.r1 adds support for the following:

- Patch 29834717: Database Release Update: 19.4.0.0.190716
- Patch 29774421: OJVM RELEASE UPDATE: 19.4.0.0.190716
- Patch 28852325: RDBMS - DSTV33 UPDATE - TZDATA2018G
- Patch 28852334: DSTV33 UPDATE - TZDATA2018G - NEED OJVM FIX
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- PreUpgrade Jar: preupgrade_19_cbuild_4_lf.zip

Oracle Release Update 19.4.0.0.190716, Released July 2019

Bugs fixed:

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Database Engine: 18.0.0.0

The following versions are available for Oracle database engine 18.0.0.0:

Version 18.0.0.0.ru-2020-04.rur-2020-04.r1

Version 18.0.0.0.ru-2020-04.rur-2020-04.r1 adds support for the following:

- Patch 30872794: Database Release Update 18.10.0.0.200414
- Patch 30805598: Oracle JVM Release Update 18.10.0.0.200414
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019B)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_181_cbuild_9_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Adds support for Purging the Recycle Bin (p. 1024).
- Adds support for Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015) using the `rdsadmin.rdsadmin_diagnostic_util` package.

Combined Patches for Version 18.0.0.0.ru-2020-04.rur-2020-04.r1, Released April 2020

Bugs fixed:

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Version 18.0.0.0.ru-2020-01.rur-2020-01.r1

Version 18.0.0.0.ru-2020-01.rur-2020-01.r1 adds support for the following:

- Patch 30480385: Database Release Update: 18.9.0.0.200114
- Patch 30501926: OJVM RELEASE UPDATE: 18.9.0.0.200114
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019B)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_181_cbuild_9_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE

Oracle Release Update 18.9.0.0.200114, Released January 2020

Bugs fixed:

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Version 18.0.0.0.ru-2019-10.rur-2019-10.r1

Version 18.0.0.0.ru-2019-10.rur-2019-10.r1 adds support for the following:

- Patch 30112122: DATABASE OCT 2019 RELEASE UPDATE 18.0.0.0.191015
- Patch 30133625: OJVM RELEASE UPDATE 12.2.0.1.191015
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_181_cbuild_8_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470
- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Adds support for Resizing the Temporary Tablespace in a Read Replica (p. 1023).

Oracle Release Update 18.8.0.0.0, Released October 2019

Bugs fixed:

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Version 18.0.0.0.ru-2019-07.rur-2019-07.r1

Version 18.0.0.0.ru-2019-07.rur-2019-07.r1 adds support for the following:

- Patch 29757256: Database Release Update: 18.7.0.0.190716
- Patch 29774410: OJVM RELEASE UPDATE: 18.7.0.0.190716
- Patch 27539475: "ORA-3816 - MISSING MESSAGE INFORMATION FOR 3816 ERROR."
- Patch 29213893: "DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER$ TABLE"
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- PreUpgrade Jar: preupgrade_181_cbuild_7_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle Release Update 18.7.0.0.190716, Released July 2019

Bugs fixed:

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Database Engine: 12.2.0.1

For Oracle 12c version 12.2.0.1, Oracle changed the way it releases Oracle Database updates. Instead of Patch Set Updates (PSUs), Oracle supplies Release Updates (RUs) and Release Updates Revisions (RURs). RUs contain optimizer changes, feature additions, and security fixes. RURs only contain security fixes for the two preceding quarterly patch cycles. With this new system, you have more control over the features that you install with each update.

The naming conventions have also changed for Oracle 12c version 12.2.0.1 versions. In previous versions, Amazon RDS for Oracle used the PSU naming convention of *oracle-version*.v*patch-version*. The *patch-version* corresponded with an Oracle PSU. For example, in Oracle for Amazon RDS version 12.1.0.2.v13, the v13 part of the version number corresponds with an Oracle PSU.

Oracle 12c version 12.2.0.1 naming conventions account for both RU and RUR updates. For example, the first Amazon RDS for Oracle version available is 12.2.0.1.ru-2018-10.rur-2018-10.r1. In this example, 12.2 is the major version, and 0.1 is the minor version. The revision version has the following parts:

- ru-2018-10 – the October RU
- rur-2018-10 – the October RUR for the October RU
- r1 – Internal Amazon RDS revision, which lets Amazon RDS differentiate between emergency patches of pre-existing RU/RURs

For more information about the new Oracle Database versioning system, see the posts Differences between PSU / BP and RU / RUR at the Upgrade your Database – NOW! blog and RU and RUR patches for Oracle 12.2 at the Oracle–Help blog.

The following versions are available for Oracle database engine 12.2.0.2:

Version 12.2.0.1.ru-2020-04.rur-2020-04.r1

Version 12.2.0.1.ru-2020-04.rur-2020-04.r1 adds support for the following:

- Patch 30886680: Database Apr 2020 Release Update 12.2.0.1.200414
- Patch 30805580: Oracle JVM Release Update 12.2.0.1.200414
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_12201_cbuild_23_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470
- Adds support for Purging the Recycle Bin (p. 1024).
- Adds support for Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015) using the `rdsadmin.rdsadmin_diagnostic_util` package.

Combined Patches for Version 12.2.0.1.ru-2020-04.rur-2020-04.r1, Released April 2020

Bugs fixed:

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Version 12.2.0.1.ru-2020-01.rur-2020-01.r1

Version 12.2.0.1.ru-2020-01.rur-2020-01.r1 adds support for the following:

- Patch 30593149: Database Jan 2020 Release Update: 12.2.0.1.200114
- Patch 30502018: OJVM RELEASE UPDATE 12.2.0.1.200114
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_12201_cbuild_23_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470

Oracle Release Update 12.2.0.1.200114, Released January 2020

Bugs fixed:

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Version 12.2.0.1.ru-2019-10.rur-2019-10.r1

Version 12.2.0.1.ru-2019-10.rur-2019-10.r1 adds support for the following:

- Patch 30138470: DATABASE OCT 2019 RELEASE UPDATE 12.2.0.1.191015
- Patch 30133625: OJVM RELEASE UPDATE 12.2.0.1.191015
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- PreUpgrade Jar: preupgrade_12201_cbuild_23_lf.zip
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR is included in DB PATCH 30138470
- Adds support for Resizing the Temporary Tablespace in a Read Replica (p. 1023).

Oracle Release Update 12.2.0.1.191015, Released October 2019

Bugs fixed:

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Version 12.2.0.1.ru-2019-07.rur-2019-07.r1

Version 12.2.0.1.ru-2019-07.rur-2019-07.r1 adds support for the following:

- Patch 29757449: DATABASE JUL 2019 RELEASE UPDATE 12.2.0.1.190716
- Patch 29774415: OJVM RELEASE UPDATE 12.2.0.1.190716
- Patch 28125601: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28127287: DSTv33 for OJVM (TZDATA2018G)
- PreUpgrade Jar: preupgrade_12201_cbuild_22_lf.zip

- Patch 29213893: DBMS_STATS FAILING WITH ERROR ORA-01422 WHEN GATHERING STATS FOR USER $ TABLE
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle Release Update 12.2.0.1.190716, Released July 2019

Bugs fixed:

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Version 12.2.0.1.ru-2019-04.rur-2019-04.r1

Version 12.2.0.1.ru-2019-04.rur-2019-04.r1 adds support for the following:

- Patch 29314339: Database Apr 2019 Release Update: 12.2.0.1.190416
- Patch 29249637: OJVM RELEASE UPDATE: 12.2.0.1.190416
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- PreUpgrade Jar: preupgrade_12201_cbuild_21_lf.zip
- Patch 28423598: GOLDENGATE AUTH CAUSES ACTIVE DG TO BE UNUSABLE UNTIL BOUNCE
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle Release Update 12.2.0.1.190416, Released April 2019

Bugs fixed:

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Version 12.2.0.1.ru-2019-01.rur-2019-01.r1

Version 12.2.0.1.ru-2019-01.rur-2019-01.r1 adds support for the following:

- Patch 28822515: Database Jan 2019 Release Update: 12.2.0.1.190115
- Patch 28790651: OJVM RELEASE UPDATE: 12.2.0.1.190115
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 28127287: DSTv32 for OJVM (TZDATA2018E)
- PreUpgrade Jar: preupgrade_12201_cbuild_19_lf.zip

Oracle Release Update 12.2.0.1.190115, Released January 2019

Bugs fixed:

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Version 12.2.0.1.ru-2018-10.rur-2018-10.r1

Version 12.2.0.1.ru-2018-10.rur-2018-10.r1 adds support for the following:

- October 2018 Release Update: 12.2.0.1.181016 (28662603)

Oracle Release Update 12.2.0.1.181016, Released October 2018

Bugs fixed:

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Database Engine: 12.1.0.2

The following versions are available for database engine 12.1.0.2:

Version 12.1.0.2.v20

Version 12.1.0.2.v20 adds support for the following:

- Patch 30700212: Database PSU 12.1.0.2.200414
- Patch 30805558: Oracle JVM Component Database PSU 12.1.0.2.200414
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- Patch 17969866: Oracle GoldenGate – 46719: ENH: REPLICATION SUPPORT FOR INSERTS / FULL UPDATES WITH LARGE VALUES
- Patch 20394750: Oracle GoldenGate – APPLY CDR RESOLUTION FAILING FOR LOBS, XML, LONG, AND OBJECTS
- Patch 24835919: Oracle GoldenGate – IR EXECUTING DEPENDENT TRANSACTIONS OUT OF ORDER WITH PARALLELISM GREATER THAN
- Patch 23262847: Oracle GoldenGate – MALFORMED REDO CAUSED OGG REPLICATION ABEND
- Patch 21171382: DBMS_STATS Patch

- Patch 21091901: ONLINE MOVE OF HASH OR REF PARTITION CAN LEAVE LOCAL INDEXES INCONSISTENT
- Patch 31164857: JSON bundle patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- PreUpgrade Jar: preupgrade_12.1.0.2.0_18_crlf.zipn
- Adds support for Purging the Recycle Bin (p. 1024).
- Adds support for Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015) using the `rdsadmin.rdsadmin_diagnostic_util` package.

Combined Patches for Version 12.1.0.2, Released April 2020

Bugs fixed:

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Version 12.1.0.2.v19

Version 12.1.0.2.v19 adds support for the following:

- Patch 30340202: DATABASE PATCH SET UPDATE 12.1.0.2.200114
- Patch 30502041: OJVM PATCH SET UPDATE 12.1.0.2.200114
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- Patch 17969866: Oracle GoldenGate – 46719: ENH: REPLICATION SUPPORT FOR INSERTS / FULL UPDATES WITH LARGE VALUES
- Patch 20394750: Oracle GoldenGate – APPLY CDR RESOLUTION FAILING FOR LOBS, XML, LONG, AND OBJECTS
- Patch 24835919: Oracle GoldenGate – IR EXECUTING DEPENDENT TRANSACTIONS OUT OF ORDER WITH PARALLELISM GREATER THAN
- Patch 23262847: Oracle GoldenGate – MALFORMED REDO CAUSED OGG REPLICATION ABEND
- Patch 21171382: DBMS_STATS Patch
- Patch 21091901: ONLINE MOVE OF HASH OR REF PARTITION CAN LEAVE LOCAL INDEXES INCONSISTENT
- Patch 30708149: JSON bundle patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- PreUpgrade Jar: preupgrade_12.1.0.2.0_18_crlf.zip

Oracle patch 29918340, released January 2020

Bugs fixed:

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Version 12.1.0.2.v18

Version 12.1.0.2.v18 adds support for the following:

- Patch 29918340: DATABASE PATCH SET UPDATE 12.1.0.2.191015
- Patch 30128197: OJVM PATCH SET UPDATE 12.1.0.2.191015
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTv34 for OJVM (TZDATA2019G)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 24835919: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 21091901: ONLINE MOVE OF HASH OR REF PARTITION CAN LEAVE LOCAL INDEXES INCONSISTENT
- Patch 30370890: JSON bundle patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

- PreUpgrade Jar: preupgrade_12.1.0.2.0_18_crlf.zip
- Adds support for Resizing the Temporary Tablespace in a Read Replica (p. 1023).

Oracle patch 29918340, released October 2019

Bugs fixed:

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Version 12.1.0.2.v17

Version 12.1.0.2.v17 adds support for the following:

- Patch 29494060: DATABASE PATCH SET UPDATE 12.1.0.2.190716
- Patch 29774383: OJVM PATCH SET UPDATE 12.1.0.2.190716
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 24835919: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 21091901: ONLINE MOVE OF HASH OR REF PARTITION CAN LEAVE LOCAL INDEXES INCONSISTENT
- Patch 29958796: JSON bundle patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]

- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 29494060, released July 2019

Bugs fixed:

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Version 12.1.0.2.v16

Version 12.1.0.2.v16 adds support for the following:

- Patch 29141015: Database Patch Set Update: 12.1.0.2.190416
- Patch 29251241: OJVM PATCH SET UPDATE 12.1.0.2.190416
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 24835919: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 21091901: ONLINE MOVE OF HASH OR REF PARTITION CAN LEAVE LOCAL INDEXES INCONSISTENT
- Patch 29600862: JSON bundle patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 22785785, released April 2019

Bugs fixed:

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Version 12.1.0.2.v15

Version 12.1.0.2.v15 adds support for the following:

- Patch 28729169: Oracle Database Patch Set Update 12.1.0.2.190115
- Patch 28790654: Oracle JVM Patch Set Update 12.1.0.2.190115
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 28127287: DSTv32 for OJVM (TZDATA2018E)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 29125200: JSON bundle patch
- Patch 20033733: KGL heap size patch

Oracle patch 28729169, released January 2019

Bugs fixed:

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Version 12.1.0.2.v14

Version 12.1.0.2.v14 adds support for the following:

- Patch 28259833: Oracle Database Patch Set Update 12.1.0.2.181016
- Patch 28440711: Oracle JVM Patch Set Update 12.1.0.2.181016
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 28127287: DSTv32 for OJVM (TZDATA2018E)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 28697469: JSON Database Patch
- Patch 20033733: KGL heap size patch

Oracle patch 28259833, released October 2018

Bugs fixed:

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Version 12.1.0.2.v13

Version 12.1.0.2.v13 adds support for the following:

- Patch 27547329: Oracle Database Patch Set Update 12.1.0.2.180717
- Patch 27923320: Oracle JVM Patch Set Update 12.1.0.2.180717
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)

- Patch 28127287: DSTv32 for OJVM (TZDATA2018E)
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: DBMS_STATS Patch
- Patch 28307069: JSON Database Patch
- Patch 20033733: KGL heap size patch

Oracle patch 27547329, released July 2018

Bugs fixed:

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Version 12.1.0.2.v12

Version 12.1.0.2.v12 adds support for the following:

- Patch 27338041: DATABASE PATCH SET UPDATE 12.1.0.2.180417
- Patch 27475603: OJVM PATCH SET UPDATE 12.1.0.2.180417
- Patch 27015449: RDBMS - PROACTIVE DSTV31 UPDATE - TZDATA2017C
- Patch 27015468: PROACTIVE DSTV31 UPDATE - TZDATA2017C - NEED OJVM FIX
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: AUTO DOP COMPUTES A HIGH DOP UNNECESSARILY
- Patch 27666699: JSON Database Patch
- Patch 20033733: PART :IMC:HIT ORA 600 [KGL-HEAP-SIZE-EXCEEDED]

Oracle patch 27338041, released April 2018

Bugs fixed:

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Version 12.1.0.2.v11

Version 12.1.0.2.v11 adds support for the following:

- Patch 26925311: DATABASE PATCH SET UPDATE 12.1.0.2.180116
- Patch 27001733: OJVM PATCH SET UPDATE 12.1.0.2.180116
- Patch 27015449: RDBMS - PROACTIVE DSTV31 UPDATE - TZDATA2017C
- Patch 27015468: PROACTIVE DSTV31 UPDATE - TZDATA2017C - NEED OJVM FIX
- Patch 17969866: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 20394750: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 21171382: AUTO DOP COMPUTES A HIGH DOP UNNECESSARILY
- Patch 27315904: JSON Database Patch
- Patch 20033733: ORA 600 [KGL-HEAP-SIZE-EXCEEDED]

Oracle patch 26925311, released January 2018

Bugs fixed:

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Version 12.1.0.2.v10

Version 12.1.0.2.v10 adds support for the following:

- Oracle October 2017 PSU, a combination of database PSU (patch 26713565) + OJVM component PSU (patch 26635845)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866)
- DBMS_STATS AUTO DOP COMPUTES A HIGH DOP UNNECESSARILY (patch 21171382)
- JSON bundle patch (patch 26750145)
- KGL heap size patch (patch 20033733)
- Timezone file DSTv30 (patch 25881255, OJVM patch 25881271)

Oracle patch 26713565, released October 2017

Bugs fixed:

```
21099555, 22175564, 19141838, 22083366, 20842388, 19865345, 20117253
20830459, 19791273, 20671094, 21542577, 19243521, 20951038, 22165897
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19134173, 20569094, 20031873, 20387265, 20322560, 21575362, 19149990
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22507210, 23338911, 19703301, 19366375, 18007682, 19001390, 18202441
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18940497, 19670108, 19649152, 18866977, 18948177, 22496904, 19404068
18964978, 19176326, 19035573, 20413820, 20717081, 19176223, 21106027
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25475853, 21322887, 22507234, 20425790, 20862087, 18966843, 25861398
21329301, 20562898, 19333670, 19468991, 20124446, 19883092, 22855193
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19461270, 20235511, 22077517, 20936905, 21220620, 18964939, 19430401
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21868720, 20938170, 22905130, 19524384, 25459958, 24350831, 17722075
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19536415, 19171086, 26546664, 21132297, 21889720, 22465352, 22168163
19335438, 24397438, 20076781, 20447445, 18856999, 20471920, 19869255
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19189525, 21847223, 21649497, 19075256, 25823754, 25079710, 20315311
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19371175, 19307662, 19154375, 20043616, 21977392, 18914624, 22529728
19708342, 20139391, 25330273, 19593445, 21291274, 19382851, 19520602
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23108128, 19383839, 20880215, 21756677, 19888853, 22458049, 19534363
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21421886, 19604659, 21285458, 23533524, 23170620, 22365117, 18288842
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19512341, 22695831, 20331945, 19587324, 24316947, 19578350, 19637186
19054077, 18674047, 19708632, 20898997, 19285025, 21091431, 19289642
25947799, 21133343, 20835241, 20869721, 21172913, 25602488, 19258504
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20831538, 19016730, 18250893, 23240358, 22179537, 16619249, 18354830
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21387128, 21315084, 18122373, 20581111, 26111842, 22624709, 19606174
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18499088, 19050649
```

Version 12.1.0.2.v9

Version 12.1.0.2.v9 adds support for the following:

- Oracle July 2017 PSU, a combination of database PSU (patch 26609783) + OJVM component PSU (patch 26027162)

- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866)
- DBMS_STATS AUTO DOP COMPUTES A HIGH DOP UNNECESSARILY (patch 21171382)
- JSON bundle patch (patch 26083365)
- KGL heap size patch (patch 20033733 for 12.1.0.2)
- Timezone file DSTv30 (patch 25881255, OJVM patch 25881271)
- Adds support for Validating DB Instance Files (p. 1035) with the `RMAN` logical validation utility
- Adds support for Setting the Default Edition for a DB Instance (p. 1019)

Oracle patch 26609783, released July 2017

Bugs fixed:

```
                    21099555, 22175564, 19141838, 22083366, 20842388, 19865345, 20117253
                    19791273, 20671094, 21542577, 20951038, 19243521, 22165897, 19238590
                    21281532, 17008068, 19908836, 24577566, 21184223, 25427662, 19134173
                    20569094, 20031873, 20387265, 20322560, 21575362, 19149990, 21263635
                    17551063, 18886413, 22160989, 22507210, 19703301, 19366375, 18007682
                    19001390, 18202441, 24285405, 25655390, 20267166, 19358317, 19706965
                    19068970, 24739928, 18549238, 22148226, 18797519, 26544823, 20825533
                    21196809, 18940497, 19670108, 19649152, 18866977, 18948177, 22496904
                    19404068, 18964978, 19176326, 19035573, 20413820, 20717081, 19176223
                    21106027, 20904530, 20134339, 19074147, 20868862, 18411216, 21072646
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                    20562898, 19333670, 19468991, 20124446, 19883092, 20878790, 18510194
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                    19469538, 17835294, 19721304, 19068610, 19791377, 22178855, 16777441
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                    20907061, 6599380, 19577410, 22092979, 19001359, 20603378, 23089357
                    21387964, 19490948, 22294260, 20832516, 17532734, 22351572, 19309466
                    19081128, 20627866, 20844426, 24908321, 21188532, 18791688, 21442094
                    20890311, 20596234, 20368850, 18973548, 19303936, 21296029, 20882568
                    21479753, 19461270, 20235511, 22077517, 20936905, 21220620, 18964939
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                    19879746, 20557786, 19684504, 21294938, 19024808, 24693382, 20528052
                    20977794, 18799993, 20466322, 18740837, 19662635, 18440095, 20228093
                    19065556, 20212067, 25547060, 21868720, 22905130, 19524384, 25459958
                    24350831, 17722075, 20446883, 25056052, 18952989, 24523374, 16870214
                    19928926, 19835133, 21629064, 21354456, 20466628, 24386767, 25490238
                    19931709, 19730508, 18819908, 20250147, 23124895, 25643931, 23220453
                    19188927, 20074391, 18307021, 23533807, 20356733, 14643995, 18090142
                    19065677, 19547370, 21225209, 21960504, 26575788, 20397490, 20172151
                    18967382, 19174430, 21241829, 19536415, 26546664, 19171086, 21132297
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                    18856999, 20471920, 19869255, 21620471, 18990693, 23096938, 19124336
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                    20897759, 21668627, 19304354, 19052488, 20543011, 20794034, 23025340
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                    23294548, 24560906, 22551446, 19777862, 19687159, 21373076, 19174942
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                    19058490, 19032777, 20171986, 22815955, 19399918, 19434529, 19018447
                    18051556, 21273804, 22757364, 18851894, 19022470, 19284031, 18043064
                    20173897, 22062026, 20475845, 17274537, 19440586, 24825843, 18974476
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                    25079710, 20315311, 22762046, 22075064, 20936731, 20437153, 18845653
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```

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19174521, 21875360, 19676012, 19326908, 20217801, 20093776, 18840932
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21188584, 19989009, 25766822, 17414008, 20688221, 20441797, 20704450
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18885870, 21785691, 20673810, 21450666, 18893947, 18705806, 22223463
18417036, 16923858, 23314180, 20919320, 20474192, 22046677, 21299490
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25110233, 19124589, 19178851, 19597583, 18499088, 19050649
```

Version 12.1.0.2.v8

Version 12.1.0.2.v8 adds support for the following:

- Oracle patch 25433980, a combination of database PSU (patch 25171037) + OJVM component PSU (patch 25437695)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866 for 12.1.0.2)
- Oracle Forms patch 18307021 for 12.1.0.2
- DBMS_STATS Patch (patch 21171382 for 12.1.0.2)
- JSON bundle patch (patch 25531469 for 12.1.0.2)
- KGL heap size patch (patch 20033733 for 12.1.0.2)
- Fixed a bug that affected PSU apply after upgrade to 12.1.0.2.v5, v6, and v7
- Timezone file DSTv28 (patch 24701840)
- Adds support for the `DBMS_CHANGE_NOTIFICATION` package
- Adds support for `XSTREAM` packages and views (may require additional licensing)

Oracle patch 25171037, released April 2017

Bugs fixed:

```
21099555, 22175564, 19141838, 22083366, 20842388, 20117253, 19865345
19791273, 21542577, 20951038, 19243521, 22165897, 17008068, 19908836
21281532, 19238590, 24577566, 21184223, 19134173, 20569094, 20031873
20322560, 20387265, 21575362, 19149990, 21263635, 17551063, 18886413
22160989, 22507210, 19366375, 19703301, 19001390, 24285405, 18202441
20267166, 19358317, 19706965, 19068970, 18549238, 24739928, 18797519
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22496904, 18964978, 19176326, 19035573, 20413820, 19176223, 21106027
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19591608, 19402853, 20618595, 21787056, 22380919, 19469538, 21266085
17835294, 19721304, 19068610, 19791377, 22178855, 16777441, 22173980
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6599380, 19577410, 22092979, 19001359, 20603378, 23089357, 21387964
19490948, 22294260, 17532734, 20832516, 22351572, 19309466, 20627866
19081128, 20844426, 21188532, 18791688, 20890311, 21442094, 20596234
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20560611, 18988834, 21756699, 18921743, 20245930, 18799063, 20373598
19571367, 20476175, 20925795, 19018206, 25264559, 20711718, 20509482
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20017509, 22359063, 19363645, 19597439, 21239530, 19383839, 20880215
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19475971, 22353199, 22243719, 21060755, 22916353, 20378086, 24808595
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23170620, 22365117, 18288842, 19048007, 19308965, 19689979, 19503821
21526048, 19197175, 19180770, 19902195, 23324000, 20318889, 19013183
20591183, 19012119, 20464614, 19067244, 21632821, 19841800, 19512341
22695831, 20331945, 19587324, 24316947, 19578350, 19637186, 19054077
```

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18674047, 19708632, 20898997, 21091431, 19289642, 21133343, 20869721
21172913, 19258504, 17365043, 21419850, 19468347, 21373473, 25093739
16359751, 21164318, 22520320, 19769480, 19439759, 19272708, 19978542
19329654, 20402832, 19873610, 23229229, 13542050, 21517440, 19291380
21915719, 20879709, 20677396, 19076343, 19561643, 19990037, 19487147
18909599, 20831538, 19016730, 18250893, 16619249, 18354830, 24411921
16756406, 18254023, 21188584, 19989009, 17414008, 20688221, 20704450
20441797, 25483815, 19157754, 24437510, 18885870, 21785691, 20673810
21450666, 18893947, 18705806, 22223463, 16923858, 18417036, 23314180
20919320, 20474192, 22046677, 21299490, 19501299, 19385656, 20920911
20899461, 21387128, 21315084, 18122373, 20581111, 19606174, 24690216
18436647, 19023822, 19124589, 19178851, 19597583, 18499088, 19050649
```

Version 12.1.0.2.v7

Version 12.1.0.2.v7 adds support for the following:

- Oracle patch 24917069, a combination of database PSU (patch 24732082) + OJVM component PSU (patch 24917972)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866 for 12.1.0.2)
- Oracle Forms patch 18307021 for 12.1.0.2
- DBMS_STATS Patch (patch 21171382 for 12.1.0.2)
- JSON bundle patch (patch 25089615 for 12.1.0.2)
- KGL heap size patch (patch 20033733 for 12.1.0.2)

Oracle patch 24917069, released January 2017

Bugs fixed:

```
24917972, 25067795, 24534298, 25076732, 25076756, 24315824, 21659726
24448240, 24448282, 23177536, 22675136, 23265914, 23265965, 23727148
22674709, 22670413, 22670385, 21188537, 22139226, 22118835, 22118851
21555660, 21811517, 19623450, 21566993, 21566944, 19176885, 21068507
21047803, 21047766, 20415564, 20408829, 20408866, 19877336, 19855285
19909862, 19895362, 19895326, 19153980, 19231857, 19223010, 19245191,
19699946,
21099555, 22175564, 19141838, 22083366, 20842388, 20117253, 19865345
19791273, 21542577, 20951038, 19243521, 22165897, 19908836, 21281532
19238590, 24577566, 21184223, 19134173, 20031873, 20387265, 21575362
19149990, 21263635, 17551063, 18886413, 22160989, 22507210, 19366375
19703301, 19001390, 24285405, 18202441, 20267166, 19358317, 19706965
24739928, 19068970, 18549238, 18797519, 22148226, 20825533, 21196809
19649152, 19670108, 18940497, 18948177, 22496904, 18964978, 19035573
19176326, 20413820, 19176223, 21106027, 20904530, 20134339, 19074147
20868862, 18411216, 21072646, 21322887, 22507234, 20425790, 18966843
21329301, 20562898, 19333670, 20124446, 19468991, 19883092, 18510194
19658708, 19591608, 19402853, 20618595, 21787056, 22380919, 19469538
21266085, 17835294, 19721304, 19791377, 19068610, 22178855, 16777441
22173980, 20048359, 20746251, 21896069, 20898391, 19185876, 20907061
20281121, 6599380, 19577410, 22092979, 19001359, 20603378, 23089357
19490948, 21387964, 22294260, 20832516, 17532734, 19309466, 20627866
19081128, 20844426, 21188532, 18791688, 20890311, 21442094, 20596234
18973548, 21296029, 19303936, 20882568, 19461270, 21479753, 22077517
20936905, 20235511, 21220620, 18964939, 19430401, 22296366, 21153266
19409212, 22657942, 19879746, 20657441, 21294938, 19684504, 24693382
20528052, 19024808, 20977794, 18799993, 20466322, 18740837, 19662635
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20228093, 20212067, 19065556, 19524384, 17722075, 20446883, 25056052
24523374, 18952989, 16870214, 19928926, 19835133, 21629064, 21354456
20466628, 24386767, 19931709, 19730508, 18819908, 23124895, 23220453
19188927, 20074391, 18307021, 20356733, 14643995, 19547370, 19065677
21960504, 21225209, 20397490, 18967382, 19174430, 21241829, 19536415
19171086, 22465352, 22168163, 19335438, 24397438, 20447445, 18856999
19869255, 20471920, 21620471, 18990693, 17890099, 24812585, 18990023
21300341, 20101006, 20848335, 21744290, 20897759, 21668627, 19304354
19052488, 20794034, 23025340, 23260854, 18681056, 20952966, 19896336
20328248, 18618122, 20440930, 18456643, 19699191, 19201867, 22865673
22022760, 20798891, 18743542, 25161298, 20347562, 19777862, 22551446
19687159, 21373076, 19174942, 20424899, 21899588, 18899974, 21476308
20598042, 24308635, 19032777, 19058490, 22815955, 19399918, 19434529
21273804, 19018447, 22757364, 18851894, 19022470, 19284031, 18043064
20173897, 22062026, 20475845, 17274537, 19440586, 24825843, 18974476
22374754, 16887946, 17319928, 20401975, 20708701, 22809871, 17655240
16439813, 19805359, 19155797, 20859910, 19393542, 17210525, 22024071
21847223, 19189525, 21649497, 19075256, 20315311, 22762046, 22075064
20936731, 19280225, 18845653, 20560611, 19248799, 21756699, 18988834
20245930, 18921743, 18799063, 20373598, 19571367, 20476175, 20925795
25264559, 19018206, 20711718, 20509482, 20181030, 20588502, 18849537
23501901, 19183343, 21917884, 19189317, 19644859, 19390567, 19279273
20669434, 22528741, 16863642, 19619732, 18607546, 20348653, 19315691
19676905, 20165574, 17867700, 20558005, 20734332, 19532017, 20922010
19818513, 19450314, 22353346, 20361671, 20009833, 22366558, 20294666
23197103, 18191823, 19195895, 19307662, 19371175, 20043616, 19154375
18914624, 22529728, 20139391, 21291274, 19382851, 19520602, 19174521
21875360, 19676012, 19326908, 20217801, 20093776, 18840932, 21097043
21246723, 20803014, 21665897, 19143550, 20428621, 19627012, 14283239
19518079, 18610915, 18674024, 24413809, 18306996, 19524158, 19915271
20122715, 20284155, 20017509, 22359063, 19363645, 19597439, 21239530
19888853, 21756677, 20880215, 22458049, 19534363, 19354335, 19044962
19639483, 19475971, 22353199, 21060755, 22243719, 22916353, 20378086
24808595, 21260431, 21756661, 22923409, 20877664, 19028800, 21059919
20879889, 21380789, 19723336, 19077215, 19604659, 21421886, 21285458
23533524, 23170620, 22365117, 18288842, 19308965, 19048007, 19689979
21526048, 19197175, 19180770, 19902195, 23324000, 20318889, 19013183
20591183, 19012119, 20464614, 19067244, 21632821, 19512341, 19841800
22695831, 20331945, 19587324, 24316947, 19578350, 19637186, 18674047
19054077, 20898997, 19708632, 21091431, 19289642, 21133343, 20869721
21172913, 19258504, 17365043, 19468347, 21373473, 16359751, 19769480
19439759, 19272708, 19978542, 20402832, 19329654, 19873610, 23229229
21517440, 13542050, 19291380, 21915719, 20879709, 20677396, 19076343
19561643, 19990037, 19487147, 18909599, 20831538, 18250893, 19016730
16619249, 18354830, 18254023, 21188584, 19989009, 17414008, 20688221
20704450, 20441797, 19157754, 24437510, 18885870, 21785691, 18893947
21450666, 18705806, 22223463, 16923858, 18417036, 23314180, 20919320
20474192, 22046677, 19385656, 19501299, 20920911, 20899461, 21315084
21387128, 18122373, 20581111, 19606174, 24690216, 18436647, 19023822
19178851, 19124589, 19597583, 18499088, 19050649
```

Version 12.1.0.2.v6

Version 12.1.0.2.v6 adds support for the following:

- Oracle patch 24433133, a combination of database PSU (patch 24006101) + OJVM component PSU (patch 24315824)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866 for 12.1.0.2)
- Oracle Forms patch 18307021 for 12.1.0.2
- DBMS_STATS Patch (patch 21171382 for 12.1.0.2)
- JSON bundle patch (patch 24568656 for 12.1.0.2)

- Fixed a bug that caused 12c upgrade scripts to drop customer directories
- Made DIAG log directory available to customers

Baseline: Oracle Database Patch Set Update 12.1.0.2.161018 (patch 24006101, released October 2016)

Bugs fixed:

```
21099555, 22175564, 19141838, 22083366, 20842388, 20117253, 19865345
19791273, 19243521, 20951038, 19908836, 21281532, 19238590, 24577566
21184223, 19134173, 20387265, 19149990, 21263635, 18886413, 17551063
22160989, 22507210, 19703301, 19366375, 19001390, 18202441, 20267166
19358317, 19706965, 18549238, 19068970, 18797519, 22148226, 20825533
19649152, 19670108, 18940497, 18948177, 18964978, 19035573, 19176326
20413820, 19176223, 20904530, 20134339, 19074147, 20868862, 18411216
21322887, 22507234, 20425790, 18966843, 21329301, 19333670, 19468991
20124446, 19883092, 19658708, 19591608, 19402853, 20618595, 21787056
22380919, 21266085, 17835294, 19721304, 19791377, 19068610, 22178855
22173980, 20746251, 20048359, 20898391, 19185876, 20281121, 20907061
6599380, 19577410, 22092979, 20603378, 19001359, 19490948, 21387964
20832516, 17532734, 19309466, 19081128, 20627866, 20844426, 21188532
18791688, 21442094, 20890311, 20596234, 18973548, 21296029, 19303936
19461270, 21479753, 20936905, 20235511, 21220620, 18964939, 19430401
22296366, 21153266, 19409212, 22657942, 20657441, 19879746, 19684504
20528052, 19024808, 20977794, 18799993, 20466322, 18740837, 19662635
20228093, 19065556, 20212067, 19524384, 17722075, 20446883, 18952989
16870214, 19928926, 19835133, 21629064, 20466628, 24386767, 19931709
19730508, 18819908, 23124895, 19188927, 20074391, 20356733, 14643995
19547370, 19065677, 21960504, 21225209, 20397490, 18967382, 19174430
21241829, 19536415, 19171086, 22465352, 22168163, 19335438, 20447445
18856999, 20471920, 19869255, 21620471, 18990693, 17890099, 18990023
20101006, 21300341, 20848335, 21744290, 20897759, 21668627, 19304354
19052488, 20794034, 23260854, 18681056, 20952966, 19896336, 18618122
20328248, 20440930, 18456643, 19699191, 19201867, 22865673, 18743542
20798891, 20347562, 22551446, 19777862, 19687159, 21373076, 19174942
20424899, 21899588, 18899974, 20598042, 19032777, 19058490, 22815955
19399918, 19434529, 21273804, 19018447, 22757364, 18851894, 19284031
19022470, 18043064, 20173897, 22062026, 20475845, 17274537, 19440586
16887946, 22374754, 17319928, 20708701, 17655240, 16439813, 19805359
19155797, 20859910, 19393542, 22024071, 17210525, 21847223, 19189525
21649497, 19075256, 22762046, 22075064, 19280225, 18845653, 20560611
19248799, 21756699, 18988834, 20245930, 18921743, 18799063, 20373598
20476175, 19571367, 20925795, 19018206, 20509482, 20711718, 20588502
18849537, 19183343, 21917884, 19189317, 19644859, 19390567, 19279273
20669434, 16863642, 22528741, 19619732, 18607546, 20348653, 19315691
19676905, 20165574, 17867700, 20558005, 20734332, 19532017, 20922010
19450314, 22353346, 20361671, 20009833, 22366558, 20294666, 18191823
19307662, 19371175, 19195895, 20043616, 19154375, 18914624, 20139391
21291274, 19174521, 19520602, 19382851, 21875360, 19676012, 19326908
20217801, 20093776, 21097043, 21246723, 21665897, 19143550, 20428621
19627012, 14283239, 19518079, 18610915, 18674024, 18306996, 19524158
19915271, 20122715, 20284155, 20017509, 19363645, 19597439, 21239530
19888853, 20880215, 21756677, 19534363, 19354335, 19044962, 19639483
22353199, 22243719, 22916353, 20378086, 21756661, 21260431, 22923409
20877664, 19028800, 20879889, 19723336, 19077215, 21421886, 19604659
19308965, 19048007, 18288842, 19689979, 21526048, 19180770, 19197175
19902195, 20318889, 19013183, 19012119, 20464614, 19067244, 21632821
19512341, 19841800, 20331945, 19587324, 24316947, 19578350, 19637186
18674047, 19054077, 20898997, 19708632, 21091431, 19289642, 20869721
19258504, 17365043, 19468347, 21373473, 16359751, 19439759, 19769480
19272708, 19978542, 20402832, 19329654, 19873610, 23229229, 21517440
13542050, 19291380, 21915719, 19076343, 19561643, 19990037, 19487147
```

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                     18909599, 20831538, 18250893, 19016730, 16619249, 18354830, 21188584
                     19989009, 17414008, 20688221, 20704450, 20441797, 19157754, 18885870
                     21785691, 21450666, 18893947, 18705806, 22223463, 16923858, 18417036
                     20919320, 20474192, 22046677, 19385656, 19501299, 20920911, 20899461
                     21387128, 21315084, 18122373, 20581111, 19606174, 18436647, 19023822
                     19178851, 19124589, 19597583, 18499088, 19050649
```

Version 12.1.0.2.v5

Version 12.1.0.2.v5 adds support for the following:

- Oracle patch 23615289, a combination of database PSU (patch 23054246) + OJVM component PSU (patch 23177536)
- Timezone file DSTv26 (patch 22873635 for 12.1.0.2)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866 for 12.1.0.2)
- Oracle Forms patch 18307021 for 12.1.0.2
- Added the ability to create custom password verify functions. For more information, see Creating Custom Functions to Verify Passwords (p. 1007).
- Fixed a bug that prevented implicit recompilation of views owned by SYS

Baseline: Oracle Database Patch Set Update 12.1.0.2.160719 (patch 23054246, released July 2016)

Bugs fixed:

```
                     19189525, 21847223, 21099555, 21649497, 19075256, 19141838, 22762046
                     22075064, 20117253, 19865345, 19791273, 18845653, 19280225, 19248799
                     19243521, 20951038, 18988834, 21756699, 21281532, 19238590, 21184223
                     18921743, 20245930, 18799063, 19134173, 20373598, 19571367, 20476175
                     20925795, 19018206, 20509482, 20711718, 20387265, 20588502, 19149990
                     21263635, 18849537, 18886413, 17551063, 22507210, 19183343, 19366375
                     19703301, 21917884, 19001390, 18202441, 19189317, 20267166, 19644859
                     19390567, 19358317, 19279273, 19706965, 18549238, 16863642, 19068970
                     22528741, 18797519, 20825533, 19619732, 18607546, 20348653, 19649152
                     19670108, 18940497, 18948177, 19315691, 19676905, 18964978, 19176326
                     20165574, 19035573, 20413820, 17867700, 20558005, 19176223, 19532017
                     20904530, 20134339, 19450314, 19074147, 22353346, 20868862, 18411216
                     22507234, 20361671, 20425790, 18966843, 20009833, 22366558, 21329301
                     20294666, 18191823, 19333670, 19195895, 19371175, 19307662, 19154375
                     20043616, 20124446, 18914624, 19468991, 19883092, 21291274, 19382851
                     19520602, 19174521, 21875360, 19676012, 19326908, 19658708, 19591608
                     19402853, 20093776, 20618595, 21787056, 22380919, 21246723, 17835294
                     19721304, 19068610, 19791377, 21665897, 22178855, 22173980, 20048359
                     20746251, 19143550, 20898391, 19185876, 19627012, 20281121, 19577410
                     22092979, 19001359, 14283239, 19518079, 18610915, 19490948, 17532734
                     18674024, 18306996, 19309466, 19081128, 19524158, 19915271, 20122715
                     21188532, 18791688, 20284155, 20890311, 21442094, 20596234, 18973548
                     21296029, 19303936, 19597439, 20936905, 20235511, 21220620, 20880215
                     18964939, 21756677, 19888853, 19534363, 19430401, 19354335, 19044962
                     19639483, 22296366, 22353199, 21153266, 19409212, 19879746, 20657441
                     19684504, 20528052, 19024808, 20977794, 20378086, 18799993, 21756661
                     21260431, 18740837, 22923409, 19028800, 20877664, 20228093, 20879889
                     19065556, 19723336, 19077215, 19604659, 21421886, 19524384, 17722075
                     19308965, 18288842, 19048007, 19689979, 20446883, 18952989, 16870214
                     19928926, 19835133, 21629064, 21526048, 19197175, 19180770, 20466628
                     19902195, 19931709, 20318889, 19013183, 19730508, 19012119, 19067244
                     20074391, 20356733, 14643995, 19512341, 19841800, 20331945, 19587324
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19065677, 19547370, 19578350, 21225209, 19637186, 20397490, 18967382
19174430, 21241829, 19054077, 18674047, 20898997, 19708632, 19536415
21091431, 19289642, 20869721, 22168163, 19335438, 19258504, 20447445
17365043, 18856999, 19468347, 19869255, 20471920, 21373473, 21620471
16359751, 18990693, 17890099, 19769480, 19439759, 19272708, 18990023
19978542, 19329654, 20101006, 21300341, 20402832, 19873610, 20848335
23229229, 21744290, 21668627, 21517440, 13542050, 19304354, 19052488
20794034, 19291380, 21915719, 23260854, 18681056, 20952966, 19896336
19076343, 19561643, 18618122, 19990037, 20440930, 18456643, 19699191
19201867, 19487147, 18909599, 20831538, 19016730, 18250893, 20798891
18743542, 20347562, 16619249, 18354830, 22551446, 19777862, 19687159
21373076, 19174942, 20424899, 21188584, 19989009, 17414008, 20688221
21899588, 20441797, 19157754, 19058490, 19032777, 22815955, 19399918
18885870, 19434529, 21273804, 19018447, 21450666, 18893947, 18851894
16923858, 18417036, 20919320, 19022470, 19284031, 20474192, 20173897
22046677, 22062026, 19501299, 19385656, 20920911, 17274537, 20899461
21315084, 19440586, 16887946, 22374754, 17319928, 19606174, 20708701
18436647, 17655240, 19023822, 19124589, 19178851, 16439813, 19805359
19597583, 18499088, 19155797, 19050649, 19393542
```

Version 12.1.0.2.v4

Version 12.1.0.2.v4 adds support for the following:

- Oracle PSU 12.1.0.2.160419 (22291127)
- Timezone file DSTv25 (patch 22037014)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 17969866)
- Adds the ability for the master user to grant the EM_EXPRESS_BASIC and EM_EXPRESS_ALL roles
- Adds the ability for the master user to grant privileges on SYS objects with the grant option using the RDSADMIN.RDSADMIN_UTIL.GRANT_SYS_OBJECT procedure
- Adds master user privileges to support most common schemas created by the Oracle Fusion Middleware Repository Creation Utility (RCU)

Baseline: Oracle Database Patch Set Update 12.1.0.2.160419 (patch 22291127, released April 2016)

Bugs fixed:

```
21847223, 19189525, 19075256, 19141838, 22762046, 20117253, 19865345
19791273, 19280225, 18845653, 19248799, 20951038, 19243521, 21756699
18988834, 21281532, 19238590, 18921743, 20245930, 18799063, 19134173
20373598, 19571367, 20476175, 20925795, 19018206, 20711718, 20387265
20509482, 20588502, 19149990, 18849537, 17551063, 18886413, 19183343
19703301, 21917884, 19001390, 18202441, 19189317, 19644859, 19358317
19390567, 19279273, 19706965, 22528741, 19068970, 20825533, 19619732
18607546, 20348653, 19649152, 19670108, 18940497, 18948177, 19315691
19676905, 18964978, 19035573, 20165574, 19176326, 20413820, 20558005
19176223, 19532017, 20904530, 20134339, 19450314, 22353346, 19074147
18411216, 20361671, 20425790, 18966843, 21329301, 20294666, 19333670
19195895, 19307662, 19371175, 20043616, 19154375, 20124446, 18914624
19468991, 19883092, 19382851, 19520602, 19174521, 21875360, 19676012
19326908, 19658708, 19591608, 20093776, 20618595, 21787056, 17835294
19721304, 19791377, 19068610, 22173980, 20746251, 20048359, 19143550
19185876, 19627012, 20281121, 19577410, 22092979, 19001359, 19518079
18610915, 19490948, 18674024, 18306996, 19309466, 19081128, 19915271
20122715, 21188532, 18791688, 20284155, 20890311, 21442094, 20596234
18973548, 19303936, 19597439, 20936905, 20235511, 19888853, 21756677
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18964939, 19354335, 19430401, 19044962, 19639483, 21153266, 22353199
19409212, 20657441, 19879746, 19684504, 19024808, 21260431, 21756661
18799993, 20877664, 19028800, 20879889, 19065556, 19723336, 19077215
19604659, 21421886, 19524384, 18288842, 19048007, 19689979, 20446883
18952989, 16870214, 19928926, 19835133, 21526048, 20466628, 19197175
19180770, 19902195, 20318889, 19730508, 19012119, 19067244, 20074391
20356733, 14643995, 19512341, 19841800, 20331945, 19587324, 19547370
19065677, 21225209, 19637186, 20397490, 18967382, 19174430, 19054077
18674047, 19536415, 19708632, 21091431, 19289642, 22168163, 20869721
19335438, 19258504, 20447445, 17365043, 18856999, 19468347, 20471920
19869255, 21620471, 16359751, 18990693, 17890099, 19769480, 19439759
19272708, 18990023, 19978542, 20402832, 20101006, 21300341, 19329654
19873610, 21744290, 13542050, 21517440, 21668627, 19304354, 19052488
20794034, 19291380, 21915719, 18681056, 20952966, 19896336, 19076343
19561643, 19990037, 18618122, 20440930, 18456643, 19699191, 19487147
18909599, 20831538, 18250893, 19016730, 18743542, 20347562, 16619249
18354830, 19777862, 19687159, 19174942, 20424899, 19989009, 20688221
21899588, 20441797, 19157754, 19032777, 19058490, 19399918, 18885870
19434529, 21273804, 19018447, 18893947, 16923858, 18417036, 20919320
19022470, 19284031, 20474192, 22046677, 20173897, 22062026, 19385656
19501299, 17274537, 20899461, 21315084, 19440586, 22374754, 16887946
19606174, 18436647, 17655240, 19023822, 19178851, 19124589, 16439813
19805359, 19597583, 18499088, 19155797, 19050649, 19393542
```

Version 12.1.0.2.v3

Version 12.1.0.2.v3 adds support for the following:

- Oracle PSU 12.1.0.2.160119 (21948354).
- Timezone file DSTv25 (patch 22037014 for 12.1.0.2). 12.1.0.1 includes DSTv24, patch 20875898 (unchanged from 12.1.0.1.v3), because a backport of DSTv25 was unavailable at build time.
- Fixed an issue that prevented customers from creating more than 10 Directory objects in the database.
- Fixed an issue that prevented customers from re-granting read privileges on the ADUMP and BDUMP Directory objects.

Baseline: Oracle Database Patch Set Update 12.1.0.2.160119 (patch 21948354, released January 2016)

Bugs fixed:

```
19189525, 19075256, 19141838, 19865345, 19791273, 19280225, 18845653
20951038, 19243521, 19248799, 21756699, 18988834, 19238590, 21281532
20245930, 18921743, 18799063, 19134173, 19571367, 20476175, 20925795
19018206, 20509482, 20387265, 20588502, 19149990, 18849537, 18886413
17551063, 19183343, 19703301, 19001390, 18202441, 19189317, 19644859
19358317, 19390567, 19279273, 19706965, 19068970, 19619732, 20348653
18607546, 18940497, 19670108, 19649152, 18948177, 19315691, 19676905
18964978, 19035573, 20165574, 19176326, 20413820, 20558005, 19176223
19532017, 20134339, 19074147, 18411216, 20361671, 20425790, 18966843
20294666, 19307662, 19371175, 19195895, 19154375, 19468991, 19174521
19520602, 19382851, 21875360, 19326908, 19658708, 20093776, 20618595
21787056, 17835294, 19791377, 19068610, 20048359, 20746251, 19143550
19185876, 19627012, 20281121, 19577410, 22092979, 19001359, 19518079
18610915, 19490948, 18674024, 18306996, 19309466, 19081128, 19915271
20122715, 21188532, 20284155, 18791688, 20890311, 21442094, 18973548
19303936, 19597439, 20235511, 18964939, 19430401, 19044962, 19409212
19879746, 20657441, 19684504, 19024808, 18799993, 20877664, 19028800
19065556, 19723336, 19077215, 19604659, 21421886, 19524384, 19048007
```

```
18288842, 19689979, 20446883, 18952989, 16870214, 19928926, 21526048
19180770, 19197175, 19902195, 20318889, 19730508, 19012119, 19067244
20074391, 19512341, 19841800, 14643995, 20331945, 19587324, 19547370
19065677, 19637186, 21225209, 20397490, 18967382, 19174430, 18674047
19054077, 19536415, 19708632, 19289642, 20869721, 19335438, 17365043
18856999, 19869255, 20471920, 19468347, 21620471, 16359751, 18990693
17890099, 19439759, 19769480, 19272708, 19978542, 20101006, 21300341
20402832, 19329654, 19873610, 21668627, 21517440, 19304354, 19052488
20794034, 19291380, 18681056, 19896336, 19076343, 19561643, 18618122
20440930, 18456643, 19699191, 18909599, 19487147, 18250893, 19016730
18743542, 20347562, 16619249, 18354830, 19687159, 19174942, 20424899
19989009, 20688221, 20441797, 19157754, 19032777, 19058490, 19399918
18885870, 19434529, 19018447, 18417036, 20919320, 19022470, 19284031
20474192, 20173897, 22062026, 19385656, 19501299, 17274537, 20899461
19440586, 16887946, 19606174, 18436647, 17655240, 19023822, 19178851
19124589, 19805359, 19597583, 19155797, 19393542, 19050649
```

Version 12.1.0.2.v2

Version 12.1.0.2.v2 adds support for the following:

- Oracle PSU 12.1.0.2.5 (21359755)
- Includes the Daylight Saving Time Patch, patch 20875898: DST-24, that came out after the April 2015 PSU.

Baseline: Oracle Database Patch Set Update 12.1.0.2.5 (patch 21359755, released October 2015)

Bugs fixed:

```
19189525, 19075256, 19865345, 19791273, 19280225, 18845653, 19248799
19243521, 18988834, 19238590, 21281532, 18921743, 20245930, 19134173
19571367, 20476175, 20925795, 19018206, 20387265, 19149990, 18849537
19183343, 19703301, 19001390, 18202441, 19189317, 19644859, 19390567
19358317, 19279273, 19706965, 19068970, 19619732, 18607546, 20348653
18940497, 19670108, 19649152, 18948177, 19315691, 19676905, 18964978
20165574, 19035573, 19176326, 20413820, 20558005, 19176223, 19532017
20134339, 19074147, 18411216, 20361671, 20425790, 18966843, 20294666
19371175, 19307662, 19195895, 19154375, 19468991, 19174521, 19520602
19382851, 19658708, 20093776, 17835294, 19068610, 19791377, 20746251
20048359, 19143550, 19185876, 19627012, 20281121, 19577410, 19001359
19518079, 18610915, 18674024, 18306996, 19309466, 19081128, 19915271
20122715, 20284155, 18791688, 21442094, 19303936, 19597439, 20235511
18964939, 19430401, 19044962, 19409212, 20657441, 19684504, 19024808
19028800, 19065556, 19723336, 19077215, 21421886, 19524384, 19048007
18288842, 18952989, 16870214, 19928926, 19180770, 19197175, 19730508
19012119, 19067244, 20074391, 19841800, 19512341, 14643995, 20331945
19587324, 19065677, 19547370, 19637186, 21225209, 20397490, 18967382
19174430, 18674047, 19054077, 19708632, 19536415, 19289642, 19335438
17365043, 18856999, 20471920, 19468347, 21620471, 16359751, 18990693
19439759, 19769480, 19272708, 19978542, 19329654, 20402832, 19873610
19304354, 19052488, 19291380, 18681056, 19896336, 19076343, 19561643
18618122, 20440930, 18456643, 19699191, 18909599, 19487147, 18250893
19016730, 18743542, 20347562, 16619249, 18354830, 19687159, 19174942
20424899, 19989009, 20688221, 20441797, 19157754, 19058490, 19032777
19399918, 18885870, 19434529, 19018447, 18417036, 20919320, 19284031
19022470, 20474192, 22062026, 19385656, 19501299, 17274537, 20899461
19440586, 19606174, 18436647, 19023822, 19178851, 19124589, 19805359
19597583, 19155797, 19393542, 19050649
```

Version 12.1.0.2.v1

Version 12.1.0.2.v1 adds support for the following:

- Oracle PSU 12.1.0.2.3 (20299023)
- The In-Memory option allows storing a subset of data in an in-memory column format optimized for performance.
- Installs additional Oracle Text knowledge bases from Oracle Database. Examples media (English and French)
- Provides access to DBMS_REPAIR through RDSADMIN.RDSADMIN_DBMS_REPAIR
- Grants ALTER DATABASE LINK, ALTER PUBLIC DATABASE LINK, EXEMPT ACCESS POLICY, EXEMPT IDENTITY POLICY, and EXEMPT REDACTION POLICY to master user

> **Note**
> Version 12.1.0.2.v1 supports Enterprise Edition only.

Baseline: Oracle Database Patch Set Update 12.1.0.2.3 (patch 20299023, released April 2015)

Bugs fixed:

```
19189525, 19065556, 19075256, 19723336, 19077215, 19865345, 18845653
19280225, 19524384, 19248799, 18988834, 19048007, 18288842, 19238590
18921743, 18952989, 16870214, 19928926, 19134173, 19180770, 19018206
19197175, 19149990, 18849537, 19730508, 19183343, 19012119, 19001390
18202441, 19067244, 19189317, 19644859, 19358317, 19390567, 20074391
19279273, 19706965, 19068970, 19841800, 19512341, 14643995, 19619732
20348653, 18607546, 18940497, 19670108, 19649152, 19065677, 19547370
18948177, 19315691, 19637186, 19676905, 18964978, 19035573, 19176326
18967382, 19174430, 19176223, 19532017, 18674047, 19074147, 19054077
19536415, 19708632, 19289642, 20425790, 19335438, 18856999, 19371175
19468347, 19195895, 19154375, 16359751, 18990693, 19439759, 19769480
19272708, 19978542, 19329654, 19873610, 19174521, 19520602, 19382851
19658708, 19304354, 19052488, 19291380, 18681056, 19896336, 17835294
19076343, 19791377, 19068610, 19561643, 18618122, 20440930, 18456643
18909599, 19487147, 19143550, 19185876, 19016730, 18250893, 20347562
19627012, 16619249, 18354830, 19577410, 19687159, 19001359, 19174942
19518079, 18610915, 18674024, 18306996, 19309466, 19081128, 19915271
19157754, 19058490, 20284155, 18791688, 18885870, 19303936, 19434529
19018447, 18417036, 19597439, 20235511, 19022470, 18964939, 19430401
19044962, 19385656, 19501299, 17274537, 19409212, 19440586, 19606174
18436647, 19023822, 19684504, 19178851, 19124589, 19805359, 19024808
19597583, 19155797, 19393542, 19050649, 19028800
```

Related Topics

- Upgrading the Oracle DB Engine (p. 888)
- Oracle on Amazon RDS (p. 845)

Database Engine: 11.2.0.4

The following versions are available for database engine 11.2.0.4:

Version 11.2.0.4.v24

Version 11.2.0.4.v24 adds support for the following:

- Patch 30670774: Database PSU 11.2.0.4.200414
- Patch 30805543: Oracle JVM Component Database PSU 11.2.0.4.200414
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTV34 OJVM (TZDATA2019B)
- Patch 31192454: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 22188219: "L1 VALIDATION" WAIT EVENT USED TO BACK OFF WHEN HW ENQUEUE CANNOT BE ACQUIRED
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR
- Adds support for Purging the Recycle Bin (p. 1024).
- Adds support for Generating Performance Reports with Automatic Workload Repository (AWR) (p. 1015) using the `rdsadmin.rdsadmin_diagnostic_util` package.

Combined Patches for Version 11.2.0.4, Released April 2020

Bugs fixed:

```
18619917, 19309466, 28876684, 28855981, 18189036, 19781326, 13609098
16285691, 16756406, 18430495, 17323222, 29483723, 19915271, 19516448
14458214, 23713236, 23140259, 29434301, 22502493, 18272672, 16410570
16494615, 19174430, 21352646, 16901385, 16596890, 22243719, 18996843
21387964, 20334344, 17174582, 22250006, 17798953, 14015842, 18031668
15955387, 21534893, 16832076, 16065166, 16579084, 25427662, 21179898
11786053, 15990359, 24589081, 17982832, 18685892, 20142975, 24835538
16315398, 20861693, 17037130, 17284817, 17891946, 17279227, 17588480
17291347, 16731148, 21097043, 24528741, 22321741, 17165204, 26245237
17891943, 17359610, 17265217, 17465741, 29621961, 22551446, 18191164
16721594, 18614015, 27825893, 18440095, 19769489, 20596234, 18482502
16043574, 17360606, 20936905, 22321756, 19211724, 17392698, 19463893
29033139, 17477958, 17040764, 18362222, 19463897, 24624166, 17853456
14521849, 17816865, 19692824, 21868720, 17951233, 25505407, 17040527
31022191, 24975421, 19888853, 18009564, 20882568, 20803583, 23026585
18604692, 17622427, 16903536, 29483771, 17865671, 17883081, 16228604
17325413, 17082359, 12747740, 22168163, 16091637, 20569094, 17468141
30365745, 29962939, 19469538, 29633753, 20598042, 16042673, 23302839
17437634, 28734355, 19049453, 20387265, 16941434, 16833527, 21343775
17297939, 16069901, 14285317, 22380919, 18436647, 23065323, 21983325
17853498, 24790914, 23571055, 16542886, 21286665, 17365043, 17752995
25914276, 17296856, 18783224, 22353199, 22083366, 28305362, 21419850
16180763, 23294548, 26679352, 13960236, 25328093, 25423453, 18339044
17282229, 25600421, 18856999, 18259031, 28806384, 21354456, 23725036
18471685, 30237239, 17258090, 16344544, 17903598, 17011832, 18135678
18704244, 17786518, 19718981, 25655390, 17242746, 20250147, 19197175
17390431, 17835627, 17672719, 17393915, 21566639, 18765602, 21425496
26544823, 22228324, 29962927, 18682983, 30179644, 25165496, 12816846
18774543, 18747196, 17824637, 19429927, 21429602, 16524926, 17343514
19271443, 17019345, 18681862, 17186905, 23330119, 17811438, 26474853
17215560, 16875449, 21380789, 17184721, 18508861, 19466309, 23330124
17811429, 17019356, 25654936, 17754782, 17752121, 22809871, 17201159
18308268, 19777862, 16198143, 29027694, 18828868, 17586955, 28076295
26654363, 22977256, 16692232, 27374796, 21142837, 20869721, 17649265
25879656, 17847764, 21756699, 19697993, 28364007, 17787259, 23628685
30252098, 23007241, 27351628, 18094246, 20031873, 17375354, 21698350
26513067, 21538567, 22683212, 16450169, 17478145, 17311728, 17648596
17308789, 22836801, 21756677, 18674047, 14084247, 19788303, 22683225
27534509, 16833845, 18948177, 17205719, 21756661, 20004021, 17922254
13837378, 18084625, 17912217, 11883252, 24842886, 12982566, 26203182
14176370, 14764829, 21847223, 16875230, 28079127, 22568797, 17237521
29511611, 25635149, 16934803, 17848897, 20441797, 20175161, 16613964
18334586, 17288409, 17341326, 17449815, 15913355, 16399083, 18740837
20294666, 14565184, 21517440, 17614134, 19854503, 14245531, 16194160
18325460, 15979965, 30562923, 20671094, 27870645, 25093656, 18247991
16912439, 30562936, 24433711, 19930276, 22092979, 20506715, 23003979
20506706, 13871092, 19272701, 17397545, 16785708, 19461270, 21051862
13829543, 16220077, 17008068, 18061914, 20448824, 30275359, 18674024
19689979, 24411921, 30275351, 17596908, 17036973, 22175564, 17612828
20725343, 28199085, 23194294, 17630484, 21051858, 20017509, 21051852
17767676, 17232014, 22893153, 12611721, 25555252, 18356166, 17071721
19315668, 25764020, 16863422, 21051840, 17267114, 17820741, 18043064
21538558, 26243698, 20324049, 30305880, 16392068, 18744139, 24348685
26746894, 18628388, 27072923, 14010183, 16595641, 17080436, 17332800
20777150, 21453153, 20299015, 18413820, 18264060, 16819962, 22465352
21351877, 21051833, 18673342, 30562907, 30562909, 29200700, 27441326
16571443, 18328509, 27567477, 18674465, 16422541, 18306996, 19359219
21424824, 17443671, 17478514, 21067387, 16268425, 17381384, 18723434
17235750, 23328639, 22195448, 24570598, 21172913, 17655240, 18384391
16992075, 22195441, 17025461, 30562891, 16472716, 19289642, 21502702
22195457, 20475845, 22148226, 26030218, 18331850, 17945983, 13498382
24652769, 18673304, 17610798, 19891090, 25369547, 18456514, 8322815
22657942, 17313525, 17050888, 18317531, 19835133, 17495022, 11733603
18798250, 19285025, 18260550, 17390160, 18316692, 19458377, 14368995
17551063, 21343838, 12905058, 14735792, 28612674, 16855292, 23315889
13364795, 18235390, 18293054, 18673325, 19393542, 30215130, 14657740
```

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17532729, 17393683, 17389192, 17783588, 17852463, 19358317, 17441661
14034426, 28254374, 20631274, 19207117, 26569225, 17518652, 24662775
19475971, 18282562, 19896336, 17348614, 19827973, 17346671, 31022281
19791273, 24476274, 22296366, 13853126, 18273830, 17570606, 13558557
26007010, 16685417, 18180390, 14692762, 18159793, 17027426, 24476265
23177648, 17851160, 16870214, 18202441, 17227073, 20657411, 19006849
22606521, 20506699, 28000269, 23536835, 17761775, 20382309, 16306373
17801017, 19680952, 16850630, 17694209, 26667015, 17877323, 18230522
24563422, 17446237, 17889549, 17551674, 16233738, 22730454, 17571039
26667023, 19972570, 18849970, 21532755, 20860659, 22905130, 21168487
17016369, 21263635, 17231779, 21343897, 17717883, 27710072, 18522509
23209741, 17484731, 21972320, 19972569, 19972568, 17716305, 21059919
19972566, 19972564, 26667032, 17394950, 20657441, 17551699, 17006570
18051556, 12364061, 18029658, 17546973, 18262334, 19699191, 17227277
18018515, 16943711, 17982555, 20828947, 18098207, 18436307, 19584068
16898135, 13936038, 19601762, 31010960, 14054676, 25505394, 18228645
19013183, 25042823, 17721717, 17239687, 25248384, 25634317, 20134113
20273319, 28501075, 21063322, 17344412, 22507210, 16354467, 21795111
25505371, 16777840, 25879984, 17811456, 19730508, 17385178, 18166013
17484762, 10136473, 6599380, 20717359, 20296213, 27097854, 13955826
18193833, 17545847, 16837842, 18964939, 19871910, 25505382, 17811447
18554763, 21132297, 25957038, 20004087, 17889583, 19544839, 26631046
22507234, 24719736, 18868646, 17042658, 20627866, 14106803, 13951456
18139690, 18277454, 13680635, 25823754, 18554871, 18515268, 20169408
24908321, 17274537, 17602269, 26575788, 19032867, 17762296, 14829250
16929165, 14602788, 28849751, 21794615, 18899974, 29944660, 18441944
17811789, 20074391, 14852021, 17705023, 13645875, 24316947, 16668584
17786278, 25947799, 20879889, 19578350, 28022101, 22594718, 16384983
26439748, 17957017, 19121551, 17570240, 19788842, 18382302, 27086138
21330264, 21197626, 14338435, 13944971, 21656630, 18886413, 17156148
17936109, 20509482, 27255377, 24717859, 18762750, 21526048, 24560906
18096714, 17238511, 26078387, 27053456, 20144308, 25364628, 18244962
19433930, 20476175, 19297917, 21174504, 18280813, 28819280, 17614227
28357401, 21911701, 17006183, 25809524, 18092127, 19727057, 17695685
26039623, 22820579, 20856766, 15861775, 17258582, 21668627, 19487147
20925795, 28100487, 26482376, 19554106, 22760679, 21629064, 18199537
18091059, 17299889, 21538485, 17546761, 26336977, 25775213, 18155762
30803210, 16956380, 19207156, 14705949, 23105538, 26198926, 19258504
16314254, 17246576, 17655634, 17890099, 16989630, 20067212, 19721304
25077278, 19490948, 18203835, 18203838, 18973907, 18203837, 29483672
19615136, 17587063, 18000422, 18641451, 18090142, 21641760, 17019086
30559616, 19373893, 18373438, 21820934, 18641461, 17346091, 21422580
22351572, 18604493, 23008056, 22901797, 18610915, 17892268, 17501491
20907061, 14354737, 17835048, 21787056, 22195485, 22782647, 17082983
18641419, 16618694, 14133975, 22195492, 18331812, 18093615, 24385983
25897615, 20513399, 21281607, 13866822, 18841764, 17600719, 17842825
20558005, 17088068, 9756271, 22195465, 18440047, 19211433, 21515534
20331945, 22686674, 18384537, 18607546, 17254374, 18315328, 23115139
28790634, 21394225, 16360112, 22195477, 17726838, 18510194, 17571306
24766121, 17302277, 21842740, 17551709, 26910644, 17634921, 25489607
16538760, 18933818, 19176885, 17201047, 25649873, 25067795, 28502128
27952577, 14774730, 27461842, 19153980, 21911849, 23727132, 18166577
27000663, 24448240, 17056813, 21811517, 19909862, 25494379, 22675136
24534298, 19895326, 22253904, 17804361, 19231857, 27642235, 26023002
17528315, 19058059, 30534664, 29992392, 19554117, 19007266, 28915933
30855121, 30160639, 17285560, 29254615, 22670385, 18458318, 19187988
23265914, 19699946, 19006757, 19374518, 29774367, 19223010, 29448234
25076732, 22118835, 26637592, 19852360, 20408829, 21047766, 21566944
28730253, 16799735, 17432124, 18759211, 19396455, 20875898, 22037014
22873635, 23614158, 24701840, 25881255, 27015449, 28125601, 28852325
29997937, 29997959, 26354017, 21893235, 18125929, 19601228, 12668795
20524085, 19403858, 18086801, 16854386, 21612959, 20563314, 18705484
16674686, 20425790, 20390564, 19032777, 21275255, 17783445, 19943771
18973548, 18411336, 18673090, 19768226, 21047407, 17030189, 18856106
19693090, 21227138, 18492302, 19831647, 12897813, 19563300, 20914870
19587324, 13254780, 18676416, 21834568, 19794897, 26744595, 17208934
```

```
17031322, 19060015, 19277336, 19455741, 21764119, 17785870, 20631846
22185234, 20023340, 20647412, 19440386, 21281961, 25885148, 17722535
20926021, 20686773, 17621643, 18662619, 19563715, 19442102, 21516611
14312810, 20672075, 21897746, 2990912, 23262847, 19644859, 19175543
17644091, 20394750, 19306797, 18819257, 22188219
```

Version 11.2.0.4.v23

Version 11.2.0.4.v23 adds support for the following:

- Patch 30298532: Database Patch Set Update: 11.2.0.4.200114
- Patch 30503372: OJVM PATCH SET UPDATE 11.2.0.4.200114
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTV34 OJVM (TZDATA2019B)
- Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 19440386: FAILED TO RAISE ORA-1 FOR PK UPDATE WHEN CONSTRAINT=IMMEDIATE
- Patch 19277336: INTEGRATED REPLICAT INVALIDATES DEPENDENT PACKAGES RESULTING IN AN ORA-4068
- Patch 24286409: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.6 FOR BUGS 20647412 21534893
- Patch 24010393: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.6 FOR BUGS 12897813 21281961
- Patch 19306797: HEARTBEAT REDO IS NOT GENERATED NON-RAC HOSTS WHEN SUPPLIMENTAL LOGGING ENABLED
- Patch 19563715: LOGMINER DOES NOT MAKE PROGRESS WHEN 4GB OR MORE MEMORY IS USED IN GOLDENGATE
- Patch 20425790: LOGMINER PATCHES SHOULD TRANSPARENTLY FUNCTION IN A NON-PARITIONING ENABLED DB
- Patch 17031322: 46719: OCIXMLDBREWRITEXML RETURNED BIND VARIABLES ARE NOT WHITESPACE PRESERVING
- Patch 30303921: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.190416 FOR BUGS 29879564 14312810
- Patch 30293609: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.190416 FOR BUGS 29600521 23262847
- Patch 26744595: LGSB:APPLY ABORTS W/ ORA-26786 (ROW-EXISTS) COLLISION WITH HCC(PR)-NO HCC(SB)
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 30298532, released January 2020

Bugs fixed:

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Version 11.2.0.4.v22

Version 11.2.0.4.v22 adds support for the following:

- Patch 29913194: DATABASE PATCH SET UPDATE 11.2.0.4.191015
- Patch 30132974: OJVM PATCH SET UPDATE 11.2.0.4.191015
- Patch 29997937: DSTv34 for RDBMS (TZDATA2019G)
- Patch 29997959: DSTV34 OJVM (TZDATA2019B)
- Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 19440386: FAILED TO RAISE ORA-1 FOR PK UPDATE WHEN CONSTRAINT=IMMEDIATE
- Patch 19277336: INTEGRATED REPLICAT INVALIDATES DEPENDENT PACKAGES RESULTING IN AN ORA-4068
- Patch 24286409: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.6 FOR BUGS 20647412 21534893
- Patch 24010393: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.6 FOR BUGS 12897813 21281961
- Patch 19306797: HEARTBEAT REDO IS NOT GENERATED NON-RAC HOSTS WHEN SUPPLIMENTAL LOGGING ENABLED

- Patch 19563715: LOGMINER DOES NOT MAKE PROGRESS WHEN 4GB OR MORE MEMORY IS USED IN GOLDENGATE
- Patch 20425790: LOGMINER PATCHES SHOULD TRANSPARENTLY FUNCTION IN A NON-PARITIONING ENABLED DB
- Patch 17031322: 46719: OCIXMLDBREWRITEXML RETURNED BIND VARIABLES ARE NOT WHITESPACE PRESERVING
- Patch 30303921: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.190416 FOR BUGS 29879564 14312810
- Patch 30293609: MERGE REQUEST ON TOP OF DATABASE PSU 11.2.0.4.190416 FOR BUGS 29600521 23262847
- Patch 26744595: LGSB:APPLY ABORTS W/ ORA-26786 (ROW-EXISTS) COLLISION WITH HCC(PR)-NO HCC(SB)
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 29913194, released October 2019

Bugs fixed:

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Version 11.2.0.4.v21

Version 11.2.0.4.v21 adds support for the following:

- Patch 29497421: DATABASE PATCH SET UPDATE 11.2.0.4.190716
- Patch 29610422: OJVM PATCH SET UPDATE 11.2.0.4.190716
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- Patch 30018733: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 29497421, released July 2019

Bugs fixed:

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Version 11.2.0.4.v20

Version 11.2.0.4.v20 adds support for the following:

- Patch 29141056: DATABASE PATCH SET UPDATE 11.2.0.4.190416
- Patch 29251270: OJVM PATCH SET UPDATE 11.2.0.4.190416
- Patch 28852325: DSTv33 for RDBMS (TZDATA2018G)
- Patch 28852334: DSTv33 for OJVM (TZDATA2018G)
- Patch 29638593: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 28730253: SUPPORT NEW ERA REIWA FOR JAPANESE IMPERIAL CALENDAR

Oracle patch 22768427, released April 2019

Bugs fixed:

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Version 11.2.0.4.v19

Version 11.2.0.4.v19 adds support for the following:

- Patch 28729262: Oracle Database Patch Set Update 11.2.0.4.190115
- Patch 28790660: Oracle JVM Patch Set Update 11.2.0.4.190115
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 27015468: DSTv32 for OJVM (TZDATA2018E)

- Patch 27216420: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches

Oracle patch 28729262, released January 2019

Bugs fixed:

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25165496, 28254374, 17201159, 17655634, 18331812, 19730508, 17551699
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17622427, 18328509, 23115139, 16943711, 22195477, 22502493, 14368995
17346671, 18996843, 17783588, 18604493, 21343838, 16618694, 17672719
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17762296, 17705023, 23294548, 22351572, 22507234, 19121551, 20324049
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17889583, 18673325, 22551446, 17242746, 18293054, 18674465, 19721304
19211433, 19888853, 25914276, 24563422, 17951233, 18094246, 17649265
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17323222, 16595641, 16524926, 18228645, 17484731, 18282562, 17596908
18272672, 18031668, 17156148, 16494615, 22683225, 20869721, 17545847
25093656, 28819280, 18682983, 17655240, 24528741, 17614134, 13558557
25427662, 17341326, 22465352, 29033139, 17891946, 17716305, 22657942
27374796, 16392068, 18440095, 19271443, 21351877, 20513399, 18092127
17614227, 18440047, 18849970, 14106803, 16903536, 20725343, 18973907
18673342, 17389192, 25505382, 22809871, 19032867, 17612828, 17006570
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17570240, 16863422, 13960236, 28100487, 18325460, 17008068, 19727057
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18765602, 16198143, 17246576, 14829250, 28364007, 17835627, 20860659
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18180390, 16538760, 26474853, 18193833, 21387964, 21051833, 17238511
19777862, 17824637, 23065323, 21656630, 19697993, 17903598, 16571443
18306996, 18166013, 19578350, 14852021, 18674047, 17853456, 12364061
24411921, 19207117, 22195448
```

Version 11.2.0.4.v18

Version 11.2.0.4.v18 adds support for the following:

- Patch 28204707: Oracle Database Patch Set Update 11.2.0.4.181016
- Patch 28440700: Oracle JVM Patch Set Update 11.2.0.4.181016
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 27015468: DSTv32 for OJVM (TZDATA2018E)
- Patch 27216420: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patches 27659043 and 19692824 are now included in the Database Patch Set Update

Oracle patch 28204707, released October 2018

Bugs fixed:

```
17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 25654936
17484762, 17816865, 20506699, 24835538, 25957038, 19692824, 23330119
17922254, 17754782, 13364795, 16934803, 17311728, 18604692, 26679352
20387265, 17284817, 17441661, 20671094, 24560906, 25635149, 16992075
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17478514, 18317531, 14338435, 18235390, 19461270, 20803583, 13944971
19475971, 20142975, 17811789, 16929165, 18704244, 24662775, 20506706
17359610, 17546973, 21422580, 20334344, 14054676, 25489607, 17570606
17088068, 17346091, 18264060, 17343514, 21538567, 19680952, 18471685
19211724, 21132297, 25775213, 13951456, 16315398, 21847223, 18744139
16850630, 23177648, 19049453, 18090142, 18673304, 17883081, 19915271
18641419, 18262334, 25600421, 17006183, 16065166, 18277454, 18685892
16833527, 10136473, 18051556, 17865671, 25879984, 18554871, 17852463
18774543, 17853498, 18334586, 19487147, 20879889, 17551709, 17588480
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18098207, 24790914, 16785708, 19891090, 17465741, 16180763, 17174582
12982566, 16777840, 19463893, 22195465, 16875449, 22148226, 12816846
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18723434, 21972320, 21532755, 19554106, 25505371, 20273319, 14034426
18339044, 19458377, 17752995, 20448824, 17891943, 17767676, 17258090
16668584, 18384391, 21063322, 17040764, 17381384, 15913355, 18356166
14084247, 20596234, 21641760, 20506715, 13853126, 21756661, 18610915
18203837, 14245531, 16043574, 21756699, 22195441, 17848897, 17877323
26667032, 21453153, 19272701, 20569094, 17468141, 17786518, 20861693
17912217, 17037130, 16956380, 18155762, 17478145, 17394950, 18641461
18189036, 17551674, 18619917, 17019356, 17027426, 21352646, 16268425
24476274, 22195492, 19584068, 26544823, 18436307, 22507210, 17265217
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16344544, 21429602, 18009564, 14354737, 21286665, 18135678, 14521849
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27441326, 17437634, 24570598, 22353199, 18093615, 19006849, 17392698
19013183, 17296856, 18674024, 26569225, 17232014, 16855292, 21051840
14692762, 17762296, 17705023, 23294548, 22351572, 22507234, 19121551
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17889583, 18673325, 22551446, 18674465, 17242746, 19721304, 18293054
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17341326, 22465352, 17891946, 17716305, 22657942, 27374796, 16392068
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21051862, 17786278, 16692232, 17227277, 24348685, 24476265, 16042673
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```

Version 11.2.0.4.v17

Version 11.2.0.4.v17 adds support for the following:

- Patch 27734982: Oracle Database Patch Set Update 11.2.0.4.180717
- Patch 27923163: Oracle JVM Patch Set Update 11.2.0.4.180717
- Patch 28125601: DSTv32 for RDBMS (TZDATA2018E)
- Patch 27015468: DSTv32 for OJVM (TZDATA2018E)
- Patch 27216420: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 27659043: MES Bundle 405
- Patch 19692824: DBCONTROL is not coming up on OEL 7

Oracle patch 27734982, released July 2018

Bugs fixed:

```
17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 25654936
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21538558, 20925795, 17449815, 19463897, 26575788, 13866822, 17235750
17982555, 17478514, 18317531, 14338435, 18235390, 19461270, 20803583
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18783224, 17851160, 17546761, 22168163, 17798953, 18273830, 22092979
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22296366, 17360606, 13645875, 22321741, 16542886, 18199537, 25879656
21787056, 17889549, 21172913, 14565184, 27825893, 20475845, 17071721
21281607, 18308268, 17610798, 20299015, 21343897, 22893153, 20657441
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21517440, 23725036, 19788842, 18508861, 14657740, 17332800, 13837378
17186905, 19972564, 19699191, 18315328, 27441326, 17437634, 24570598
22353199, 18093615, 19006849, 17392698, 19013183, 17296856, 18674024
26569225, 17232014, 16855292, 21051840, 14692762, 17762296, 17705023
23294548, 22351572, 22507234, 19121551, 20324049, 21330264, 26198926
19854503, 23315889, 26910644, 26030218, 21868720, 19309466, 25764020
18681862, 17365043, 17390160, 20031873, 20558005, 18554763, 24717859
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18203838, 18765602, 16198143, 17246576, 14829250, 17835627, 20860659
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16837842, 20144308, 17393683, 23536835, 25823754, 18899974, 17787259
24719736, 20331945, 19490948, 20074391, 15861775, 16399083, 25947799
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```

Version 11.2.0.4.v16

Version 11.2.0.4.v16 adds support for the following:

- Patch 27338049: DATABASE PATCH SET UPDATE 11.2.0.4.180417
- Patch 27475598: OJVM PATCH SET UPDATE 11.2.0.4.180417
- Patch 27015449: RDBMS - PROACTIVE DSTV31 UPDATE - TZDATA2017C
- Patch 27015468: PROACTIVE DSTV31 UPDATE - TZDATA2017C - NEED OJVM FIX
- Patch 27216420: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 27659043: MES 405 BUNDLE ON TOP OF RDBMS 11.2.0.4.180116 PSU
- Patch 19692824: DBCONTROL is not coming up on OEL 7
- Adds support for the `DBMS_ADVANCED_REWRITE` package
- Fixed a bug where `DBA_LOCKS` and associated views available in new DB instances of 11.2.0.4.v15 were not created in upgrades to 11.2.0.4.v15. Views are now created in new and upgraded DB instances of 11.2.0.4.v16 and later.

Oracle patch 27338049, released April 2018

Bugs fixed:

```
                    21174504, 17184721, 21538558, 16091637, 18092127, 17381384, 15979965
                    20671094, 16731148, 16314254, 13837378, 18441944, 17835048, 13558557
                    17008068, 17201159, 25427662, 17853498, 20717359, 17246576, 18356166
                    18681862, 18440047, 20569094, 20031873, 16875449, 20387265, 19788842
                    17296856, 21330264, 14010183, 17648596, 17551063, 17025461, 24719736
                    17267114, 22507210, 17912217, 17889583, 18202441, 17040764, 17478145
                    16524926, 25655390, 19358317, 22148226, 18747196, 26544823, 18641419
                    17036973, 18948177, 17811789, 16542886, 14285317, 18009564, 16618694
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                    20861693, 18000422, 17551709, 26575788, 23315889, 20506699, 19006849
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16756406, 20441797, 19769489, 17545847, 25093656, 18260550, 13853126
17227277, 23536835, 25957038, 24652769, 19207117, 9756271, 18868646
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21168487, 16220077, 16929165
```

Version 11.2.0.4.v15

Version 11.2.0.4.v15 adds support for the following:

- Patch 26925576: DATABASE PATCH SET UPDATE 11.2.0.4.180116
- Patch 26925532: OJVM PATCH SET UPDATE 11.2.0.4.180116
- Patch 27015449: RDBMS - PROACTIVE DSTV31 UPDATE - TZDATA2017C
- Patch 27015468: PROACTIVE DSTV31 UPDATE - TZDATA2017C - NEED OJVM FIX
- Patch 27216420: Oracle GoldenGate – Oracle RDBMS Server Recommended Patches
- Patch 27244661: MES 405 BUNDLE ON TOP OF RDBMS 11.2.0.4.180116 PSU
- Patch 19692824: DBCONTROL is not coming up on OEL 7
- Adds support for `DBA_LOCKS` and associated views

Oracle patch 26925576, released January 2018

Bugs fixed:

```
17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 25654936
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```

Version 11.2.0.4.v14

Version 11.2.0.4.v14 adds support for the following:

- Oracle October 2017 PSU, a combination of database PSU (patch 26392168) + OJVM component PSU (patch 26635834)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 26950781)
- RSA Micro-Edition Suite Bundle (patch 26963526)
- Timezone file DSTv30 (patch 25881255, OJVM patch 25881271)

Oracle patch 26392168, released October 2017

Bugs fixed:

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      17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 25654936
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      18317531, 14338435, 18235390, 20803583, 19461270, 13944971, 20142975
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16524926, 18228645, 18282562, 17596908, 18031668, 17156148, 16494615
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```

Version 11.2.0.4.v13

Version 11.2.0.4.v13 adds support for the following:

- Oracle July 2017 PSU, a combination of database PSU (patch 26609445) + OJVM component PSU (patch 26027154)

- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 26554712)
- RSA Micro-Edition Suite Bundle (patch 26770426)
- Timezone file DSTv30 (patch 25881255, OJVM patch 25881271)
- Adds support for Validating DB Instance Files (p. 1035) with the `RMAN` logical validation utility
- Adds support for Setting the Default Edition for a DB Instance (p. 1019)

Oracle patch 26609445, released July 2017

Bugs fixed:

```
                    17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 20506699
                    17816865, 25957038, 23330119, 17922254, 17754782, 13364795, 16934803
                    17311728, 20387265, 17284817, 17441661, 24560906, 16992075, 17446237
                    14015842, 19972569, 21756677, 17375354, 21538558, 20925795, 17449815
                    26575788, 19463897, 13866822, 17235750, 17982555, 17478514, 18317531
                    14338435, 18235390, 20803583, 19461270, 13944971, 20142975, 17811789
                    16929165, 18704244, 20506706, 17546973, 20334344, 14054676, 17088068
                    17346091, 18264060, 17343514, 21538567, 19680952, 18471685, 19211724
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                    16065166, 18277454, 16833527, 10136473, 18051556, 17865671, 17852463
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                    17344412, 17842825, 18828868, 20509482, 17025461, 11883252, 13609098
                    17239687, 17602269, 19197175, 18316692, 22195457, 17313525, 12611721
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                    15913355, 18356166, 14084247, 20596234, 20506715, 21756661, 13853126
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                    18155762, 17478145, 17394950, 18641461, 18189036, 18619917, 17027426
                    21352646, 16268425, 24476274, 22195492, 19584068, 26544823, 18436307
                    22507210, 17265217, 17634921, 13498382, 19469538, 21526048, 19258504
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                    21168487, 14133975, 13829543, 17215560, 17694209, 17385178, 18091059
                    8322815, 18259031, 19689979, 17586955, 17201159, 17655634, 18331812
                    19730508, 18868646, 17648596, 16220077, 16069901, 17348614, 17393915
                    17957017, 17274537, 18096714, 17308789, 18436647, 14285317, 19289642
                    14764829, 17622427, 18328509, 16943711, 22195477, 14368995, 22502493
                    17346671, 18996843, 17783588, 21343838, 16618694, 17672719, 18856999
                    18783224, 17851160, 17546761, 22168163, 17798953, 18273830, 22092979
                    16596890, 19972566, 13871092, 17726838, 16384983, 22296366, 17360606
                    22321741, 13645875, 25879656, 18199537, 16542886, 21787056, 17889549
                    14565184, 17071721, 17610798, 20299015, 21343897, 22893153, 20657441
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                    18430495, 25423453, 17016369, 17042658, 14602788, 17551063, 19972568
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                    19972564, 19699191, 18315328, 17437634, 22353199, 18093615, 19006849
                    19013183, 17296856, 18674024, 17232014, 16855292, 17762296, 14692762
                    21051840, 17705023, 22507234, 19121551, 21330264, 19854503, 26030218
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17891946, 17716305, 22657942, 18440095, 16392068, 19271443, 21351877
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25505407, 16685417, 17721717, 17390431, 17570240, 16863422, 18325460
19727057, 16422541, 19972570, 17267114, 18244962, 21538485, 18203838
18765602, 16198143, 17246576, 14829250, 17835627, 18247991, 14458214
21051862, 16692232, 17786278, 17227277, 24476265, 16042673, 16314254
16228604, 16837842, 17393683, 23536835, 25823754, 18899974, 17787259
20331945, 20074391, 15861775, 16399083, 18018515, 22683212, 21051858
18260550, 17080436, 16613964, 17036973, 16579084, 24433711, 18384537
18280813, 20296213, 16901385, 15979965, 23330124, 18441944, 16450169
9756271, 17892268, 11733603, 16285691, 17587063, 21343775, 18180390
16538760, 18193833, 21387964, 21051833, 17238511, 19777862, 17824637
16571443, 18306996, 19578350, 14852021, 17853456, 18674047, 12364061
24411921, 19207117, 22195448
```

Version 11.2.0.4.v12

Version 11.2.0.4.v12 adds support for the following:

- Oracle patch 25440428, a combination of database PSU (patch 24732075) + OJVM component PSU (patch 25434033)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 25734992)
- MES Bundle (patch 24975421 for 11.2.0.4)
- Timezone file DSTv28 (patch 24701840)
- Adds support for the `DBMS_CHANGE_NOTIFICATION` package
- Adds support for `XSTREAM` packages and views (may require additional licensing)

Oracle patch 24732075, released April 2017

Bugs fixed:

```
17288409, 21051852, 24316947, 17811429, 17205719, 18607546, 20506699
17816865, 17922254, 23330119, 17754782, 16934803, 13364795, 17311728
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21756677, 17375354, 20925795, 21538558, 17449815, 19463897, 13866822
17235750, 17982555, 17478514, 18317531, 14338435, 18235390, 20803583
13944971, 20142975, 17811789, 16929165, 18704244, 20506706, 17546973
20334344, 14054676, 17088068, 17346091, 18264060, 17343514, 21538567
19680952, 18471685, 19211724, 13951456, 21847223, 16315398, 18744139
16850630, 23177648, 19049453, 18673304, 17883081, 19915271, 18641419
18262334, 17006183, 16065166, 18277454, 16833527, 10136473, 18051556
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17239687, 17602269, 19197175, 18316692, 22195457, 17313525, 12611721
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18482502, 19466309, 22243719, 17040527, 17165204, 18098207, 16785708
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21352646, 16268425, 24476274, 22195492, 19584068, 18436307, 22507210
17265217, 17634921, 13498382, 21526048, 19258504, 20004087, 17443671
22195485, 18000422, 22321756, 20004021, 17571039, 21067387, 22905130
16344544, 18009564, 14354737, 21286665, 18135678, 18614015, 20441797
18362222, 17835048, 16472716, 17936109, 17050888, 14010183, 17325413
18747196, 17761775, 16721594, 17082983, 20067212, 21179898, 17302277
18084625, 15990359, 24842886, 18203835, 17297939, 17811456, 22380919
16731148, 21168487, 14133975, 13829543, 17215560, 17694209, 17385178
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16542886, 21787056, 17889549, 14565184, 17071721, 17610798, 20299015
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17551063, 19972568, 21517440, 18508861, 19788842, 14657740, 17332800
13837378, 19972564, 17186905, 18315328, 19699191, 17437634, 22353199
18093615, 19006849, 19013183, 17296856, 18674024, 17232014, 16855292
17762296, 14692762, 21051840, 17705023, 22507234, 19121551, 21330264
19854503, 21868720, 19309466, 18681862, 20558005, 18554763, 17390160
18456514, 16306373, 13955826, 18139690, 17501491, 17752121, 21668627
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17267114, 18244962, 21538485, 18765602, 18203838, 16198143, 17246576
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17227277, 24476265, 16042673, 16314254, 16228604, 16837842, 17393683
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24411921, 22195448
```

Version 11.2.0.4.v11

Version 11.2.0.4.v11 adds support for the following:

- Oracle patch 24918033, a combination of database PSU (patch 24006111) + OJVM component PSU (patch 24917954)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 24491261)
- MES Bundle (patch 24975421 for 11.2.0.4)

Oracle patch 24918033, released January 2017

Bugs fixed:

```
18933818, 19176885, 17201047, 25067795, 14774730, 19153980, 21911849
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17288409, 21051852, 24316947, 17811429, 18607546, 17205719, 20506699
17816865, 17922254, 23330119, 17754782, 16934803, 13364795, 17311728
17441661, 17284817, 16992075, 17446237, 14015842, 19972569, 21756677
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17982555, 17478514, 18317531, 14338435, 18235390, 20803583, 13944971
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14054676, 17088068, 17346091, 18264060, 17343514, 21538567, 19680952
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```

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```

Version 11.2.0.4.v10

Version 11.2.0.4.v10 adds support for the following:

- Oracle patch 24436313, a combination of database PSU (patch 24006111) + OJVM component PSU (patch 24315821)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 24491261)
- MES Bundle (patch 24975421 for 11.2.0.4)

Baseline: Oracle Database Patch Set Update 11.2.0.4.161018 (patch 24006111, released October 2016)

Bugs fixed:

```
17288409, 21051852, 24316947, 17811429, 18607546, 17205719, 20506699
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17375354, 20925795, 21538558, 17449815, 19463897, 13866822, 17235750
17982555, 17478514, 18317531, 14338435, 18235390, 20803583, 13944971
20142975, 17811789, 16929165, 18704244, 20506706, 17546973, 20334344
14054676, 17088068, 17346091, 18264060, 17343514, 21538567, 19680952
18471685, 19211724, 13951456, 21847223, 16315398, 18744139, 16850630
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17344412, 17842825, 18828868, 17025461, 11883252, 13609098, 17239687
17602269, 19197175, 22195457, 18316692, 17313525, 12611721, 19544839
18964939, 17600719, 18191164, 19393542, 17571306, 20777150, 18482502
19466309, 22243719, 17040527, 17165204, 18098207, 16785708, 17465741
17174582, 16180763, 16777840, 12982566, 19463893, 22195465, 22148226
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20067212, 21179898, 17302277, 18084625, 15990359, 18203835, 17297939
17811456, 22380919, 16731148, 21168487, 14133975, 13829543, 17215560
17694209, 17385178, 18091059, 8322815, 17586955, 17201159, 17655634
18331812, 19730508, 18868646, 17648596, 16220077, 16069901, 17348614
17393915, 17274537, 17957017, 18096714, 17308789, 18436647, 14285317
19289642, 14764829, 18328509, 17622427, 16943711, 22195477, 14368995
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18856999, 18783224, 17851160, 17546761, 17798953, 18273830, 22092979
16596890, 19972566, 16384983, 17726838, 22296366, 17360606, 22321741
13645875, 18199537, 16542886, 21787056, 17889549, 14565184, 17071721
17610798, 20299015, 21343897, 22893153, 20657441, 17397545, 18230522
16360112, 19769489, 12905058, 18641451, 12747740, 18430495, 17016369
17042658, 14602788, 17551063, 19972568, 21517440, 18508861, 19788842
14657740, 17332800, 13837378, 19972564, 17186905, 18315328, 19699191
17437634, 22353199, 18093615, 19006849, 19013183, 17296856, 18674024
17232014, 16855292, 17762296, 14692762, 21051840, 17705023, 22507234
19121551, 21330264, 19854503, 21868720, 19309466, 18681862, 20558005
18554763, 17390160, 18456514, 16306373, 13955826, 18139690, 17501491
17752121, 21668627, 17299889, 17889583, 18673325, 19721304, 18293054
17242746, 17951233, 18094246, 17649265, 19615136, 17011832, 16870214
17477958, 18522509, 20631274, 16091637, 17323222, 16595641, 16524926
18228645, 18282562, 17596908, 18031668, 17156148, 16494615, 22683225
17545847, 17655240, 24528741, 17614134, 13558557, 17341326, 17891946
17716305, 22657942, 16392068, 19271443, 21351877, 18092127, 17614227
18440047, 16903536, 14106803, 18973907, 18673342, 19032867, 17389192
17612828, 16194160, 17006570, 17721717, 17390431, 17570240, 16863422
18325460, 19727057, 16422541, 19972570, 17267114, 18244962, 21538485
18765602, 18203838, 16198143, 17246576, 14829250, 17835627, 18247991
14458214, 21051862, 16692232, 17786278, 17227277, 24476265, 16042673
16314254, 16228604, 16837842, 17393683, 23536835, 17787259, 20331945
20074391, 15861775, 16399083, 18018515, 22683212, 18260550, 21051858
17080436, 16613964, 17036973, 16579084, 24433711, 18384537, 18280813
20296213, 16901385, 15979965, 23330124, 18441944, 16450169, 9756271
17892268, 11733603, 16285691, 17587063, 21343775, 18180390, 16538760
18193833, 21387964, 21051833, 17238511, 17824637, 16571443, 18306996
14852021, 17853456, 18674047, 12364061, 22195448
```

Version 11.2.0.4.v9

Version 11.2.0.4.v9 adds support for the following:

- Oracle patch 23615392, a combination of database PSU (patch 23054359) + OJVM component PSU (patch 23177551)
- Timezone file DSTv26 (patch 22873635 for 11.2.0.4)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 24320398 for 11.2.0.4.160719)
- MES Bundle (patch 22695784 for 11.2.0.4)
- Added the ability to create custom password verify functions. For more information, see Creating Custom Functions to Verify Passwords (p. 1007).
- Fixed a bug that prevented implicit recompilation of views owned by SYS

Baseline: Oracle Database Patch Set Update 11.2.0.4.160719 (patch 23054359, released July 2016)

Bugs fixed:

```
17288409, 21051852, 17811429, 18607546, 17205719, 20506699, 17816865
23330119, 17922254, 17754782, 16934803, 13364795, 17311728, 17441661
17284817, 16992075, 17446237, 14015842, 19972569, 21756677, 17375354
21538558, 20925795, 17449815, 19463897, 13866822, 17982555, 17235750
17478514, 18317531, 14338435, 18235390, 20803583, 13944971, 20142975
17811789, 16929165, 18704244, 20506706, 17546973, 20334344, 14054676
17088068, 17346091, 18264060, 17343514, 21538567, 19680952, 18471685
19211724, 13951456, 21847223, 16315398, 18744139, 16850630, 23177648
```

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19049453, 18673304, 17883081, 19915271, 18641419, 18262334, 17006183
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18554871, 17853498, 18334586, 17551709, 17588480, 19827973, 17344412
17842825, 18828868, 17025461, 11883252, 13609098, 17239687, 17602269
19197175, 22195457, 18316692, 17313525, 12611721, 19544839, 18964939
17600719, 18191164, 19393542, 17571306, 18482502, 20777150, 19466309
17040527, 17165204, 18098207, 16785708, 17465741, 17174582, 16180763
16777840, 12982566, 19463893, 22195465, 16875449, 12816846, 17237521
19358317, 17811438, 17811447, 17945983, 21983325, 18762750, 16912439
17184721, 18061914, 17282229, 18331850, 18202441, 17082359, 18723434
21972320, 19554106, 14034426, 18339044, 19458377, 17752995, 20448824
17891943, 17258090, 17767676, 16668584, 18384391, 17040764, 17381384
15913355, 18356166, 14084247, 20596234, 20506715, 21756661, 13853126
18203837, 14245531, 16043574, 21756699, 22195441, 17848897, 17877323
21453153, 17468141, 20861693, 17786518, 17912217, 17037130, 16956380
18155762, 17478145, 17394950, 18641461, 18189036, 18619917, 17027426
21352646, 16268425, 22195492, 19584068, 18436307, 22507210, 17265217
17634921, 13498382, 21526048, 19258504, 20004087, 17443671, 22195485
18000422, 22321756, 20004021, 17571039, 21067387, 16344544, 18009564
14354737, 21286665, 18135678, 18614015, 20441797, 18362222, 17835048
16472716, 17936109, 17050888, 17325413, 14010183, 18747196, 17761775
16721594, 17082983, 20067212, 21179898, 17302277, 18084625, 15990359
18203835, 17297939, 22380919, 17811456, 16731148, 21168487, 13829543
17215560, 14133975, 17694209, 17385178, 18091059, 8322815, 17586955
17201159, 17655634, 18331812, 19730508, 18868646, 17648596, 16220077
16069901, 17348614, 17393915, 17274537, 17957017, 18096714, 17308789
18436647, 14285317, 19289642, 14764829, 18328509, 17622427, 16943711
22195477, 14368995, 22502493, 17346671, 18996843, 17783588, 21343838
16618694, 17672719, 18856999, 18783224, 17851160, 17546761, 17798953
18273830, 22092979, 16596890, 19972566, 16384983, 17726838, 22296366
17360606, 22321741, 13645875, 18199537, 16542886, 21787056, 17889549
14565184, 17071721, 17610798, 20299015, 21343897, 22893153, 20657441
17397545, 18230522, 16360112, 19769489, 12905058, 18641451, 12747740
18430495, 17016369, 17042658, 14602788, 17551063, 19972568, 21517440
18508861, 19788842, 14657740, 17332800, 13837378, 19972564, 17186905
18315328, 19699191, 17437634, 22353199, 18093615, 19006849, 19013183
17296856, 18674024, 17232014, 16855292, 17762296, 14692762, 21051840
17705023, 22507234, 19121551, 21330264, 19854503, 21868720, 19309466
18681862, 18554763, 20558005, 17390160, 18456514, 16306373, 13955826
18139690, 17501491, 17752121, 21668627, 17299889, 17889583, 18673325
19721304, 18293054, 17242746, 17951233, 18094246, 17649265, 19615136
17011832, 16870214, 17477958, 18522509, 20631274, 16091637, 17323222
16595641, 16524926, 18228645, 18282562, 17596908, 18031668, 17156148
16494615, 22683225, 17545847, 17655240, 17614134, 13558557, 17341326
17891946, 17716305, 16392068, 19271443, 21351877, 18092127, 17614227
18440047, 16903536, 14106803, 18973907, 18673342, 19032867, 17389192
17612828, 16194160, 17006570, 17721717, 17390431, 17570240, 16863422
18325460, 19727057, 16422541, 19972570, 17267114, 18244962, 21538485
18765602, 18203838, 16198143, 17246576, 14829250, 17835627, 18247991
14458214, 21051862, 16692232, 17786278, 17227277, 16042673, 16314254
16228604, 16837842, 17393683, 23536835, 17787259, 20331945, 20074391
15861775, 16399083, 18018515, 22683212, 18260550, 21051858, 17080436
16613964, 17036973, 16579084, 18384537, 18280813, 20296213, 16901385
15979965, 23330124, 18441944, 16450169, 9756271, 17892268, 11733603
16285691, 17587063, 21343775, 16538760, 18180390, 18193833, 21387964
21051833, 17238511, 17824637, 16571443, 18306996, 14852021, 17853456
18674047, 12364061, 22195448
```

Version 11.2.0.4.v8

Version 11.2.0.4.v8 adds support for the following:

- Oracle PSU 11.2.0.4.160419 (22502456)

- Timezone file DSTv25 (patch 22037014)
- Oracle recommended RDBMS patches for Oracle GoldenGate (patch 22576728)
- MES Bundle (patch 22695784 for 11.2.0.4)
- Adds the ability for the master user to grant privileges on SYS objects with the grant option using the RDSADMIN.RDSADMIN_UTIL.GRANT_SYS_OBJECT procedure
- Adds master user privileges to support most common schemas created by the Oracle Fusion Middleware Repository Creation Utility (RCU)

Baseline: Oracle Database Patch Set Update 11.2.0.4.160419 (patch 22502456, released April 2016)

Bugs fixed:

```
                  17288409, 21051852, 17811429, 18607546, 17205719, 20506699, 17816865
                  17922254, 17754782, 16934803, 13364795, 17311728, 17441661, 17284817
                  16992075, 17446237, 14015842, 19972569, 21756677, 21538558, 20925795
                  17449815, 17375354, 19463897, 13866822, 17982555, 17235750, 17478514
                  18317531, 14338435, 18235390, 20803583, 13944971, 20142975, 17811789
                  16929165, 18704244, 20506706, 17546973, 20334344, 14054676, 17088068
                  17346091, 18264060, 17343514, 21538567, 19680952, 18471685, 19211724
                  13951456, 21847223, 16315398, 18744139, 16850630, 19049453, 18673304
                  17883081, 19915271, 18641419, 18262334, 17006183, 16065166, 18277454
                  16833527, 10136473, 18051556, 17865671, 17852463, 18554871, 17853498
                  18334586, 17551709, 17588480, 19827973, 17344412, 17842825, 18828868
                  17025461, 11883252, 13609098, 17239687, 17602269, 19197175, 22195457
                  18316692, 17313525, 12611721, 19544839, 18964939, 17600719, 18191164
                  19393542, 17571306, 18482502, 20777150, 19466309, 17040527, 17165204
                  18098207, 16785708, 17465741, 17174582, 16180763, 16777840, 12982566
                  19463893, 22195465, 16875449, 12816846, 17237521, 19358317, 17811438
                  17811447, 21983325, 17945983, 18762750, 16912439, 17184721, 18061914
                  17282229, 18331850, 18202441, 17082359, 18723434, 21972320, 19554106
                  14034426, 18339044, 19458377, 17752995, 20448824, 17891943, 17258090
                  17767676, 16668584, 18384391, 17040764, 17381384, 15913355, 18356166
                  14084247, 20596234, 20506715, 21756661, 13853126, 18203837, 14245531
                  21756699, 16043574, 22195441, 17848897, 17877323, 21453153, 17468141
                  20861693, 17786518, 17912217, 17037130, 18155762, 16956380, 17478145
                  17394950, 18641461, 18189036, 18619917, 17027426, 21352646, 16268425
                  22195492, 19584068, 18436307, 17265217, 17634921, 13498382, 21526048
                  19258504, 20004087, 17443671, 22195485, 18000422, 20004021, 22321756
                  17571039, 21067387, 16344544, 18009564, 14354737, 21286665, 18135678
                  18614015, 20441797, 18362222, 17835048, 16472716, 17936109, 17050888
                  17325413, 14010183, 18747196, 17761775, 16721594, 17082983, 20067212
                  21179898, 17302277, 18084625, 15990359, 18203835, 17297939, 17811456
                  16731148, 21168487, 13829543, 17215560, 14133975, 17694209, 17385178
                  18091059, 8322815, 17586955, 17201159, 17655634, 18331812, 19730508
                  18868646, 17648596, 16220077, 16069901, 17348614, 17393915, 17274537
                  17957017, 18096714, 17308789, 18436647, 14285317, 19289642, 14764829
                  18328509, 17622427, 22195477, 16943711, 22502493, 14368995, 17346671
                  18996843, 17783588, 21343838, 16618694, 17672719, 18856999, 18783224
                  17851160, 17546761, 17798953, 18273830, 22092979, 16596890, 19972566
                  16384983, 17726838, 17360606, 22321741, 13645875, 18199537, 16542886
                  21787056, 17889549, 14565184, 17071721, 17610798, 20299015, 21343897
                  22893153, 20657441, 17397545, 18230522, 16360112, 19769489, 12905058
                  18641451, 12747740, 18430495, 17016369, 17042658, 14602788, 17551063
                  19972568, 21517440, 18508861, 19788842, 14657740, 17332800, 13837378
                  19972564, 17186905, 18315328, 19699191, 17437634, 22353199, 18093615
                  19006849, 19013183, 17296856, 18674024, 17232014, 16855292, 17762296
                  14692762, 21051840, 17705023, 19121551, 21330264, 19854503, 21868720
                  19309466, 18681862, 18554763, 20558005, 17390160, 18456514, 16306373
                  13955826, 18139690, 17501491, 17752121, 21668627, 17299889, 17889583
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17323222, 16595641, 16524926, 18228645, 18282562, 17596908, 17156148
18031668, 16494615, 22683225, 17545847, 17655240, 17614134, 13558557
17341326, 17891946, 17716305, 16392068, 19271443, 21351877, 18092127
18440047, 17614227, 14106803, 16903536, 18973907, 18673342, 19032867
17389192, 17612828, 16194160, 17006570, 17721717, 17390431, 17570240
16863422, 18325460, 19727057, 16422541, 19972570, 17267114, 18244962
21538485, 18765602, 18203838, 16198143, 17246576, 14829250, 17835627
18247991, 14458214, 21051862, 16692232, 17786278, 17227277, 16042673
16314254, 16228604, 16837842, 17393683, 17787259, 20331945, 20074391
15861775, 16399083, 18018515, 22683212, 18260550, 21051858, 17036973
16613964, 17080436, 16579084, 18384537, 18280813, 20296213, 16901385
15979965, 18441944, 16450169, 9756271, 17892268, 11733603, 16285691
17587063, 21343775, 16538760, 18180390, 18193833, 21387964, 21051833
17238511, 17824637, 16571443, 18306996, 14852021, 18674047, 17853456
12364061, 22195448
```

Version 11.2.0.4.v7

Version 11.2.0.4.v7 adds support for the following:

- Oracle PSU 11.2.0.4.160119 (21948347)
- Timezone file DSTv25 - patch 22037014 for 11.2.0.4 and 12.1.0.2 (12.1.0.1 includes DSTv24, patch 20875898 (unchanged from 12.1.0.1.v3), as a backport of DSTv25 was unavailable at build time)
- Fixed an issue that prevented customers from creating more than 10 Directory objects in the database
- Fixed an issue that prevented customers from re-granting read privileges on the ADUMP and BDUMP Directory objects

Baseline: Oracle Database Patch Set Update 11.2.0.4.160119 (patch 21948347, released January 2016)

Bugs fixed:

```
17288409, 21051852, 18607546, 17205719, 17811429, 17816865, 20506699
17922254, 17754782, 16934803, 13364795, 17311728, 17441661, 17284817
16992075, 17446237, 14015842, 19972569, 17449815, 21538558, 20925795
17375354, 19463897, 17982555, 17235750, 13866822, 17478514, 18317531
18235390, 14338435, 20803583, 13944971, 20142975, 17811789, 16929165
18704244, 20506706, 17546973, 20334344, 14054676, 17088068, 18264060
17346091, 17343514, 21538567, 19680952, 18471685, 19211724, 13951456
21847223, 16315398, 18744139, 16850630, 19049453, 18673304, 17883081
19915271, 18641419, 18262334, 17006183, 16065166, 18277454, 16833527
10136473, 18051556, 17865671, 17852463, 18554871, 17853498, 18334586
17588480, 17551709, 19827973, 17842825, 17344412, 18828868, 17025461
11883252, 13609098, 17239687, 17602269, 19197175, 22195457, 18316692
17313525, 12611721, 19544839, 18964939, 17600719, 18191164, 19393542
17571306, 18482502, 20777150, 19466309, 17040527, 17165204, 18098207
16785708, 17174582, 16180763, 17465741, 16777840, 12982566, 19463893
22195465, 12816846, 16875449, 17237521, 19358317, 17811438, 17811447
17945983, 18762750, 17184721, 16912439, 18061914, 17282229, 18331850
18202441, 17082359, 18723434, 21972320, 19554106, 14034426, 18339044
19458377, 17752995, 20448824, 17891943, 17258090, 17767676, 16668584
18384391, 17040764, 17381384, 15913355, 18356166, 14084247, 20506715
13853126, 18203837, 14245531, 21756699, 16043574, 22195441, 17848897
17877323, 21453153, 17468141, 20861693, 17786518, 17912217, 17037130
18155762, 16956380, 17478145, 17394950, 18189036, 18641461, 18619917
17027426, 21352646, 16268425, 22195492, 19584068, 18436307, 17265217
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17634921, 13498382, 21526048, 20004087, 22195485, 17443671, 18000422
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18135678, 18614015, 20441797, 18362222, 17835048, 16472716, 17936109
17050888, 17325413, 14010183, 18747196, 17761775, 16721594, 17082983
20067212, 21179898, 17302277, 18084625, 15990359, 18203835, 17297939
17811456, 16731148, 21168487, 17215560, 13829543, 14133975, 17694209
18091059, 17385178, 8322815, 17586955, 17201159, 17655634, 18331812
19730508, 18868646, 17648596, 16220077, 16069901, 17348614, 17393915
17274537, 17957017, 18096714, 17308789, 18436647, 14285317, 19289642
14764829, 18328509, 17622427, 22195477, 16943711, 14368995, 17346671
18996843, 17783588, 21343838, 16618694, 17672719, 18856999, 18783224
17851160, 17546761, 17798953, 18273830, 22092979, 19972566, 16384983
17726838, 17360606, 22321741, 13645875, 18199537, 16542886, 21787056
17889549, 14565184, 17071721, 17610798, 20299015, 21343897, 20657441
17397545, 18230522, 16360112, 19769489, 12905058, 18641451, 12747740
18430495, 17042658, 17016369, 14602788, 17551063, 19972568, 21517440
18508861, 19788842, 14657740, 17332800, 13837378, 19972564, 17186905
18315328, 19699191, 17437634, 19006849, 19013183, 17296856, 18674024
17232014, 16855292, 21051840, 14692762, 17762296, 17705023, 19121551
21330264, 19854503, 19309466, 18681862, 18554763, 20558005, 17390160
18456514, 16306373, 13955826, 18139690, 17501491, 21668627, 17299889
17752121, 17889583, 18673325, 18293054, 17242746, 17951233, 17649265
18094246, 19615136, 17011832, 16870214, 17477958, 18522509, 20631274
16091637, 17323222, 16595641, 16524926, 18228645, 18282562, 17596908
17156148, 18031668, 16494615, 17545847, 17655240, 17614134, 13558557
17341326, 17891946, 17716305, 16392068, 19271443, 21351877, 18092127
18440047, 17614227, 14106803, 16903536, 18973907, 18673342, 19032867
17389192, 17612828, 16194160, 17006570, 17721717, 17570240, 17390431
16863422, 18325460, 19727057, 16422541, 19972570, 17267114, 18244962
21538485, 18765602, 18203838, 16198143, 17246576, 14829250, 17835627
18247991, 14458214, 21051862, 16692232, 17786278, 17227277, 16042673
16314254, 16228604, 16837842, 17393683, 17787259, 20331945, 20074391
15861775, 16399083, 18018515, 21051858, 18260550, 17036973, 16613964
17080436, 16579084, 18384537, 18280813, 20296213, 16901385, 15979965
18441944, 16450169, 9756271, 17892268, 11733603, 16285691, 17587063
21343775, 16538760, 18180390, 18193833, 21051833, 17238511, 17824637
16571443, 18306996, 14852021, 18674047, 17853456, 12364061, 22195448
```

Version 11.2.0.4.v6

Version 11.2.0.4.v6 adds support for the following:

- Enable SSL encryption for Standard Edition and Standard Edition One

Version 11.2.0.4.v5

Version 11.2.0.4.v5 adds support for the following:

- Oracle PSU 11.2.0.4.8 (21352635)
- Includes the Daylight Saving Time Patch, patch 20875898: DST-24, that came out after the April 2015 PSU.

Baseline: Oracle Database Patch Set Update 11.2.0.4.8 (patch 21352635, released October 2015)

Bugs fixed:

```
17288409, 21051852, 18607546, 17205719, 17811429, 17816865, 20506699
17922254, 17754782, 16934803, 13364795, 17311728, 17441661, 17284817
16992075, 17446237, 14015842, 19972569, 21538558, 20925795, 17449815
17375354, 19463897, 17982555, 17235750, 13866822, 18317531, 17478514
18235390, 14338435, 20803583, 13944971, 20142975, 17811789, 16929165
18704244, 20506706, 17546973, 20334344, 14054676, 17088068, 18264060
17346091, 17343514, 21538567, 19680952, 18471685, 19211724, 13951456
16315398, 18744139, 16850630, 19049453, 18673304, 17883081, 19915271
18641419, 18262334, 17006183, 16065166, 18277454, 16833527, 10136473
18051556, 17865671, 17852463, 18554871, 17853498, 18334586, 17588480
17551709, 19827973, 17842825, 17344412, 18828868, 17025461, 11883252
13609098, 17239687, 17602269, 19197175, 18316692, 17313525, 12611721
19544839, 18964939, 17600719, 18191164, 19393542, 17571306, 18482502
20777150, 19466309, 17040527, 17165204, 18098207, 16785708, 17174582
16180763, 17465741, 16777840, 12982566, 19463893, 12816846, 16875449
17237521, 19358317, 17811438, 17811447, 17945983, 18762750, 17184721
16912439, 18061914, 17282229, 18331850, 18202441, 17082359, 18723434
19554106, 14034426, 18339044, 19458377, 17752995, 20448824, 17891943
17258090, 17767676, 16668584, 18384391, 17040764, 17381384, 15913355
18356166, 14084247, 20506715, 13853126, 18203837, 14245531, 16043574
17848897, 17877323, 17468141, 17786518, 17912217, 17037130, 18155762
16956380, 17478145, 17394950, 18189036, 18641461, 18619917, 17027426
21352646, 16268425, 19584068, 18436307, 17265217, 17634921, 13498382
20004087, 17443671, 18000422, 20004021, 17571039, 21067387, 16344544
18009564, 14354737, 18135678, 18614015, 20441797, 18362222, 17835048
16472716, 17936109, 17050888, 17325413, 14010183, 18747196, 17761775
16721594, 17082983, 20067212, 21179898, 17302277, 18084625, 15990359
18203835, 17297939, 17811456, 16731148, 17215560, 13829543, 14133975
17694209, 18091059, 17385178, 8322815, 17586955, 17201159, 17655634
18331812, 19730508, 18868646, 17648596, 16220077, 16069901, 17348614
17393915, 17274537, 17957017, 18096714, 17308789, 18436647, 14285317
19289642, 14764829, 18328509, 17622427, 16943711, 14368995, 17346671
18996843, 17783588, 16618694, 17672719, 18856999, 18783224, 17851160
17546761, 17798953, 18273830, 19972566, 16384983, 17726838, 17360606
13645875, 18199537, 16542886, 17889549, 14565184, 17071721, 20299015
17610798, 20657441, 17397545, 18230522, 16360112, 19769489, 12905058
18641451, 12747740, 18430495, 17042658, 17016369, 14602788, 19972568
18508861, 19788842, 14657740, 17332800, 13837378, 19972564, 17186905
18315328, 19699191, 17437634, 19006849, 19013183, 17296856, 18674024
17232014, 16855292, 21051840, 14692762, 17762296, 17705023, 19121551
19854503, 19309466, 18681862, 18554763, 20558005, 17390160, 18456514
16306373, 13955826, 18139690, 17501491, 17299889, 17752121, 17889583
18673325, 18293054, 17242746, 17951233, 17649265, 18094246, 19615136
17011832, 16870214, 17477958, 18522509, 20631274, 16091637, 17323222
16595641, 16524926, 18228645, 18282562, 17596908, 17156148, 18031668
16494615, 17545847, 17614134, 13558557, 17341326, 17891946, 17716305
16392068, 19271443, 18092127, 18440047, 17614227, 14106803, 16903536
18973907, 18673342, 17389192, 16194160, 17006570, 17612828, 17721717
17570240, 17390431, 16863422, 18325460, 19727057, 16422541, 19972570
17267114, 18244962, 21538485, 18765602, 18203838, 16198143, 17246576
14829250, 17835627, 18247991, 14458214, 21051862, 16692232, 17786278
17227277, 16042673, 16314254, 16228604, 16837842, 17393683, 17787259
20331945, 20074391, 15861775, 16399083, 18018515, 18260550, 21051858
17036973, 16613964, 17080436, 16579084, 18384537, 18280813, 20296213
16901385, 15979965, 18441944, 16450169, 9756271, 17892268, 11733603
16285691, 17587063, 16538760, 18180390, 18193833, 21051833, 17238511
17824637, 16571443, 18306996, 14852021, 18674047, 17853456, 12364061
```

Version 11.2.0.4.v4

Version 11.2.0.4.v4 adds support for the following:

- Oracle PSU 11.2.0.4.6 (20299013)

- Installs additional Oracle Text knowledge bases from Oracle Database. Examples media (English and French)
- Provides access to DBMS_REPAIR through RDSADMIN.RDSADMIN_DBMS_REPAIR
- Grants ALTER DATABASE LINK, ALTER PUBLIC DATABASE LINK, EXEMPT ACCESS POLICY, EXEMPT IDENTITY POLICY, and EXEMPT REDACTION POLICY to master user

Baseline: Oracle Database Patch Set Update 11.2.0.4.6 (patch 20299013, released April 2015)

Bugs fixed:

```
                    17288409, 17798953, 18273830, 18607546, 17811429, 17205719, 20506699
                    17816865, 19972566, 17922254, 17754782, 16384983, 17726838, 13364795
                    16934803, 17311728, 17284817, 17441661, 17360606, 13645875, 18199537
                    16992075, 16542886, 17446237, 14015842, 17889549, 14565184, 19972569
                    17071721, 20299015, 17610798, 17375354, 17449815, 17397545, 19463897
                    18230522, 13866822, 17235750, 17982555, 16360112, 18317531, 17478514
                    19769489, 12905058, 14338435, 18235390, 13944971, 18641451, 20142975
                    17811789, 16929165, 18704244, 12747740, 18430495, 20506706, 17546973
                    14054676, 17088068, 17346091, 18264060, 17016369, 17042658, 17343514
                    14602788, 19972568, 19680952, 18471685, 19788842, 18508861, 14657740
                    17332800, 19211724, 13837378, 13951456, 16315398, 17186905, 18744139
                    19972564, 16850630, 18315328, 17437634, 19049453, 18673304, 17883081
                    19006849, 19915271, 19013183, 18641419, 17296856, 18674024, 18262334
                    17006183, 18277454, 16833527, 17232014, 16855292, 10136473, 17762296
                    14692762, 17705023, 18051556, 17865671, 17852463, 18554871, 17853498
                    19121551, 18334586, 19854503, 17551709, 19309466, 17588480, 19827973
                    17344412, 17842825, 18828868, 18681862, 18554763, 17390160, 18456514
                    16306373, 17025461, 13955826, 18139690, 11883252, 13609098, 17501491
                    17239687, 17752121, 17299889, 17602269, 19197175, 17889583, 18316692
                    17313525, 18673325, 12611721, 19544839, 18293054, 17242746, 18964939
                    17600719, 18191164, 19393542, 17571306, 18482502, 19466309, 17951233
                    17649265, 18094246, 19615136, 17040527, 17011832, 17165204, 18098207
                    16785708, 16870214, 17465741, 16180763, 17174582, 17477958, 12982566
                    16777840, 18522509, 20631274, 16091637, 17323222, 19463893, 16595641
                    16875449, 12816846, 16524926, 17237521, 18228645, 18282562, 17596908
                    19358317, 17811438, 17811447, 17945983, 18762750, 17156148, 18031668
                    16912439, 17184721, 16494615, 18061914, 17282229, 17545847, 18331850
                    18202441, 17082359, 18723434, 19554106, 17614134, 13558557, 17341326
                    14034426, 17891946, 18339044, 17716305, 19458377, 17752995, 16392068
                    19271443, 17891943, 18092127, 17258090, 17767676, 16668584, 18384391
                    17614227, 17040764, 16903536, 17381384, 14106803, 15913355, 18973907
                    18356166, 18673342, 17389192, 14084247, 16194160, 17612828, 17006570
                    20506715, 17721717, 13853126, 17390431, 18203837, 17570240, 14245531
                    16043574, 16863422, 17848897, 17877323, 18325460, 19727057, 17468141
                    17786518, 17912217, 16422541, 19972570, 17267114, 17037130, 18244962
                    18765602, 18203838, 18155762, 16956380, 16198143, 17246576, 17478145
                    17394950, 14829250, 18189036, 18641461, 18619917, 17835627, 17027426
                    16268425, 18247991, 19584068, 14458214, 18436307, 17265217, 17634921
                    13498382, 16692232, 17786278, 17227277, 16042673, 16314254, 17443671
                    18000422, 16228604, 16837842, 17571039, 17393683, 16344544, 17787259
                    18009564, 20074391, 14354737, 15861775, 18135678, 18614015, 16399083
                    18362222, 18018515, 16472716, 17835048, 17050888, 17936109, 14010183
                    17325413, 18747196, 17080436, 16613964, 17036973, 17761775, 16579084
                    16721594, 17082983, 18384537, 18280813, 20296213, 17302277, 16901385
                    18084625, 15979965, 15990359, 18203835, 17297939, 17811456, 16731148
                    13829543, 14133975, 17215560, 17694209, 18091059, 17385178, 8322815
                    17586955, 18441944, 17201159, 16450169, 9756271, 17655634, 19730508
                    17892268, 18868646, 17648596, 16220077, 16069901, 11733603, 16285691
                    17587063, 18180390, 16538760, 18193833, 17348614, 17393915, 17957017
                    17274537, 18096714, 17308789, 17238511, 18436647, 17824637, 14285317
```

```
19289642, 14764829, 17622427, 18328509, 16571443, 16943711, 14368995
18306996, 17346671, 14852021, 18996843, 17783588, 16618694, 17853456
18674047, 17672719, 18856999, 12364061, 18783224, 17851160, 17546761
```

Version 11.2.0.4.v3

Version 11.2.0.4.v3 adds support for the following:

- Oracle PSU 11.2.0.4.4 (19121551)
- Latest DST file (DSTv23 – patch 19396455, released Oct 2014). This patch is incorporated by default in new instances only.

Baseline: Oracle Database Patch Set Update 11.2.0.4.4 (patch 19121551, released October 2014)

Bugs fixed:

```
19396455, 18759211, 17432124, 16799735,
17288409, 17205719, 17811429, 17754782, 17726838, 13364795, 17311728
17284817, 17441661, 13645875, 18199537, 16992075, 16542886, 17446237
14565184, 17071721, 17610798, 17375354, 17449815, 17397545, 19463897
18230522, 17235750, 16360112, 13866822, 17982555, 17478514, 12905058
14338435, 13944971, 16929165, 12747740, 17546973, 14054676, 17088068
18264060, 17343514, 17016369, 17042658, 14602788, 14657740, 17332800
19211724, 13951456, 16315398, 17186905, 18744139, 16850630, 17437634
19049453, 18673304, 17883081, 18641419, 17296856, 18262334, 17006183
18277454, 17232014, 16855292, 10136473, 17705023, 17865671, 18554871
19121551, 17588480, 17551709, 17344412, 17842825, 18681862, 17390160
13955826, 13609098, 18139690, 17501491, 17239687, 17752121, 17299889
17602269, 18673325, 17313525, 17242746, 19544839, 17600719, 18191164
17571306, 19466309, 17951233, 18094246, 17165204, 17011832, 17040527
16785708, 16180763, 17477958, 17174582, 17465741, 18522509, 17323222
19463893, 16875449, 16524926, 17237521, 17596908, 17811438, 17811447
18031668, 16912439, 16494615, 18061914, 17545847, 17082359, 19554106
17614134, 17341326, 17891946, 19458377, 17716305, 17752995, 16392068
19271443, 17767676, 17614227, 17040764, 17381384, 18973907, 18673342
14084247, 17389192, 17006570, 17612828, 17721717, 13853126, 18203837
17390431, 17570240, 14245531, 16043574, 16863422, 19727057, 17468141
17786518, 17037130, 17267114, 18203838, 16198143, 16956380, 17478145
14829250, 17394950, 17027426, 16268425, 18247991, 19584068, 14458214
18436307, 17265217, 13498382, 16692232, 17786278, 17227277, 16042673
16314254, 17443671, 16228604, 16837842, 17393683, 17787259, 18009564
15861775, 16399083, 18018515, 16472716, 17050888, 14010183, 17325413
16613964, 17080436, 17036973, 17761775, 16721594, 18280813, 15979965
18203835, 17297939, 16731148, 17811456, 14133975, 17385178, 17586955
16450169, 17655634, 9756271, 17892268, 17648596, 16220077, 16069901
11733603, 16285691, 17587063, 18180390, 17393915, 18096714, 17238511
17824637, 14285317, 19289642, 14764829, 18328509, 17622427, 16943711
17346671, 18996843, 14852021, 17783588, 16618694, 17672719, 17546761
```

Version 11.2.0.4.v2 (Deprecated)

Version 11.2.0.4.v2 adds support for the following:

- Oracle PSU 11.2.0.4.3 (18522509)

- User access to DBMS_TRANSACTION package to clean-up failed distributed transactions
- Latest DST file (DSTv22 – patch 18759211, released June 2014). This patch is incorporated by default only in new Oracle DB instances.
- Grants DBMS_REPUTIL to DBA role (upgrade to 11.2.0.4 revokes it from public)
- Privileges granted on DBMS_TRANSACTION, `v$pending_xatrans$`, and `v$xatrans$`
- Resolves a problem with DDL commands when user objects have "SYSTEM" in their names
- Installs schema objects to support XA Transactions, allowing transactions to be managed by an external transaction manager
- Permits truncation of temporary SYS and SYSTEM objects, allowing tools like LogMiner to function correctly

Baseline: Oracle Database Patch Set Update 11.2.0.4.3 (patch 18522509, released July 2014)

Bugs fixed:

```
                    17432124, 18759211, 18522509, 18031668, 17478514,
                    17752995, 17288409, 16392068, 17205719, 17811429, 17767676, 17614227
                    17040764, 17381384, 17754782, 17726838, 13364795, 17311728, 17389192
                    17006570, 17612828, 17284817, 17441661, 13853126, 17721717, 13645875
                    18203837, 17390431, 16542886, 16992075, 16043574, 17446237, 16863422
                    14565184, 17071721, 17610798, 17468141, 17786518, 17375354, 17397545
                    18203838, 16956380, 17478145, 16360112, 17235750, 17394950, 13866822
                    17478514, 17027426, 12905058, 14338435, 16268425, 13944971, 18247991
                    14458214, 16929165, 17265217, 13498382, 17786278, 17227277, 17546973
                    14054676, 17088068, 16314254, 17016369, 14602788, 17443671, 16228604
                    16837842, 17332800, 17393683, 13951456, 16315398, 18744139, 17186905
                    16850630, 17437634, 19049453, 17883081, 15861775, 17296856, 18277454
                    16399083, 16855292, 18018515, 10136473, 16472716, 17050888, 17865671
                    17325413, 14010183, 18554871, 17080436, 16613964, 17761775, 16721594
                    17588480, 17551709, 17344412, 18681862, 15979965, 13609098, 18139690
                    17501491, 17239687, 17752121, 17602269, 18203835, 17297939, 17313525
                    16731148, 17811456, 14133975, 17600719, 17385178, 17571306, 16450169
                    17655634, 18094246, 17892268, 17165204, 17011832, 17648596, 16785708
                    17477958, 16180763, 16220077, 17465741, 17174582, 18522509, 16069901
                    16285691, 17323222, 18180390, 17393915, 16875449, 18096714, 17238511
```

Version 11.2.0.4.v1

Version 11.2.0.4.v1 adds support for the following:

- Oracle PSU 11.2.0.4.1
- Creating New Directories in the Main Data Storage Space (p. 1051)

Baseline: Oracle Database Patch Set Update 11.2.0.4.1 (released January 2014)

Bugs fixed:

```
                    17432124, 16850630, 17551709, 13944971, 17811447, 13866822, 17811429,
16069901
                    16721594, 17443671, 17478514, 17612828, 17610798, 17239687, 17501491
                    17446237, 16450169, 17811438, 17288409, 17811456, 12905058, 17088068
                    16285691, 17332800
```

Related Topics

- Upgrading the Oracle DB Engine (p. 888)
- Oracle on Amazon RDS (p. 845)

PostgreSQL on Amazon RDS

Amazon RDS supports DB instances running several versions of PostgreSQL. You can create DB instances and DB snapshots, point-in-time restores and backups. DB instances running PostgreSQL support Multi-AZ deployments, read replicas, Provisioned IOPS, and can be created inside a VPC. You can also use Secure Socket Layer (SSL) to connect to a DB instance running PostgreSQL.

Before creating a DB instance, you should complete the steps in the Setting Up for Amazon RDS (p. 58) section of this guide.

You can use any standard SQL client application to run commands for the instance from your client computer. Such applications include *pgAdmin*, a popular Open Source administration and development tool for PostgreSQL, or *psql*, a command line utility that is part of a PostgreSQL installation. To deliver a managed service experience, Amazon RDS doesn't provide host access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges. Amazon RDS supports access to databases on a DB instance using any standard SQL client application. Amazon RDS doesn't allow direct host access to a DB instance by using Telnet or Secure Shell (SSH).

Amazon RDS for PostgreSQL is compliant with many industry standards. For example, you can use Amazon RDS for PostgreSQL databases to build HIPAA-compliant applications and to store healthcare-related information, including protected health information (PHI) under an executed Business Associate Agreement (BAA) with AWS. Amazon RDS for PostgreSQL also meets Federal Risk and Authorization Management Program (FedRAMP) security requirements. Amazon RDS for PostgreSQL has received a FedRAMP Joint Authorization Board (JAB) Provisional Authority to Operate (P-ATO) at the FedRAMP HIGH Baseline within the AWS GovCloud (US-West) Region. For more information on supported compliance standards, see AWS Cloud Compliance.

To import PostgreSQL data into a DB instance, follow the information in the Importing Data into PostgreSQL on Amazon RDS (p. 1248) section.

Topics

Common Management Tasks for PostgreSQL on Amazon RDS

The following are the common management tasks you perform with an Amazon RDS for PostgreSQL DB instance, with links to relevant documentation for each task.

Task Area	Relevant Documentation
Setting up Amazon RDS for first-time use There are prerequisites you must complete before you create your DB instance. For example, DB instances are created by default with a firewall that prevents access to it. You therefore must create a security group with the correct IP addresses and network configuration to access the DB instance.	Setting Up for Amazon RDS (p. 58)
Understanding Amazon RDS DB instances If you are creating a DB instance for production purposes, you should understand how instance classes, storage types, and Provisioned IOPS work in Amazon RDS.	DB Instance Classes (p. 7) Amazon RDS Storage Types (p. 29) Provisioned IOPS SSD Storage (p. 31)
Finding supported PostgreSQL versions Amazon RDS supports several versions of PostgreSQL.	Supported PostgreSQL Database Versions (p. 1310)
Setting up high availability and failover support A production DB instance should use Multi-AZ deployments. Multi-AZ deployments provide increased availability, data durability, and fault tolerance for DB instances.	High Availability (Multi-AZ) for Amazon RDS (p. 41)
Understanding the Amazon Virtual Private Cloud (VPC) network If your AWS account has a default VPC, then your DB instance is automatically created inside the default VPC. In some cases, your account might not have a default VPC, and you might want the DB instance in a VPC. In these cases, create the VPC and subnet groups before you create the DB instance.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Working with a DB Instance in a VPC (p. 1442)
Importing data into Amazon RDS PostgreSQL You can use several different tools to import data into your PostgreSQL DB instance on Amazon RDS.	Importing Data into PostgreSQL on Amazon RDS (p. 1248)
Setting up read-only read replicas (masters and standbys) PostgreSQL on Amazon RDS supports read replicas in both the same AWS Region and in a different AWS Region from the master instance.	Working with Read Replicas (p. 250) Working with PostgreSQL Read Replicas in Amazon RDS (p. 1244) Creating a Read Replica in a Different AWS Region (p. 257)
Understanding security groups By default, DB instances are created with a firewall that prevents access to them. You therefore must create a security group with the correct IP addresses and network configuration to access the DB instance.	Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434) Controlling Access with Security Groups (p. 1414)

Task Area	Relevant Documentation
In general, if your DB instance is on the EC2-Classic platform, you need to create a DB security group. If your DB instance is on the EC2-VPC platform, you need to create a VPC security group.	
Setting up parameter groups and features If your DB instance is going to require specific database parameters, you should create a parameter group before you create the DB instance.	Working with DB Parameter Groups (p. 202)
Performing common DBA tasks for PostgreSQL Some of the more common tasks for PostgreSQL DBAs include: • Creating Roles (p. 1268) • Managing PostgreSQL Database Access (p. 1269) • Working with PostgreSQL Parameters (p. 1269) • Working with PostgreSQL Autovacuum on Amazon RDS (p. 1278) • Audit Logging for a PostgreSQL DB Instance (p. 1286) • Working with PostGIS (p. 1289) • Using pgBadger for Log Analysis with PostgreSQL (p. 1291) • Using a Custom DNS Server for Outbound Network Access (p. 1293)	Common DBA Tasks for PostgreSQL (p. 1268)
Connecting to your PostgreSQL DB instance After creating a security group and associating it to a DB instance, you can connect to the DB instance using any standard SQL client application such as pgadmin III.	Connecting to a DB Instance Running the PostgreSQL Database Engine (p. 1226) Using SSL with a PostgreSQL DB Instance (p. 1353)
Backing up and restoring your DB instance You can configure your DB instance to take automated backups, or take manual snapshots, and then restore instances from the backups or snapshots.	Backing Up and Restoring an Amazon RDS DB Instance (p. 290)
Monitoring the activity and performance of your DB instance You can monitor a PostgreSQL DB instance by using CloudWatch Amazon RDS metrics, events, and enhanced monitoring.	Viewing DB Instance Metrics (p. 356) Viewing Amazon RDS Events (p. 448)
Upgrading the PostgreSQL database version You can do both major and minor version upgrades for your PostgreSQL DB instance.	Upgrading a PostgreSQL DB Instance (p. 1353) Major Version Upgrades for PostgreSQL (p. 1236)
Working with log files You can access the log files for your PostgreSQL DB instance.	PostgreSQL Database Log Files (p. 482)

Task Area	Relevant Documentation
Understanding the best practices for PostgreSQL DB instances Find some of the best practices for working with PostgreSQL on Amazon RDS.	Best Practices for Working with PostgreSQL (p. 132)

Connecting to a DB Instance Running the PostgreSQL Database Engine

After Amazon RDS provisions your DB instance, you can use any standard SQL client application to connect to the instance. To list the details of an Amazon RDS DB instance, you can use the AWS Management Console, the AWS CLI describe-db-instances command, or the Amazon RDS API DescribeDBInstances operation. You need the following information to connect:

- The host or host name for the DB instance, for example:

```
myinstance.123456789012.us-east-1.rds.amazonaws.com
```

- The port on which the DB instance is listening. For example, the default PostgreSQL port is 5432.
- The user name and password for the DB instance.

Following are two ways to connect to a PostgreSQL DB instance. The first example uses pgAdmin, a popular open-source administration and development tool for PostgreSQL. The second example uses psql, a command line utility that is part of a PostgreSQL installation.

Using pgAdmin to Connect to a PostgreSQL DB Instance

You can use the open-source tool pgAdmin to connect to a PostgreSQL DB instance.

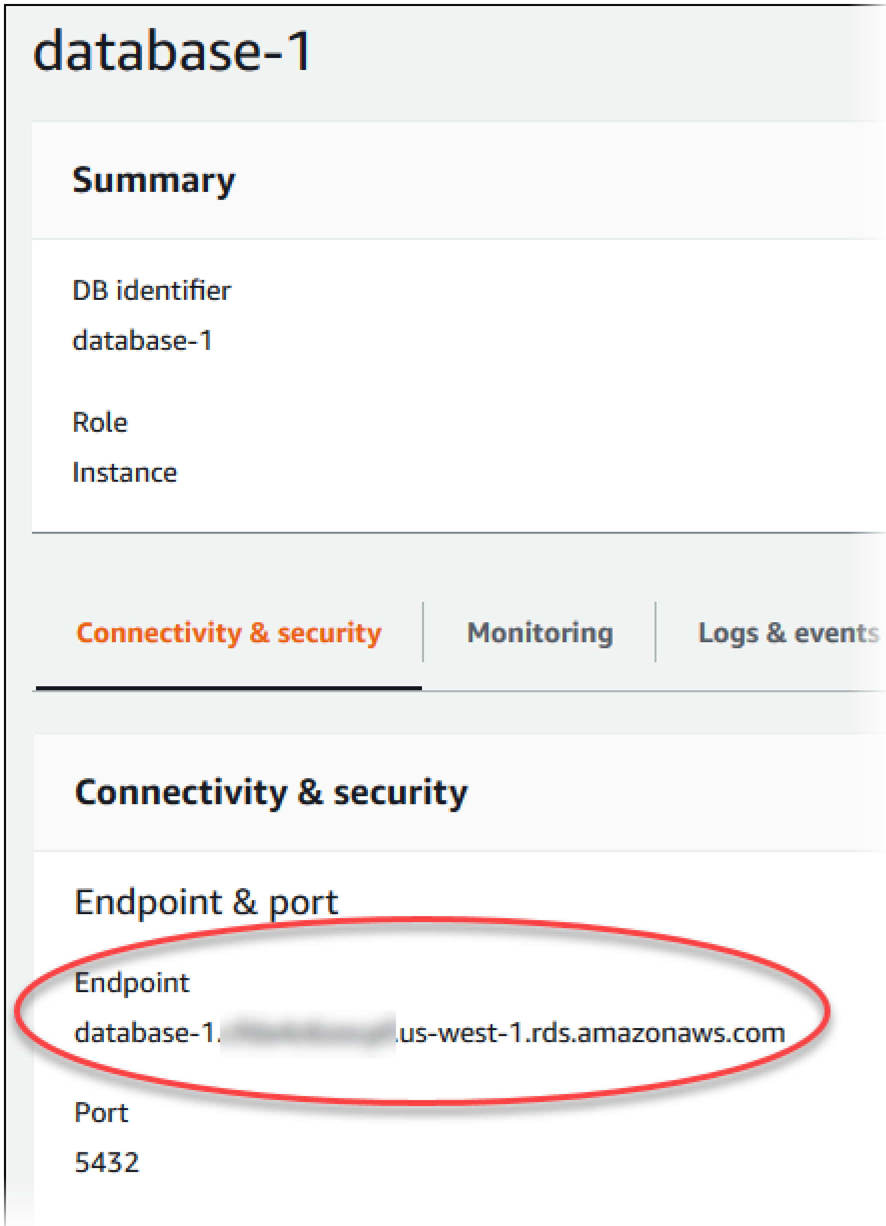
To connect to a PostgreSQL DB instance using pgAdmin

1. Find the endpoint (DNS name) and port number for your DB Instance.

   a. Open the RDS console and then choose **Databases** to display a list of your DB instances.

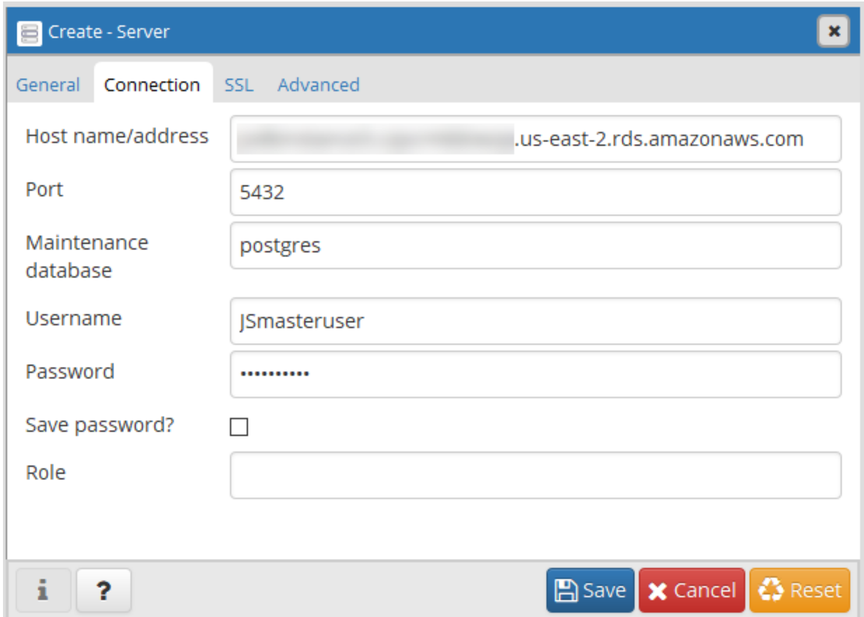
   b. Choose the PostgreSQL DB instance name to display its details.

   c. On the **Connectivity & security** tab, copy the endpoint. Also, note the port number. You need both the endpoint and the port number to connect to the DB instance.



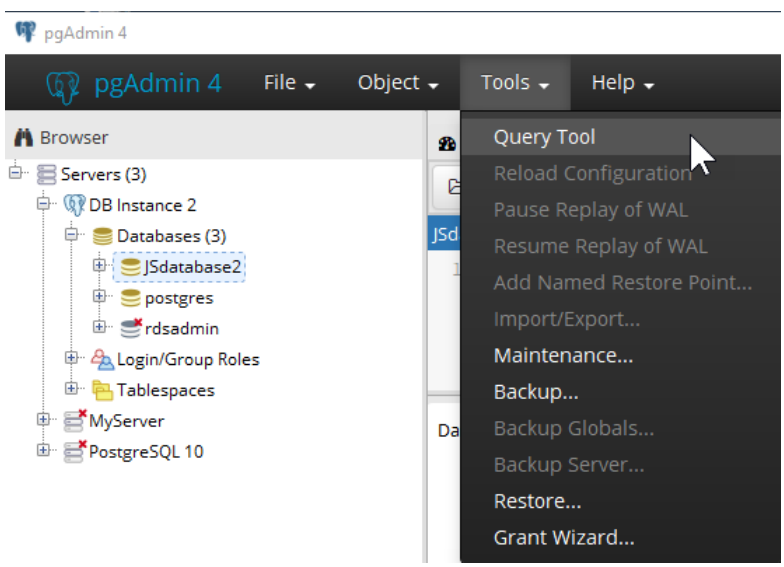
2. Install pgAdmin from http://www.pgadmin.org/. You can download and use pgAdmin without having a local instance of PostgreSQL on your client computer.
3. Launch the pgAdmin application on your client computer.
4. On the **Dashboard** tab, choose **Add New Server**.
5. In the **Create - Server** dialog box, type a name on the **General** tab to identify the server in pgAdmin.
6. On the **Connection** tab, type the following information from your DB instance:

   - For **Host**, type the endpoint, for example `mypostgresql.c6c8dntfzzhgv0.us-east-2.rds.amazonaws.com`.
   - For **Port**, type the assigned port.
   - For **Username**, type the user name that you entered when you created the DB instance.
   - For **Password**, type the password that you entered when you created the DB instance.



7. Choose **Save**.

   If you have any problems connecting, see Troubleshooting Connections to Your PostgreSQL Instance (p. 1229).
8. To access a database in the pgAdmin browser, expand **Servers**, the DB instance, and **Databases**. Choose the DB instance's database name.



9. To open a panel where you can enter SQL commands, choose **Tools**, **Query Tool**.

Using psql to Connect to a PostgreSQL DB Instance

You can use a local instance of the psql command line utility to connect to a PostgreSQL DB instance. You need either PostgreSQL or the psql client installed on your client computer. To connect to your PostgreSQL DB instance using psql, you need to provide host information and access credentials.

Use one of the following formats to connect to a PostgreSQL DB instance on Amazon RDS. When you connect, you're prompted for a password. For batch jobs or scripts, use the `--no-password` option.

If this is the first time you are connecting to this DB instance, try using the default database name **postgres** for the `--dbname` option.

For Unix, use the following format.

```
psql \
   --host=<DB instance endpoint> \
   --port=<port> \
   --username=<master user name> \
   --password \
   --dbname=<database name>
```

For Windows, use the following format.

```
psql ^
   --host=<DB instance endpoint> ^
   --port=<port> ^
   --username=<master user name> ^
   --password ^
   --dbname=<database name>
```

For example, the following command connects to a database called `mypgdb` on a PostgreSQL DB instance called `mypostgresql` using fictitious credentials.

```
psql --host=mypostgresql.c6c8mwvfdgv0.us-west-2.rds.amazonaws.com --port=5432 --
username=awsuser --password --dbname=mypgdb
```

Troubleshooting Connections to Your PostgreSQL Instance

If you can't connect to the DB instance, the most common error is `Could not connect to server: Connection timed out.` If you receive this error, do the following:

- Check that the host name used is the DB instance endpoint and that the port number used is correct.
- Make sure that the DB instance's public accessibility is set to **Yes**.
- Check that the security group assigned to the DB instance has rules to allow access through any firewall your connection might go through. For example, if the DB instance was created using the default port of 5432, your company might have firewall rules blocking connections to that port from company devices.

  To fix this failure, modify the DB instance to use a different port. Also, make sure that the security group applied to the DB instance allows connections to the new port.
- Check whether the DB instance was created using a security group that doesn't authorize connections from the device or Amazon EC2 instance where the application is running. For the connection to work, the security group you assigned to the DB instance at its creation must allow access to the DB instance. For example, if the DB instance was created in a VPC, it must have a VPC security group that authorizes connections.

  You can add or edit an inbound rule in the security group. For **Source**, choosing **My IP** allows access to the DB instance from the IP address detected in your browser. For more information, see Provide Access to Your DB Instance in Your VPC by Creating a Security Group (p. 61).

Alternatively, if the DB instance was created outside of a VPC, it must have a database security group that authorizes those connections.

By far the most common connection problem is with the security group's access rules assigned to the DB instance. If you used the default DB security group when you created the DB instance, the security group likely didn't have access rules that allow you to access the instance. For more information about Amazon RDS security groups, see Controlling Access with Security Groups (p. 1414).

If you receive an error like `FATAL: database some-name does not exist` when connecting, try using the default database name **postgres** for the `--dbname` option.

Updating Applications to Connect to PostgreSQL DB Instances Using New SSL/TLS Certificates

As of September 19, 2019, Amazon RDS has published new Certificate Authority (CA) certificates for connecting to your RDS DB instances using Secure Socket Layer or Transport Layer Security (SSL/TLS). Following, you can find information about updating your applications to use the new certificates.

This topic can help you to determine whether any client applications use SSL/TLS to connect to your DB instances. If they do, you can further check whether those applications require certificate verification to connect.

> **Note**
> Some applications are configured to connect to PostgreSQL DB instances only if they can successfully verify the certificate on the server.
> For such applications, you must update your client application trust stores to include the new CA certificates.

After you update your CA certificates in the client application trust stores, you can rotate the certificates on your DB instances. We strongly recommend testing these procedures in a development or staging environment before implementing them in your production environments.

For more information about certificate rotation, see Rotating Your SSL/TLS Certificate (p. 1363). For more information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361). For information about using SSL/TLS with PostgreSQL DB instances, see Using SSL with a PostgreSQL DB Instance (p. 1353).

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Determining Whether Applications Are Connecting to PostgreSQL DB Instances Using SSL

Check the DB instance configuration for the value of the `rds.force_ssl` parameter. By default, the `rds.force_ssl` parameter is set to `0` (off). If the `rds.force_ssl` parameter is set to `1` (on), clients are required to use SSL/TLS for connections. For more information about parameter groups, see Working with DB Parameter Groups (p. 202).

If you are using RDS PostgreSQL version 9.5 or later major version and `rds.force_ssl` is not set to `1` (on), query the `pg_stat_ssl` view to check connections using SSL. For example, the following query returns only SSL connections and information about the clients using SSL.

```
select datname, usename, ssl, client_addr from pg_stat_ssl inner join pg_stat_activity on
 pg_stat_ssl.pid = pg_stat_activity.pid where ssl is true and usename<>'rdsadmin';
```

Only rows using SSL/TLS connections are displayed with information about the connection. The following is sample output.

```
 datname  | usename | ssl | client_addr
----------+---------+-----+-------------
 benchdb  | pgadmin | t   | 53.95.6.13
 postgres | pgadmin | t   | 53.95.6.13
(2 rows)
```

This query displays only the current connections at the time of the query. The absence of results doesn't indicate that no applications are using SSL connections. Other SSL connections might be established at a different time.

If you are using RDS PostgreSQL version 9.4 and `rds.force_ssl` is not set to `1` (on), then to determine whether your applications are connecting with SSL, you must enable the `log_connections` parameter. This parameter logs SSL connection information when a client connects. The following is an example of an SSL connection entry in the error log.

```
2018-04-19 10:19:20 UTC:123.45.67.8(6789):[unknown]@[unknown]:[17196]:LOG: connection
 received: host=123.45.67.8 port=12345
2018-04-19 10:19:20 UTC:123.45.67.8(6789):test_user@Test_DB:[17196]:LOG: connection
 authorized: user=test_user database=Test_DB SSL enabled (protocol=xxxx, cipher=xxxx,
 compression=off)
```

For more information about viewing the error log, see Amazon RDS Database Log Files (p. 453).

Determining Whether a Client Requires Certificate Verification in Order to Connect

When a client, such as psql or JDBC, is configured with SSL support, the client first tries to connect to the database with SSL by default. If the client can't connect with SSL, it reverts to connecting without SSL. The default `sslmode` mode used is different between libpq-based clients (such as psql) and JDBC. The libpq-based clients default to `prefer`, where JDBC clients default to `verify-full`. The certificate on the server is verified only when `sslrootcert` is provided with `sslmode` set to `require`, `verify-ca`, or `verify-full`. An error is thrown if the certificate is invalid.

Use `PGSSLROOTCERT` to verify the certificate with the `PGSSLMODE` environment variable, with `PGSSLMODE` set to `require`, `verify-ca`, or `verify-full`.

```
PGSSLMODE=require PGSSLROOTCERT=/fullpath/rds-ca-2019-root.pem psql -h
 pgdbidentifier.cxxxxxxxx.us-east-2.rds.amazonaws.com -U masteruser -d postgres
```

Use the `sslrootcert` argument to verify the certificate with `sslmode` in connection string format, with `sslmode` set to `require`, `verify-ca`, or `verify-full` to verify the certificate.

```
psql "host=pgdbidentifier.cxxxxxxxx.us-east-2.rds.amazonaws.com sslmode=require
 sslrootcert=/full/path/rds-ca-2019-root.pem user=masteruser dbname=postgres"
```

For example, in the preceding case, if you are using an invalid root certificate, then you see an error similar to the following on your client.

```
psql: SSL error: certificate verify failed
```

Updating Your Application Trust Store

For information about updating the trust store for PostgreSQL applications, see Secure TCP/IP Connections with SSL in the PostgreSQL documentation.

> **Note**
> When you update the trust store, you can retain older certificates in addition to adding the new certificates.

Updating Your Application Trust Store for JDBC

You can update the trust store for applications that use JDBC for SSL/TLS connections.

To update the trust store for JDBC applications

1. Download the 2019 root certificate that works for all AWS Regions and put the file in your trust store directory.

   For information about downloading the root certificate, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Convert the certificate to .der format using the following command.

   ```
   openssl x509 -outform der -in rds-ca-2019-root.pem -out rds-ca-2019-root.der
   ```

   Replace the file name with the one that you downloaded.
3. Import the certificate into the key store using the following command.

   ```
   keytool -import -alias rds-root -keystore clientkeystore -file rds-ca-2019-root.der
   ```
4. Confirm that the key store was updated successfully.

   ```
   keytool -list -v -keystore clientkeystore.jks
   ```

   Enter the key store password when you are prompted for it.

   Your output should contain the following:

   ```
   rds-root,date, trustedCertEntry,
   Certificate fingerprint (SHA1):
    D4:0D:DB:29:E3:75:0D:FF:A6:71:C3:14:0B:BF:5F:47:8D:1C:80:96
   # This fingerprint should match the output from the below command
   openssl x509 -fingerprint -in rds-ca-2019-root.pem -noout
   ```

Using SSL/TLS Connections for Different Types of Applications

The following provides information about using SSL/TLS connections for different types of applications:

- **psql**

  The client is invoked from the command line by specifying options either as a connection string or as environment variables. For SSL/TLS connections, the relevant options are `sslmode` (environment variable `PGSSLMODE`), `sslrootcert` (environment variable `PGSSLROOTCERT`).

  For the complete list of options, see Parameter Key Words in the PostgreSQL documentation. For the complete list of environment variables, see Environment Variables in the PostgreSQL documentation.
- **pgAdmin**

  This browser-based client is a more user-friendly interface for connecting to a PostgreSQL database.

  For information about configuring connections, see the pgAdmin documentation.
- **JDBC**

  JDBC enables database connections with Java applications.

  For general information about connecting to a PostgreSQL database with JDBC, see Connecting to the Database in the PostgreSQL documentation. For information about connecting with SSL/TLS, see Configuring the Client in the PostgreSQL documentation.
- **Python**

  A popular Python library for connecting to PostgreSQL databases is `psycopg2`.

  For information about using `psycopg2`, see the psycopg2 documentation. For a short tutorial on how to connect to a PostgreSQL database, see Psycopg2 Tutorial. You can find information about the options the connect command accepts in The psycopg2 module content.

Important
After you have determined that your database connections use SSL/TLS and have updated your application trust store, you can update your database to use the rds-ca-2019 certificates. For instructions, see step 3 in Updating Your CA Certificate by Modifying Your DB Instance (p. 1363).

Upgrading the PostgreSQL DB Engine for Amazon RDS

When Amazon RDS supports a new version of a database engine, you can upgrade your DB instances to the new version. There are two kinds of upgrades for PostgreSQL DB instances: major version upgrades and minor version upgrades.

Major version upgrades can contain database changes that are not backward-compatible with existing applications. As a result, you must manually perform major version upgrades of your DB instances. You can initiate a major version upgrade by modifying your DB instance. However, before you perform a major version upgrade, we recommend that you follow the steps described in Major Version Upgrades for PostgreSQL (p. 1236).

In contrast, *minor version upgrades* include only changes that are backward-compatible with existing applications. You can initiate a minor version upgrade manually by modifying your DB instance. Or you can enable the **Auto minor version upgrade** option when creating or modifying a DB instance. Doing so means that your DB instance is automatically upgraded after Amazon RDS tests and approves the new version. For more details, see Automatic Minor Version Upgrades for PostgreSQL (p. 1240). For information about manually performing a minor version upgrade, see Manually Upgrading the Engine Version (p. 241).

If your PostgreSQL DB instance is using read replicas, you must upgrade all of the read replicas before upgrading the source instance. If your DB instance is in a Multi-AZ deployment, both the writer and standby replicas are upgraded. Your DB instance might not be available until the upgrade is complete.

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Overview of Upgrading PostgreSQL

To safely upgrade your DB instances, Amazon RDS uses the pg_upgrade utility described in the PostgreSQL documentation.

Amazon RDS takes two DB snapshots during the upgrade process if your backup retention period is greater than 0. The first DB snapshot is of the DB instance before any upgrade changes have been made. If the upgrade doesn't work for your databases, you can restore this snapshot to create a DB instance running the old version. The second DB snapshot is taken after the upgrade completes.

> **Note**
> Amazon RDS takes DB snapshots during the upgrade process only if you have set the backup retention period for your DB instance to a number greater than 0. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220).

If your DB instance is in a Multi-AZ deployment, both the primary writer DB instance and standby DB instances are upgraded. The writer and standby DB instances are upgraded at the same time. You experience an outage until the upgrade is complete.

After an upgrade is complete, you can't revert to the previous version of the database engine. If you want to return to the previous version, restore the DB snapshot that was taken before the upgrade to create a new DB instance.

Major Version Upgrades for PostgreSQL

Major version upgrades can contain database changes that are not backward-compatible with previous versions of the database. This functionality can cause your existing applications to stop working correctly.

As a result, Amazon RDS doesn't apply major version upgrades automatically. To perform a major version upgrade, you modify your DB instance manually. Make sure that you thoroughly test any upgrade to verify that your applications work correctly before applying the upgrade to your production DB instances. When you do a PostgreSQL major version upgrade, we recommend that you follow the steps described in How to Perform a Major Version Upgrade (p. 1237).

Choosing from Multiple Major Versions

You can upgrade a PostgreSQL database to its next major version. From some PostgreSQL database versions, you can skip to a higher major version when upgrading. The following table lists the source PostgreSQL database versions and the associated target major versions available for upgrading.

> **Note**
> Upgrade targets are enabled to a higher version released at the same time as the source minor version or later.
> If a database uses the `PostGIS` extension, you can't skip major versions for some source to target combinations. For these circumstances, upgrade in steps to the next major version one step at a time until you reach the desired target version.
> The `pgRouting` extension isn't supported for an upgrade that skips a major version to versions 11.x. A major version is skipped when the upgrade goes from versions 9.4.x, 9.5.x, or 9.6.x to versions 11.x. You can drop the `pgRouting` extension and then add it again after an upgrade.
> The `tsearch2` and `chkpass` extensions aren't supported in PostgreSQL 11 or later. If you are upgrading to version 11.x, drop these extensions before the upgrade.

Current Source Version	Major Version Targets	Additional Major Version Targets (Without PostGIS Extension)
9.3.x	9.4.x, 9.5.x	
9.3.23	9.4.x, 9.5.13	9.6.9
9.3.24	9.4.x, 9.5.14	9.6.10
9.3.25	9.4.x, 9.5.15	9.6.11
9.4.x	9.5.x	
9.4.20	9.5.x	11.1
9.4.21	9.5.x	10.7, 11.2
9.4.23	9.5.x	10.9, 11.4
9.4.24	9.5.x, 10.10, 11.5	
9.5.x	9.6.x	
9.5.15	9.6.x	11.1
9.5.16	9.6.x	10.7, 11.2
9.5.18	9.6.x	10.9, 11.4

Current Source Version	Major Version Targets	Additional Major Version Targets (Without PostGIS Extension)
9.5.19	9.6.x, 10.10, 11.5	
9.5.21	9.6.x, 10.12, 11.7, 12.2	
9.6.x	10.x	
9.6.11	10.x	11.1
9.6.12	10.x	11.2
9.6.14	10.x	11.4
9.6.15	10.x, 11.5	
9.6.17	10.x, 11.7, 12.2	
10.x	11.x	
10.12	11.x, 12.2	
11.x	12.x	

How to Perform a Major Version Upgrade

We recommend the following process when upgrading an Amazon RDS PostgreSQL DB instance:

1. **Have a version-compatible parameter group ready** – If you are using a custom parameter group, you have two options. You can specify a default parameter group for the new DB engine version. Or you can create your own custom parameter group for the new DB engine version.

   If you associate a new parameter group with a DB instance, reboot the database after the upgrade completes. If the instance needs to be rebooted to apply the parameter group changes, the instance's parameter group status shows `pending-reboot`. You can view an instance's parameter group status in the console or by using a describe command, such as `describe-db-instances`.
2. **Check for unsupported usage:**
   - **Prepared transactions** – Commit or roll back all open prepared transactions before attempting an upgrade.

     You can use the following query to verify that there are no open prepared transactions on your instance.

     ```
     SELECT count(*) FROM pg_catalog.pg_prepared_xacts;
     ```
   - **The line data type** – If you are upgrading an RDS PostgreSQL 9.3 instance, remove all uses of the `line` data type before attempting an upgrade. The `line` data type wasn't fully implemented in PostgreSQL until version 9.4.

     To verify that there are no uses of the `line` data type, use the following query on each database to be upgraded.

     ```
     SELECT count(*) FROM pg_catalog.pg_class c, pg_catalog.pg_namespace n,
      pg_catalog.pg_attribute a
     ```

```
 WHERE c.oid = a.attrelid
     AND NOT a.attisdropped
     AND a.atttypid = 'pg_catalog.line'::pg_catalog.regtype
     AND c.relnamespace = n.oid
     AND n.nspname !~ '^pg_temp_'
     AND n.nspname !~ '^pg_toast_temp_'
     AND n.nspname NOT IN ('pg_catalog', 'information_schema');
```

Note
To list all databases for an instance, use the following query.

```
SELECT d.datname FROM pg_catalog.pg_database d WHERE d.datallowconn = true;
```

- **Reg* data types** – Remove all uses of the *reg** data types before attempting an upgrade. Except for `regtype` and `regclass`, you can't upgrade the *reg** data types. The pg_upgrade utility can't persist this data type, which is used by Amazon RDS to do the upgrade.

  To verify that there are no uses of unsupported *reg** data types, use the following query for each database.

```
SELECT count(*) FROM pg_catalog.pg_class c, pg_catalog.pg_namespace n,
 pg_catalog.pg_attribute a
  WHERE c.oid = a.attrelid
      AND NOT a.attisdropped
      AND a.atttypid IN ('pg_catalog.regproc'::pg_catalog.regtype,
                         'pg_catalog.regprocedure'::pg_catalog.regtype,
                         'pg_catalog.regoper'::pg_catalog.regtype,
                         'pg_catalog.regoperator'::pg_catalog.regtype,
                         'pg_catalog.regconfig'::pg_catalog.regtype,
                         'pg_catalog.regdictionary'::pg_catalog.regtype)
      AND c.relnamespace = n.oid
      AND n.nspname NOT IN ('pg_catalog', 'information_schema');
```

3. **Handle read replicas** – A read replica can't undergo a major version upgrade but the read replica's source instance can. If a read replica's source instance undergoes a major version upgrade, all read replicas for that source instance remain with the previous engine version. In this case, the read replicas can no longer replicate changes performed on the source instance.

   We recommend that you either promote your read replicas, or delete and recreate them after the source instance has upgraded to a different major version. For more information, see Working with PostgreSQL Read Replicas in Amazon RDS (p. 1244).
4. **Perform a backup** – We recommend that you perform a backup before performing the major version upgrade so that you have a known restore point for your database. If your backup retention period is greater than 0, the upgrade process creates DB snapshots of your DB instance before and after upgrading. To change your backup retention period, see Modifying an Amazon RDS DB Instance (p. 220). To perform a backup manually, see Creating a DB Snapshot (p. 301).
5. **Upgrade certain extensions before the major version upgrade** – If you plan to skip a major version with the upgrade, you need to update certain extensions *before* performing the major version upgrade. Upgrading from versions 9.4.x, 9.5.x, or 9.6.x to versions 11.x skip a major version. The extensions to be updated include:
   - `address_standardizer`
   - `address_standardizer_data_us`
   - `postGIS`
   - `postgis_tiger_geocoder`
   - `postgis_topology`

Run the following command for each extension you are using.

```
ALTER EXTENSION PostgreSQL-extension UPDATE TO 'new-version'
```

For more information, see Upgrading PostgreSQL Extensions (p. 1241).

6. **Drop certain extensions before the major version upgrade** – An upgrade that skips a major version to version 11.x doesn't support updating the `pgRouting` extension. Upgrading from versions 9.4.x, 9.5.x, or 9.6.x to versions 11.x skip a major version. It's safe to drop the `pgRouting` extension and then reinstall it to a compatible version after the upgrade. For the extension versions you can update to, see PostgreSQL Extensions and Modules Supported on Amazon RDS (p. 1328).

   The `tsearch2` and `chkpass` extensions are no longer supported for PostgreSQL versions 11 or later. If you are upgrading to version 11.x, drop the `tsearch2`, and `chkpass` extensions before the upgrade.

7. **Perform an upgrade dry run** – We highly recommend testing a major version upgrade on a duplicate of your production database before attempting the upgrade on your production database. To create a duplicate test instance, you can either restore your database from a recent snapshot or do a point-in-time restore of your database to its latest restorable time. For more information, see Restoring from a Snapshot (p. 304) or Restoring a DB Instance to a Specified Time (p. 336). For details on performing the upgrade, see Manually Upgrading the Engine Version (p. 241).

   During the major version upgrade, the `public` and `template1` databases and the `public` schema in every database on the instance are temporarily renamed. These objects appear in the logs with their original name and a random string appended. The string is appended so that custom settings such as `locale` and `owner` are preserved during the major version upgrade. After the upgrade completes, the objects are renamed back to their original names.

   Note
   During the major version upgrade process, you can't do a point-in-time restore of your instance. After Amazon RDS performs the upgrade, it takes an automatic backup of the instance. You can perform a point-in-time restore to times before the upgrade began and after the automatic backup of your instance has completed.

8. **If an upgrade fails with precheck procedure errors, resolve the issues** – During the major version upgrade process, Amazon RDS for PostgreSQL first runs a precheck procedure to identify any issues that might cause the upgrade to fail. The precheck procedure checks all potential incompatible conditions across all databases in the instance.

   If the precheck encounters an issue, it creates a log event indicating the upgrade precheck failed. The precheck process details are in an upgrade log named `pg_upgrade_precheck.log` for all the databases of a DB instance. Amazon RDS appends a timestamp to the file name. For more information about viewing logs, see Amazon RDS Database Log Files (p. 453).

   Resolve all of the issues identified in the precheck log and then retry the major version upgrade. The following is an example of a precheck log.

```
------------------------------------------------------------------------
Upgrade could not be run on Wed Apr 4 18:30:52 2018
-------------------------------------------------------------------------
The instance could not be upgraded from 9.6.11 to 10.6 for the following reasons.
Please take appropriate action on databases that have usage incompatible with the
 requested major engine version upgrade and try the upgrade again.

* There are uncommitted prepared transactions. Please commit or rollback all prepared
 transactions.* One or more role names start with 'pg_'. Rename all role names that start
 with 'pg_'.
```

```
* The following issues in the database 'my"million$"db' need to be corrected before
 upgrading:** The ["line","reg*"] data types are used in user tables. Remove all usage of
 these data types.
** The database name contains characters that are not supported by RDS PostgreSQL. Rename
 the database.
** The database has extensions installed that are not supported on the target database
 version. Drop the following extensions from your database: ["tsearch2"].

* The following issues in the database 'mydb' need to be corrected before upgrading:**
 The database has views or materialized views that depend on 'pg_stat_activity'. Drop the
 views.
```

9. **Upgrade your production instance** – When the dry-run major version upgrade is successful, you should be able to upgrade your production database with confidence. For more information, see Manually Upgrading the Engine Version (p. 241).

After the major version upgrade is complete, we recommend the following:

- Run the `ANALYZE` operation to refresh the `pg_statistic` table.
- A PostgreSQL upgrade doesn't upgrade any PostgreSQL extensions. To upgrade extensions, see Upgrading PostgreSQL Extensions (p. 1241).
- Optionally, use Amazon RDS to view two logs that the pg_upgrade utility produces. These are `pg_upgrade_internal.log` and `pg_upgrade_server.log`. Amazon RDS appends a timestamp to the file name for these logs. You can view these logs as you can any other log. For more information, see Amazon RDS Database Log Files (p. 453).

  You can also upload the upgrade logs to Amazon CloudWatch Logs. For more information, see Publishing PostgreSQL Logs to CloudWatch Logs (p. 483).
- To verify that everything works as expected, test your application on the upgraded database with a similar workload. After the upgrade is verified, you can delete this test instance.

Automatic Minor Version Upgrades for PostgreSQL

If you enable the **Auto minor version upgrade** option when creating or modifying a DB instance, you can have your DB instance automatically upgraded.

For each RDS for PostgreSQL major version, one minor version is designated by RDS as the automatic upgrade version. After a minor version has been tested and approved by Amazon RDS, the minor version upgrade occurs automatically during your maintenance window. RDS doesn't automatically set newer released minor versions as the automatic upgrade version. Before RDS designates a newer automatic upgrade version, several criteria are considered, such as the following:

- Known security issues
- Bugs in the PostgreSQL community version
- Overall fleet stability since the minor version was released

You can use the following AWS CLI command and script to determine the current automatic upgrade minor versions.

```
aws rds describe-db-engine-versions --engine postgres | grep -A 1 AutoUpgrade| grep -A 2
 true |grep PostgreSQL | sort --unique | sed -e 's/"Description": "//g'
```

A PostgreSQL DB instance is automatically upgraded during your maintenance window if the following criteria are met:

- The DB instance has the **Auto minor version upgrade** option enabled.
- The DB instance is running a minor DB engine version that is less than the current automatic upgrade minor version.

For more information, see Automatically Upgrading the Minor Engine Version (p. 242).

> **Note**
> A PostgreSQL upgrade doesn't upgrade any PostgreSQL extensions. To upgrade extensions, see Upgrading PostgreSQL Extensions (p. 1241).

Upgrading PostgreSQL Extensions

A PostgreSQL engine upgrade doesn't upgrade any PostgreSQL extensions. To update an extension after a minor version upgrade, use the `ALTER EXTENSION UPDATE` command.

> **Note**
> If you are running the `PostGIS` extension in your Amazon RDS PostgreSQL DB instance, make sure that you follow the PostGIS upgrade instructions in the PostGIS documentation before you update the extension.

To upgrade an extension, use the following command.

```
ALTER EXTENSION extension_name UPDATE TO 'new_version'
```

For the list of supported versions of PostgreSQL extensions, see PostgreSQL Extensions and Modules Supported on Amazon RDS (p. 1328).

To list your currently installed extensions, use the PostgreSQL pg_extension catalog in the following command.

```
SELECT * FROM pg_extension;
```

To view a list of the specific extension versions that are available for your installation, use the PostgreSQL pg_available_extension_versions view in the following command.

```
SELECT * FROM pg_available_extension_versions;
```

Upgrading a PostgreSQL DB Snapshot

With Amazon RDS, you can create a storage volume DB snapshot of your PostgreSQL DB instance. When you create a DB snapshot, the snapshot is based on the engine version used by your Amazon RDS instance. In addition to upgrading the DB engine version of your DB instance, you can also upgrade the engine version for your DB snapshots.

After restoring a DB snapshot upgraded to a new engine version, make sure to test that the upgrade was successful. For more information about a major version upgrade, see Upgrading the PostgreSQL DB Engine for Amazon RDS (p. 1235). To learn how to restore a DB snapshot, see Restoring from a DB Snapshot (p. 303).

You can upgrade manual DB snapshots that are either encrypted or not encrypted.

For the list of engine versions that are available for upgrading a DB snapshot, see Upgrading the PostgreSQL DB Engine for Amazon RDS.

Note

- The DB snapshot must be from the same AWS Region as the account.
- You can't upgrade DB snapshots that are copied within region, copied across regions, or shared across accounts.
- You can't upgrade automated DB snapshots that are created during the automated backup process.

Console

To upgrade a DB snapshot

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the snapshot that you want to upgrade.
4. For **Actions**, choose **Upgrade snapshot**. The **Upgrade snapshot** page appears.
5. Choose the **New engine version** to upgrade to.
6. Choose **Save changes** to upgrade the snapshot.

   During the upgrade process, all snapshot actions are disabled for this DB snapshot. Also, the DB snapshot status changes from **available** to **upgrading**, and then changes to **active** upon completion. If the DB snapshot can't be upgraded because of snapshot corruption issues, the status changes to **unavailable**. You can't recover the snapshot from this state.

   Note
   If the DB snapshot upgrade fails, the snapshot is rolled back to the original state with the original version.

AWS CLI

To upgrade a DB snapshot to a new database engine version, use the AWS CLI modify-db-snapshot command.

Parameters

- `--db-snapshot-identifier` – The identifier of the DB snapshot to upgrade. The identifier must be a unique Amazon Resource Name (ARN). For more information, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).
- `--engine-version` – The engine version to upgrade the DB snapshot to.

Example

For Linux, macOS, or Unix:

```
aws rds modify-db-snapshot \
    --db-snapshot-identifier my_db_snapshot \
    --engine-version new_version
```

For Windows:

```
aws rds modify-db-snapshot ^
    --db-snapshot-identifier my_db_snapshot ^
    --engine-version new_version
```

RDS API

To upgrade a DB snapshot to a new database engine version, call the Amazon RDS API ModifyDBSnapshot operation.

- `DBSnapshotIdentifier` – The identifier of the DB snapshot to upgrade. The identifier must be a unique Amazon Resource Name (ARN). For more information, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).
- `EngineVersion` – The engine version to upgrade the DB snapshot to.

Example

```
https://rds.us-west-2.amazonaws.com/
   ?Action=ModifyDBSnapshot
   &DBSnapshotIdentifier=mydbsnapshot
   &EngineVersion=newversion
   &SignatureVersion=4
   &Version=2014-10-31
   &X-Amz-Algorithm=AWS4-HMAC-SHA256
   &X-Amz-Credential=AKIADQKE4SARGYLE/20161222/us-west-1/rds/aws4_request
   &X-Amz-Date=20161222T233051Z
   &X-Amz-SignedHeaders=content-type;host;user-agent;x-amz-content-sha256;x-amz-date
   &X-Amz-Signature=8052a76dfb18469393c5f0182cdab0ebc224a9c7c5c949155376c1c250fc7ec3
```

Working with PostgreSQL Read Replicas in Amazon RDS

You usually use read replicas to configure replication between Amazon RDS DB instances. For general information about read replicas, see Working with Read Replicas (p. 250).

This section contains specific information about working with read replicas on PostgreSQL.

Topics

Read Replica Configuration with PostgreSQL

Amazon RDS PostgreSQL uses PostgreSQL native streaming replication to create a read-only copy of a source (a "master" in PostgreSQL terms) DB instance. This read replica (a "standby" in PostgreSQL terms) DB instance is an asynchronously created physical replication of the master DB instance. It's created by a special connection that transmits write ahead log (WAL) data between the source DB instance and the read replica where PostgreSQL asynchronously streams database changes as they are made.

PostgreSQL uses a "replication" role to perform streaming replication. The role is privileged, but can't be used to modify any data. PostgreSQL uses a single process for handling replication.

Before a DB instance can serve as a source DB instance, you must enable automatic backups on the source DB instance by setting the backup retention period to a value other than 0.

Creating a PostgreSQL read replica doesn't require an outage for the master DB instance. Amazon RDS sets the necessary parameters and permissions for the source DB instance and the read replica without any service interruption. A snapshot is taken of the source DB instance, and this snapshot becomes the read replica. No outage occurs when you delete a read replica.

You can create up to five read replicas from one source DB instance. For replication to operate effectively, each read replica should have the same amount of compute and storage resources as the source DB instance. If you scale the source DB instance, also scale the read replicas.

Amazon RDS overrides any incompatible parameters on a read replica if it prevents the read replica from starting. For example, suppose that the `max_connections` parameter value is higher on the source DB instance than on the read replica. In that case, Amazon RDS updates the parameter on the read replica to be the same value as that on the source DB instance.

PostgreSQL DB instances use a secure connection that you can encrypt by setting the `ssl` parameter to `1` for both the source and the read replica instances.

You can create a read replica from either single-AZ or Multi-AZ DB instance deployments. You use Multi-AZ deployments to improve the durability and availability of critical data, but you can't use the Multi-AZ secondary to serve read-only queries. Instead, you can create read replicas from high-traffic Multi-AZ DB instances to offload read-only queries. If the source instance of a Multi-AZ deployment fails over to the secondary, any associated read replicas automatically switch to use the secondary (now primary) as their replication source. For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

You can create a read replica as a Multi-AZ DB instance. Amazon RDS creates a standby of your replica in another Availability Zone for failover support for the replica. Creating your read replica as a Multi-AZ DB instance is independent of whether the source database is a Multi-AZ DB instance.

If you use the postgres_fdw extension to access data from a remote server, the read replica will also have access to the remote server. For more information about using `postgres_fdw`, see Accessing External Data with the postgres_fdw Extension (p. 1293).

Monitoring PostgreSQL Read Replicas

For PostgreSQL read replicas, you can monitor replication lag in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric. The `ReplicaLag` metric reports the value of `SELECT extract(epoch from now() - pg_last_xact_replay_timestamp()) AS slave_lag`.

Read Replica Limitations with PostgreSQL

The following are limitations for PostgreSQL read replicas:

- Each PostgreSQL read replicas is read-only and can't be made a writable read replica.
- You can't create a read replica from another read replica (that is, you can't create cascading read replicas).
- You can promote a PostgreSQL read replica to be a new source DB instance. However, the read replica doesn't become the new source DB instance automatically. The read replica, when promoted, stops receiving WAL communications and is no longer a read-only instance. You must set up any replication you intend to have going forward because the promoted read replica is now a new source DB instance.
- A PostgreSQL read replica reports a replication lag of up to five minutes if there are no user transactions occurring on the source DB instance.

Replication Interruptions with PostgreSQL Read Replicas

In several situations, a PostgreSQL source DB instance can unintentionally break replication with a read replica. These situations include the following:

- The `max_wal_senders` parameter is set too low to provide enough data to the number of read replicas. This situation causes replication to stop.
- The PostgreSQL parameter `wal_keep_segments` dictates how many WAL files are kept to provide data to the read replicas. The parameter value specifies the number of logs to keep. If you set the parameter value too low, you can cause a read replica to fall so far behind that streaming replication stops. In this case, Amazon RDS reports a replication error and begins recovery on the read replica by replaying the source DB instance's archived WAL logs. This recovery process continues until the read replica has caught up enough to continue streaming replication. For more information, see Troubleshooting a PostgreSQL Read Replica Problem (p. 1245).
- A PostgreSQL read replica requires a reboot if the source DB instance endpoint changes.

When the WAL stream that provides data to a read replica is broken, PostgreSQL switches into recovery mode to restore the read replica by using archived WAL files. When this process is complete, PostgreSQL attempts to re-establish streaming replication.

Troubleshooting a PostgreSQL Read Replica Problem

PostgreSQL uses replication slots for cross-Region replication, so the process for troubleshooting same-region replication problems and cross-Region replication problems is different.

Troubleshooting PostgreSQL Read Replica Problems Within an AWS Region

The PostgreSQL parameter, `wal_keep_segments`, dictates how many write ahead log (WAL) files are kept to provide data to the read replicas. The parameter value specifies the number of logs to keep. If you set the parameter value too low, you can cause a read replica to fall so far behind that streaming replication stops. In this case, Amazon RDS reports a replication error and begins recovery on the read replica by replaying the source DB instance's archived WAL logs. This recovery process continues until the read replica has caught up enough to continue streaming replication.

The PostgreSQL log on the read replica shows when Amazon RDS is recovering a read replica that is this state by replaying archived WAL files.

```
 2014-11-07 19:01:10 UTC::@:[23180]:DEBUG:  switched WAL source from archive to stream
after
     failure 2014-11-07 19:01:10 UTC::@:[11575]:LOG:  started streaming WAL from primary
at
     1A/D3000000 on timeline 1 2014-11-07 19:01:10 UTC::@:[11575]:FATAL:  could not
receive
     data from WAL stream: ERROR:  requested WAL segment 000000010000001A000000D3 has
already been
     removed 2014-11-07 19:01:10 UTC::@:[23180]:DEBUG:  could not restore file
     "00000002.history" from archive: return code 0 2014-11-07 19:01:15
     UTC::@:[23180]:DEBUG:  switched WAL source from stream to archive after failure
     recovering 000000010000001A000000D3 2014-11-07 19:01:16 UTC::@:[23180]:LOG:  restored
log file "000000010000001A000000D3"
       from archive
```

After a certain amount of time, Amazon RDS replays enough archived WAL files on the replica to catch up and allow the read replica to begin streaming again. At this point, PostgreSQL resumes streaming and writes a similar line to the following to the log file.

```
 2014-11-07 19:41:36 UTC::@:[24714]:LOG:  started streaming WAL from primary at 1B/
B6000000
      on timeline 1
```

You can determine how many WAL files you should keep by looking at the checkpoint information in the log. The PostgreSQL log shows the following information at each checkpoint. By looking at the "# recycled" transaction log files of these log statements, you can understand how many transaction files will be recycled during a time range and use this information to tune the `wal_keep_segments` parameter.

```
 2014-11-07 19:59:35 UTC::@:[26820]:LOG:  checkpoint complete: wrote 376 buffers (0.2%); 0
     transaction log file(s) added, 0 removed, 1 recycled; write=35.681 s, sync=0.013 s,
     total=35.703 s; sync files=10, longest=0.013 s, average=0.001 s
```

For example, suppose that the PostgreSQL log shows that 35 files are recycled from the "checkpoint completed" log statements within a 5-minute time frame. In that case, we know that with this usage pattern a read replica relies on 35 transaction files in five minutes. A read replica can't survive five minutes in a nonstreaming state if the source DB instance is set to the default `wal_keep_segments` parameter value of 32.

Troubleshooting PostgreSQL Read Replica Problems Across AWS Regions

PostgreSQL (versions 9.4.7 and 9.5.2 exclusively) uses physical replication slots to manage write ahead log (WAL) retention on the source DB instance. For each cross-Region read replica instance, Amazon

RDS creates and associates a physical replication slot. You can use two Amazon CloudWatch metrics, `Oldest Replication Slot Lag` and `Transaction Logs Disk Usage`, to see how far behind the most lagging replica is in terms of WAL data received and to see how much storage is being used for WAL data. The `Transaction Logs Disk Usage` value can substantially increase when a cross-Region read replica is lagging significantly.

If the workload on your DB instance generates a large amount of WAL data, you might need to change the DB instance class of your source DB instance and read replica. In that case, you change it to one with high (10 Gbps) network performance for the replica to keep up. The Amazon CloudWatch metric `Transaction Logs Generation` can help you understand the rate at which your workload is generating WAL data.

To determine the status of a cross-Region read replica, you can query `pg_replication_slots` on the source instance, as in the following example:

```
postgres=# select * from pg_replication_slots;

                  slot_name                  | plugin | slot_type | datoid | database |
 active | active_pid | xmin | catalog_xmin | restart_lsn
------------------------------------------------------------------------------------------
 rds_us_east_1_db_uzwlholddgpblksce6hgw4nkte |        | physical  |        |          | t
    |      12598 |      |              | 4E/95000060
(1 row)
```

Importing Data into PostgreSQL on Amazon RDS

Suppose that you have an existing PostgreSQL deployment that you want to move to Amazon RDS. The complexity of your task depends on the size of your database and the types of database objects that you're transferring. For example, consider a database that contains datasets on the order of gigabytes, along with stored procedures and triggers. Such a database is going to be more complicated than a simple database with only a few megabytes of test data and no triggers or stored procedures.

We recommend that you use native PostgreSQL database migration tools under the following conditions:

- You have a homogeneous migration, where you are migrating from a database with the same database engine as the target database.
- You are migrating an entire database.
- The native tools allow you to migrate your system with minimal downtime.

In most other cases, performing a database migration using AWS Database Migration Service (AWS DMS) is the best approach. AWS DMS can migrate databases without downtime and, for many database engines, continue ongoing replication until you are ready to switch over to the target database. You can migrate to either the same database engine or a different database engine using AWS DMS. If you are migrating to a different database engine than your source database, you can use the AWS Schema Conversion Tool (AWS SCT). You use AWS SCT to migrate schema objects that are not migrated by AWS DMS. For more information about AWS DMS, see What Is AWS Database Migration Service?

Modify your DB parameter group to include the following settings *for your import only*. You should test the parameter settings to find the most efficient settings for your DB instance size. You also need to revert back to production values for these parameters after your import completes.

Modify your DB instance settings to the following:

- Disable DB instance backups (set backup_retention to 0).
- Disable Multi-AZ.

Modify your DB parameter group to include the following settings. You should only use these settings when importing data. You should test the parameter settings to find the most efficient settings for your DB instance size. You also need to revert back to production values for these parameters after your import completes.

Parameter	Recommended Value When Importing	Description
`maintenance_work_mem`	524288, 1048576, 2097152 or 4194304 (in KB). These settings are comparable to 512 MB, 1 GB, 2 GB, and 4 GB.	The value for this setting depends on the size of your host. This parameter is used during CREATE INDEX statements and each parallel command can use this much memory. Calculate the best value so that you don't set this value so high that you run out of memory.
`checkpoint_segments`	256	The value for this setting consumes more disk space, but gives you less contention on your WAL logs. For PostgreSQL versions 9.5.x and 9.6.x, this value would be `max_wal_size`.
`checkpoint_timeout`	1800	The value for this setting allows for less frequent WAL rotation.

Parameter	Recommended Value When Importing	Description
`synchronous_commit`	Off	Disable this setting to speed up writes. Turning this parameter off can increase the risk of data loss in the event of a server crash (do not turn off FSYNC)
`wal_buffers`	8192	This is value is in 8 KB units. This again helps your WAL generation speed
`autovacuum`	Off	Disable the PostgreSQL auto vacuum parameter while you are loading data so that it doesn't use resources

Use the `pg_dump -Fc` (compressed) or `pg_restore -j` (parallel) commands with these settings.

Note
The PostgreSQL command `pg_dumpall` requires super_user permissions that are not granted when you create a DB instance, so it cannot be used for importing data.

Topics

Importing a PostgreSQL Database from an Amazon EC2 Instance

If you have data in a PostgreSQL server on an Amazon EC2 instance and want to move it to a PostgreSQL DB instance, you can use the following process. The following list shows the steps to take. Each step is discussed in more detail in the following sections.

1. Create a file using pg_dump that contains the data to be loaded
2. Create the target DB instance
3. Use *psql* to create the database on the DB instance and load the data
4. Create a DB snapshot of the DB instance

Step 1: Create a File Using pg_dump That Contains the Data to Load

The `pg_dump` utility uses the COPY command to create a schema and data dump of a PostgreSQL database. The dump script generated by `pg_dump` loads data into a database with the same name and recreates the tables, indexes, and foreign keys. You can use the `pg_restore` command and the `-d` parameter to restore the data to a database with a different name.

Before you create the data dump, you should query the tables to be dumped to get a row count so you can confirm the count on the target DB instance.

The following command creates a dump file called mydb2dump.sql for a database called mydb2.

```
prompt>pg_dump dbname=mydb2 -f mydb2dump.sql
```

Step 2: Create the Target DB Instance

Create the target PostgreSQL DB instance using either the Amazon RDS console, AWS CLI, or API. Create the instance with the backup retention setting set to 0 and disable Multi-AZ. Doing so allows faster data import. You must create a database on the instance before you can dump the data. The database can have the same name as the database that is contained the dumped data. Alternatively, you can create a database with a different name. In this case, you use the `pg_restore` command and the `-d` parameter to restore the data into the newly named database.

For example, the following commands can be used to dump, restore, and rename a database.

```
pg_dump -Fc -v -h [endpoint of instance] -U [master username] [database] > [database].dump
createdb [new database name]
pg_restore -v -h [endpoint of instance] -U [master username] -d [new database
 name] [database].dump
```

Step 3: Use psql to Create the Database on the DB Instance and Load Data

You can use the same connection you used to execute the pg_dump command to connect to the target DB instance and recreate the database. Using *psql*, you can use the master user name and master password to create the database on the DB instance

The following example uses *psql* and a dump file named mydb2dump.sql to create a database called mydb2 on a PostgreSQL DB instance called mypginstance:

For Linux, macOS, or Unix:

```
psql \
   -f mydb2dump.sql \
   --host mypginstance.c6c8mntzhgv0.us-west-2.rds.amazonaws.com \
   --port 8199 \
   --username myawsuser \
   --password password \
   --dbname mydb2
```

For Windows:

```
psql ^
   -f mydb2dump.sql ^
   --host mypginstance.c6c8mntzhgv0.us-west-2.rds.amazonaws.com ^
   --port 8199 ^
   --username myawsuser ^
   --password password ^
   --dbname mydb2
```

Step 4: Create a DB Snapshot of the DB Instance

Once you have verified that the data was loaded into your DB instance, we recommend that you create a DB snapshot of the target PostgreSQL DB instance. DB snapshots are complete backups of your DB instance that can be used to restore your DB instance to a known state. A DB snapshot taken immediately after the load protects you from having to load the data again in case of a mishap. You can also use such a snapshot to seed new DB instances. For information about creating a DB snapshot, see Creating a DB Snapshot (p. 301).

Using the \copy Command to Import Data to a Table on a PostgreSQL DB Instance

You can run the `\copy` command from the *psql* prompt to import data into a table on a PostgreSQL DB instance. The table must already exist on the DB instance. For more information on the \copy command, see the PostgreSQL documentation.

> **Note**
> The `\copy` command doesn't provide confirmation of actions, such as a count of rows inserted. PostgreSQL does provide error messages if the copy command fails due to an error.

Create a .csv file from the data in the source table, log on to the target database on the PostgreSQL instance using *psql*, and then run the following command. This example uses *source-table* as the source table name, *source-table.csv* as the .csv file, and *target-db* as the target database:

```
target-db=> \copy source-table from 'source-table.csv' with DELIMITER ',';
```

You can also run the following command from your client computer command prompt. This example uses *source-table* as the source table name, *source-table.csv* as the .csv file, and *target-db* as the target database:

For Linux, macOS, or Unix:

```
$psql target-db \
    -U <admin user> \
    -p <port> \
    -h <DB instance name> \
    -c "\copy source-table from 'source-table.csv' with DELIMITER ','"
```

For Windows:

```
$psql target-db ^
    -U <admin user> ^
    -p <port> ^
    -h <DB instance name> ^
    -c "\copy source-table from 'source-table.csv' with DELIMITER ','"
```

Importing Amazon S3 Data into an RDS for PostgreSQL DB Instance

You can import data from Amazon S3 into a table belonging to an RDS for PostgreSQL DB instance. To do this, you use the `aws_s3` PostgreSQL extension that Amazon RDS provides.

> **Note**
> To import from Amazon S3 into RDS for PostgreSQL, your database must be running PostgreSQL version 10.7 or later.

For more information on storing data with Amazon S3, see Create a Bucket in the *Amazon Simple Storage Service Getting Started Guide*. For instructions on how to upload a file to an Amazon S3 bucket, see Add an Object to a Bucket in the *Amazon Simple Storage Service Getting Started Guide*.

Topics

- Function Reference (p. 1259)

Overview of Importing Amazon S3 Data

To import data stored in an Amazon S3 bucket to a PostgreSQL database table, follow these steps.

To import S3 data into Amazon RDS

1. Install the required PostgreSQL extensions. These include the `aws_s3` and `aws_commons` extensions. To do so, start psql and use the following command.

   ```
   psql=> CREATE EXTENSION aws_s3 CASCADE;
   NOTICE: installing required extension "aws_commons"
   ```

   The `aws_s3` extension provides the aws_s3.table_import_from_s3 (p. 1259) function that you use to import Amazon S3 data. The `aws_commons` extension provides additional helper functions.
2. Identify the database table and Amazon S3 file to use.

   The aws_s3.table_import_from_s3 (p. 1259) function requires the name of the PostgreSQL database table that you want to import data into. The function also requires that you identify the Amazon S3 file to import. To provide this information, take the following steps.

   a. Identify the PostgreSQL database table to put the data in. For example, the following is a sample `t1` database table used in the examples for this topic.

      ```
      psql=> CREATE TABLE t1 (col1 varchar(80), col2 varchar(80), col3 varchar(80));
      ```

   b. Get the following information to identify the Amazon S3 file that you want to import:

      - Bucket name – A *bucket* is a container for Amazon S3 objects or files.
      - File path – The file path locates the file in the Amazon S3 bucket.
      - AWS Region – The AWS Region is the location of the Amazon S3 bucket. For example, if the S3 bucket is in the US East (N. Virginia) Region, use `us-east-1`. For a listing of AWS Region names and associated values, see Regions, Availability Zones, and Local Zones (p. 37).

      To find how to get this information, see View an Object in the *Amazon Simple Storage Service Getting Started Guide*. You can confirm the information by using the AWS CLI command `aws s3 cp`. If the information is correct, this command downloads a copy of the Amazon S3 file.

      ```
      aws s3 cp s3://sample_s3_bucket/sample_file_path ./
      ```

   c. Use the aws_commons.create_s3_uri (p. 1261) function to create an `aws_commons._s3_uri_1` structure to hold the Amazon S3 file information. You provide this `aws_commons._s3_uri_1` structure as a parameter in the call to the aws_s3.table_import_from_s3 (p. 1259) function.

      For a psql example, see the following.

      ```
      psql=> SELECT aws_commons.create_s3_uri(
         'sample_s3_bucket',
         'sample.csv',
         'us-east-1'
      ) AS s3_uri \gset
      ```

3. Provide permission to access the Amazon S3 file.

To import data from an Amazon S3 file, give the RDS for PostgreSQL DB instance permission to access the Amazon S3 bucket the file is in. To do this, you use either an AWS Identity and Access Management (IAM) role or security credentials. For more information, see Setting Up Access to an Amazon S3 Bucket (p. 1253).

4. Import the Amazon S3 data by calling the `aws_s3.table_import_from_s3` function.

   After you complete the previous preparation tasks, use the aws_s3.table_import_from_s3 (p. 1259) function to import the Amazon S3 data. For more information, see Using the aws_s3.table_import_from_s3 Function to Import Amazon S3 Data (p. 1257).

Setting Up Access to an Amazon S3 Bucket

To import data from an Amazon S3 file, give the RDS for PostgreSQL DB instance permission to access the Amazon S3 bucket the file is in. You provide access to an Amazon S3 bucket in one of two ways, as described in the following topics.

Topics

Using an IAM Role to Access an Amazon S3 Bucket

Before you load data from an Amazon S3 file, give your RDS for PostgreSQL DB instance permission to access the Amazon S3 bucket the file is in. This way, you don't have to manage additional credential information or provide it in the aws_s3.table_import_from_s3 (p. 1259) function call.

To do this, create an IAM policy that provides access to the Amazon S3 bucket. Create an IAM role and attach the policy to the role. Then assign the IAM role to your DB instance.

To give an RDS for PostgreSQL DB instance access to Amazon S3 through an IAM role

1. Create an IAM policy. This policy provides the bucket and object permissions that allow your RDS for PostgreSQL DB instance to access Amazon S3.

   Include in the policy the following required actions to allow the transfer of files from an Amazon S3 bucket to Amazon RDS:

   - `s3:GetObject`
   - `s3:ListBucket`

   Include in the policy the following resources to identify the Amazon S3 bucket and objects in the bucket. This shows the Amazon Resource Name (ARN) format for accessing Amazon S3.

   - arn:aws:s3:::*your-s3-bucket*
   - arn:aws:s3:::*your-s3-bucket*/*

   For more information on creating an IAM policy for Amazon RDS for PostgreSQL, see Creating and Using an IAM Policy for IAM Database Access (p. 1390). See also Tutorial: Create and Attach Your First Customer Managed Policy in the *IAM User Guide*.

   The following AWS CLI command creates an IAM policy named `rds-s3-import-policy` with these options. It grants access to a bucket named `your-s3-bucket`.

> **Note**
> After you create the policy, note the Amazon Resource Name (ARN) of the policy. You need the ARN for a subsequent step when you attach the policy to an IAM role.

Example

For Linux, macOS, or Unix:

```
aws iam create-policy \
   --policy-name rds-s3-import-policy \
   --policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Sid": "s3import",
         "Action": [
           "s3:GetObject",
           "s3:ListBucket"
         ],
         "Effect": "Allow",
         "Resource": [
           "arn:aws:s3:::your-s3-bucket",
           "arn:aws:s3:::your-s3-bucket/*"
         ]
       }
     ]
   }'
```

For Windows:

```
aws iam create-policy ^
   --policy-name rds-s3-import-policy ^
   --policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Sid": "s3import",
         "Action": [
           "s3:GetObject",
           "s3:ListBucket"
         ],
         "Effect": "Allow",
         "Resource": [
           "arn:aws:s3:::your-s3-bucket",
           "arn:aws:s3:::your-s3-bucket/*"
         ]
       }
     ]
   }'
```

2. Create an IAM role. You do this so Amazon RDS can assume this IAM role on your behalf to access your Amazon S3 buckets. For more information, see Creating a Role to Delegate Permissions to an IAM User in the *IAM User Guide*.

   The following example shows using the AWS CLI command to create a role named `rds-s3-import-role`.

   Example

   For Linux, macOS, or Unix:

```
aws iam create-role \
   --role-name rds-s3-import-role \
   --assume-role-policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Principal": {
            "Service": "rds.amazonaws.com"
          },
         "Action": "sts:AssumeRole"
       }
     ]
   }'
```

For Windows:

```
aws iam create-role ^
   --role-name rds-s3-import-role ^
   --assume-role-policy-document '{
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Principal": {
            "Service": "rds.amazonaws.com"
          },
         "Action": "sts:AssumeRole"
       }
     ]
   }'
```

3. Attach the IAM policy that you created to the IAM role that you created.

   The following AWS CLI command attaches the policy created earlier to the role named `rds-s3-import-role` Replace *`your-policy-arn`* with the policy ARN that you noted in an earlier step.

   Example

   For Linux, macOS, or Unix:

```
aws iam attach-role-policy \
   --policy-arn your-policy-arn \
   --role-name rds-s3-import-role
```

   For Windows:

```
aws iam attach-role-policy ^
   --policy-arn your-policy-arn ^
   --role-name rds-s3-import-role
```

4. Add the IAM role to the DB instance. You do so by using the AWS Management Console or AWS CLI, as described following.

Console

To add an IAM role for a PostgreSQL DB instance using the console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose the PostgreSQL DB instance name to display its details.
3. On the **Connectivity & security** tab, in the **Manage IAM roles** section, choose the role to add under **Add IAM roles to this instance**.
4. Under **Feature**, choose **s3Import**.
5. Choose **Add role**.

AWS CLI

To add an IAM role for a PostgreSQL DB instance using the CLI

- Use the following command to add the role to the PostgreSQL DB instance named `my-db-instance`. Replace *`your-role-arn`* with the role ARN that you noted in a previous step. Use `s3Import` for the value of the `--feature-name` option.

  Example

  For Linux, macOS, or Unix:

  ```
  aws rds add-role-to-db-instance \
     --db-instance-identifier my-db-instance \
     --feature-name s3Import \
     --role-arn your-role-arn   \
     --region your-region
  ```

  For Windows:

  ```
  aws rds add-role-to-db-instance ^
     --db-instance-identifier my-dbi-nstance ^
     --feature-name s3Import ^
     --role-arn your-role-arn ^
     --region your-region
  ```

Using Security Credentials to Access an Amazon S3 Bucket

If you prefer, you can use security credentials to provide access to an Amazon S3 bucket instead of providing access with an IAM role. To do this, use the `credentials` parameter in the aws_s3.table_import_from_s3 (p. 1259) function call.

The `credentials` parameter is a structure of type `aws_commons._aws_credentials_1`, which contains AWS credentials. Use the aws_commons.create_aws_credentials (p. 1262) function to set the access key and secret key in an `aws_commons._aws_credentials_1` structure, as shown following.

```
psql=> SELECT aws_commons.create_aws_credentials(
   'sample_access_key', 'sample_secret_key', '')
AS creds \gset
```

After creating the `aws_commons._aws_credentials_1` structure, use the aws_s3.table_import_from_s3 (p. 1259) function with the `credentials` parameter to import the data, as shown following.

```
psql=> SELECT aws_s3.table_import_from_s3(
   't', '', '(format csv)',
   :'s3_uri',
   :'creds'
);
```

Or you can include the aws_commons.create_aws_credentials (p. 1262) function call inline within the `aws_s3.table_import_from_s3` function call.

```
psql=> SELECT aws_s3.table_import_from_s3(
   't', '', '(format csv)',
   :'s3_uri',
   aws_commons.create_aws_credentials('sample_access_key', 'sample_secret_key', '')
);
```

Troubleshooting Access to Amazon S3

If you encounter connection problems when attempting to import Amazon S3 file data, see the following for recommendations:

- Troubleshooting Amazon RDS Identity and Access (p. 1407)
- Troubleshooting Amazon S3
- Troubleshooting Amazon S3 and IAM

Using the aws_s3.table_import_from_s3 Function to Import Amazon S3 Data

Import your Amazon S3 data by calling the aws_s3.table_import_from_s3 (p. 1259) function.

> **Note**
> The following examples use the IAM role method for providing access to the Amazon S3 bucket. Thus, there are no credential parameters in the `aws_s3.table_import_from_s3` function calls.

The following shows a typical PostgreSQL example using psql.

```
psql=> SELECT aws_s3.table_import_from_s3(
   't1',
   '',
   '(format csv)',
   :'s3_uri'
);
```

The parameters are the following:

- `t1` – The name for the table in the PostgreSQL DB instance to copy the data into.
- `''` – An optional list of columns in the database table. You can use this parameter to indicate which columns of the S3 data go in which table columns. If no columns are specified, all the columns are copied to the table. For an example of using a column list, see Importing an Amazon S3 File That Uses a Custom Delimiter (p. 1258).
- `(format csv)` – PostgreSQL COPY arguments. The copy process uses the arguments and format of the PostgreSQL COPY command. In the preceding example, the `COPY` command uses the comma-separated value (CSV) file format to copy the data.
- `s3_uri` – A structure that contains the information identifying the Amazon S3 file. For an example of using the aws_commons.create_s3_uri (p. 1261) function to create an `s3_uri` structure, see Overview of Importing Amazon S3 Data (p. 1252).

For the full reference of this function, see aws_s3.table_import_from_s3 (p. 1259).

The following examples show how to specify different kinds of files when importing Amazon S3 data.

Topics

Importing an Amazon S3 File That Uses a Custom Delimiter

The following example shows how to import a file that uses a custom delimiter. It also shows how to control where to put the data in the database table using the `column_list` parameter of the aws_s3.table_import_from_s3 (p. 1259) function.

For this example, assume that the following information is organized into pipe-delimited columns in the Amazon S3 file.

```
1|foo1|bar1|elephant1
2|foo2|bar2|elephant2
3|foo3|bar3|elephant3
4|foo4|bar4|elephant4
...
```

To import a file that uses a custom delimiter

1. Create a table in the database for the imported data.

```
psql=> CREATE TABLE test (a text, b text, c text, d text, e text);
CREATE TABLE
```

2. Use the following form of the aws_s3.table_import_from_s3 (p. 1259) function to import data from the Amazon S3 file.

   You can include the aws_commons.create_s3_uri (p. 1261) function call inline within the `aws_s3.table_import_from_s3` function call to specify the file.

```
psql=> SELECT aws_s3.table_import_from_s3(
   'test',
   'a,b,d,e',
   'DELIMITER ''|''',
   aws_commons.create_s3_uri('sampleBucket', 'pipeDelimitedSampleFile', 'us-east-2')
);
```

The data is now in the table in the following columns.

```
psql=> SELECT * FROM test;
a | b | c | d | e
---+------+---+---+------+-----------
1 | foo1 | | bar1 | elephant1
2 | foo2 | | bar2 | elephant2
3 | foo3 | | bar3 | elephant3
4 | foo4 | | bar4 | elephant4
```

Importing an Amazon S3 Compressed (gzip) File

The following example shows how to import a file from Amazon S3 that is compressed with gzip.

Ensure that the file contains the following Amazon S3 metadata:

- Key: `Content-Encoding`
- Value: `gzip`

For more about adding these values to Amazon S3 metadata, see How Do I Add Metadata to an S3 Object? in the *Amazon Simple Storage Service Console User Guide*.

Import the gzip file into your RDS for PostgreSQL DB instance as shown following.

```
psql=> CREATE TABLE test_gzip(id int, a text, b text, c text, d text);
CREATE TABLE
psql=> SELECT aws_s3.table_import_from_s3(
 'test_gzip', '', '(format csv)',
 'myS3Bucket', 'test-data.gz', 'us-east-2'
);
```

Importing an Encoded Amazon S3 File

The following example shows how to import a file from Amazon S3 that has Windows-1252 encoding.

```
psql=> SELECT aws_s3.table_import_from_s3(
 'test_table', '', 'encoding ''WIN1252''',
 aws_commons.create_s3_uri('sampleBucket', 'SampleFile', 'us-east-2')
);
```

Function Reference

Functions

aws_s3.table_import_from_s3

Imports Amazon S3 data into an Amazon RDS table. The `aws_s3` extension provides the `aws_s3.table_import_from_s3` function.

Syntax

The three required parameters are `table_name`, `column_list` and `options`. These identify the database table and specify how the data is copied into the table.

You can also use these parameters:

- The `s3_info` parameter specifies the Amazon S3 file to import. When you use this parameter, access to Amazon S3 is provided by an IAM role for the PostgreSQL DB instance.

```
aws_s3.table_import_from_s3 (
   table_name text,
   column_list text,
   options text,
   s3_info aws_commons._s3_uri_1
)
```

- The `credentials` parameter specifies the credentials to access Amazon S3. When you use this parameter, you don't use an IAM role.

```
aws_s3.table_import_from_s3 (
   table_name text,
   column_list text,
   options text,
   s3_info aws_commons._s3_uri_1,
   credentials aws_commons._aws_credentials_1
)
```

Parameters

table_name

A required text string containing the name of the PostgreSQL database table to import the data into.

column_list

A required text string containing an optional list of the PostgreSQL database table columns in which to copy the data. If the string is empty, all columns of the table are used. For an example, see Importing an Amazon S3 File That Uses a Custom Delimiter (p. 1258).

options

A required text string containing arguments for the PostgreSQL `COPY` command. These arguments specify how the data is to be copied into the PostgreSQL table. For more details, see the PostgreSQL COPY documentation.

s3_info

An `aws_commons._s3_uri_1` composite type containing the following information about the S3 object:

- `bucket` – The name of the Amazon S3 bucket containing the file.
- `file_path` – The Amazon S3 path of the file.
- `region` – The AWS Region that the file is in. For a listing of AWS Region names and associated values, see Regions, Availability Zones, and Local Zones (p. 37).

credentials

An `aws_commons._aws_credentials_1` composite type containing the following credentials to use for the import operation:

- Access key
- Secret key
- Session token

For information about creating an `aws_commons._aws_credentials_1` composite structure, see aws_commons.create_aws_credentials (p. 1262).

Alternate Syntax

To help with testing, you can use an expanded set of parameters instead of the `s3_info` and `credentials` parameters. Following are additional syntax variations for the `aws_s3.table_import_from_s3` function:

- Instead of using the `s3_info` parameter to identify an Amazon S3 file, use the combination of the `bucket`, `file_path`, and `region` parameters. With this form of the function, access to Amazon S3 is provided by an IAM role on the PostgreSQL DB instance.

```
aws_s3.table_import_from_s3 (
   table_name text,
   column_list text,
   options text,
   bucket text,
   file_path text,
   region text
)
```

- Instead of using the `credentials` parameter to specify Amazon S3 access, use the combination of the `access_key`, `session_key`, and `session_token` parameters.

```
aws_s3.table_import_from_s3 (
   table_name text,
   column_list text,
   options text,
   bucket text,
   file_path text,
   region text,
   access_key text,
   secret_key text,
   session_token text
)
```

Alternate Parameters

bucket

A text string containing the name of the Amazon S3 bucket that contains the file.

file_path

A text string containing the Amazon S3 path of the file.

region

A text string containing the AWS Region that the file is in. For a listing of AWS Region names and associated values, see Regions, Availability Zones, and Local Zones (p. 37).

access_key

A text string containing the access key to use for the import operation. The default is NULL.

secret_key

A text string containing the secret key to use for the import operation. The default is NULL.

session_token

(Optional) A text string containing the session key to use for the import operation. The default is NULL.

aws_commons.create_s3_uri

Creates an `aws_commons._s3_uri_1` structure to hold Amazon S3 file information. Use the results of the `aws_commons.create_s3_uri` function in the `s3_info` parameter of the aws_s3.table_import_from_s3 (p. 1259) function.

Syntax

```
aws_commons.create_s3_uri(
```

```
   bucket text,
   file_path text,
   region text
)
```

Parameters

bucket

A required text string containing the Amazon S3 bucket name for the file.

file_path

A required text string containing the Amazon S3 path of the file.

region

A required text string containing the AWS Region that the file is in. For a listing of AWS Region names and associated values, see Regions, Availability Zones, and Local Zones (p. 37).

aws_commons.create_aws_credentials

Sets an access key and secret key in an `aws_commons._aws_credentials_1` structure. Use the results of the `aws_commons.create_aws_credentials` function in the `credentials` parameter of the aws_s3.table_import_from_s3 (p. 1259) function.

Syntax

```
aws_commons.create_aws_credentials(
   access_key text,
   secret_key text,
   session_token text
)
```

Parameters

access_key

A required text string containing the access key to use for importing an Amazon S3 file. The default is NULL.

secret_key

A required text string containing the secret key to use for importing an Amazon S3 file. The default is NULL.

session_token

An optional text string containing the session token to use for importing an Amazon S3 file. The default is NULL. If you provide an optional `session_token`, you can use temporary credentials.

Transporting PostgreSQL Databases Between DB Instances

By using PostgreSQL Transportable Databases for Amazon RDS, you can transport a PostgreSQL database between two DB instances. This provides an extremely fast method of migrating large databases between separate DB instances. To transport databases using this method, your DB instances must both run the same major version of PostgreSQL.

To use transportable databases, install the `pg_transport` extension. This extension provides a physical transport mechanism to move each database. By streaming the database files with minimal processing, physical transport moves data much faster than traditional dump and load processes and takes minimal downtime. PostgreSQL transportable databases use a pull model where the destination DB instance imports the database from the source DB instance.

> **Note**
> PostgreSQL transportable databases are available in RDS for PostgreSQL versions 10.10 and later, and 11.5 and later.

Topics

Limitations for Using PostgreSQL Transportable Databases

Transportable databases have the following limitations:

- **Read replicas** – You can't use transportable databases on read replicas or parent instances of read replicas.
- **Unsupported column types** – You can't use the `reg` data types in any database tables that you plan to transport with this method. These types depend on system catalog object IDs (OIDs), which often change during transport.
- **Tablespaces** – All source database objects must be in the default `pg_default` tablespace.
- **Compatibility** – Both the source and destination DB instances must run the same major version of PostgreSQL.

  Before transport begins, the `transport.import_from_server` function compares the source and destination DB instances to ensure database compatibility. This includes verifying PostgreSQL major version compatibility. Also, the function verifies that the destination DB instance likely has enough space to receive the source database. The function performs several additional checks to make sure that the transport is smooth.
- **Extensions** – The only extension that you can install on the source DB instance during transport is `pg_transport`.
- **Roles and ACLs** – The source database's access privileges and ownership information aren't carried over to the destination database. All database objects are created and owned by the local destination user of the transport.
- **Concurrent transports** – You can run up to 32 total transports at the same time on a DB instance, including both imports and exports. To define the worker processes used for each transport, use the `pg_transport.work_mem` and `pg_transport.num_workers` parameters. To accommodate concurrent transports, you might need to increase the `max_worker_processes` parameter quite a bit. For more information, see Configuration Parameters for the pg_transport Extension (p. 1266).

Setting Up to Transport PostgreSQL Databases

To prepare to transport a PostgreSQL database from one DB instance to another, take the following steps.

To set up for transporting a PostgreSQL database

1. Make sure that the source DB instance's security group allows inbound traffic from the destination DB instance. This is required because the destination DB instance starts the database transport with an import call to the source DB instance. For information about how to use security groups, see Controlling Access with Security Groups (p. 1414).
2. For both the source and destination DB instances, add `pg_transport` to the `shared_preload_libraries` parameter for each parameter group. The `shared_preload_libraries` parameter is static and requires a database restart for changes to take effect. For information about parameter groups, see Working with DB Parameter Groups (p. 202).
3. For both the source and destination DB instances, install the required `pg_transport` PostgreSQL extension.

   To do so, start psql as a user with the `rds_superuser` role for each DB instance, and then run the following command.

   ```
   psql=> CREATE EXTENSION pg_transport;
   ```

Transporting a PostgreSQL Database Using the transport.import_from_server Function

After you complete the process described in Setting Up to Transport PostgreSQL Databases (p. 1263), you can start the transport. To do so, run the transport.import_from_server (p. 1265) function on the destination DB instance.

> **Note**
> Both the destination user for transport and the source user for the connection must be members of the `rds_superuser` role.
> The destination DB instance can't already contain a database with the same name as the source database to be transported, or the transport fails.

The following shows an example transport.

```
SELECT transport.import_from_server(
   'source-db-instance-endpoint',
    source-db-instance-port,
   'source-db-instance-user',
   'source-user-password',
   'source-database-name',
   'destination-user-password',
   false);
```

This function requires that you provide database user passwords. Thus, we recommend that you change the passwords of the user roles you used after transport is complete. Or, you can use SQL bind variables to create temporary user roles. Use these temporary roles for the transport and then discard the roles afterwards.

For details of the `transport.import_from_server` function and its parameters, see transport.import_from_server Function Reference (p. 1265).

What Happens During Database Transport

The `transport.import_from_server` function creates the in-transit database on the destination DB instance. The in-transit database is inaccessible on the destination DB instance for the duration of the transport.

When transport begins, all current sessions on the source database are ended. Any databases other than the source database on the source DB instance aren't affected by the transport.

The source database is put into a special read-only mode. While it's in this mode, you can connect to the source database and run read-only queries. However, write-enabled queries and some other types of commands are blocked. Only the specific source database that is being transported is affected by these restrictions.

During transport, you can't restore the destination DB instance to a point in time. This is because the transport isn't transactional and doesn't use the PostgreSQL write-ahead log to record changes. If the destination DB instance has automatic backups enabled, a backup is automatically taken after transport completes. Point-in-time restores are available for times after the backup finishes.

If the transport fails, the `pg_transport` extension attempts to undo all changes to the source and destination DB instances. This includes removing the destination's partially transported database. Depending on the type of failure, the source database might continue to reject write-enabled queries. If this happens, use the following command to allow write-enabled queries.

```
ALTER DATABASE my-database SET default_transaction_read_only = false;
```

transport.import_from_server Function Reference

The `transport.import_from_server` function transports a PostgreSQL database by importing it from a source DB instance to a destination DB instance. It does this by using a physical database connection transport mechanism.

Syntax

```
transport.import_from_server(
   host text,
   port int,
   username text,
   password text,
   database text,
   local_password text,
   dry_run bool
)
```

Return Value

None.

Parameters

You can find descriptions of the `transport.import_from_server` function parameters in the following table.

Parameter	Description
`host`	The endpoint of the source DB instance.
`port`	An integer representing the port of the source DB instance. PostgreSQL DB instances often use port 5432.
`username`	The user of the source DB instance. This user must be a member of the `rds_superuser` role.

Parameter	Description
password	The user password of the source DB instance.
database	The name of the database in the source DB instance to transport.
local_password	The local password of the current user for the destination DB instance. This user must be a member of the rds_superuser role.
dry_run	An optional Boolean value specifying whether to perform a dry run. The default is false, which means the transport proceeds. To confirm compatibility between the source and destination DB instances without performing the actual transport, set dry_run to true.

Example

For an example, see Transporting a PostgreSQL Database Using the transport.import_from_server Function (p. 1264).

Configuration Parameters for the pg_transport Extension

Use the following parameters to configure the pg_transport extension behavior.

```
SET pg_transport.num_workers = integer;
SET pg_transport.work_mem = kilobytes;
SET pg_transport.timing = Boolean;
```

You can find descriptions of these parameters in the following table.

Parameter	Description
pg_transport.num_workers	The number of workers to use for a physical transport. The default is 3. Valid values are 1–32. Even large transports typically reach their maximum throughput with fewer than 8 workers. During transport, the pg_transport.num_workers setting on the destination DB instance is used on both the destination and source DB instances. A related parameter is the PostgreSQL max_worker_processes parameter. The transport process creates several background worker processes. Thus, your setting for the pg_transport.num_workers parameter might require you to set the max_worker_processes parameter significantly higher on both the source and destination DB instances. We recommend that you set max_worker_processes on both the source and destination DB instances to at least three times the destination DB instance's setting for the pg_transport.num_workers parameter. Add a few more to provide nontransport background worker processes. For more information about the max_worker_processes parameter, see the PostgreSQL documentation about Asynchronous Behavior.
pg_transport.timing	A Boolean value that specifies whether to report timing information during the transport. The default is true. Valid values are true to report timing information and false to disable the reporting of timing information.

Parameter	Description
	We don't recommend that you set this parameter to `false`. Disabling `pg_transport.timing` significantly reduces your ability to track the progress of transports.
`pg_transport.work_mem`	The maximum amount of memory to allocate for each worker. The default is 131,072 kilobytes (KB). The minimum value is 64 megabytes (65,536 KB). Valid values are in kilobytes (KBs) as binary base-2 units, where 1 KB = 1,024 bytes. The transport might use less memory than is specified in this parameter. Even large transports typically reach their maximum throughput with less than 256 MB (262,144 KB) of memory per worker.

Common DBA Tasks for PostgreSQL

This section describes the Amazon RDS implementations of some common DBA tasks for DB instances running the PostgreSQL database engine. To deliver a managed service experience, Amazon RDS doesn't provide shell access to DB instances, and it restricts access to certain system procedures and tables that require advanced privileges.

For information about working with PostgreSQL log files on Amazon RDS, see PostgreSQL Database Log Files (p. 482).

Topics

Creating Roles

When you create a DB instance, the master user system account that you create is assigned to the `rds_superuser` role. The `rds_superuser` role is a predefined Amazon RDS role similar to the PostgreSQL superuser role (customarily named `postgres` in local instances), but with some restrictions. As with the PostgreSQL superuser role, the `rds_superuser` role has the most privileges for your DB instance. You should not assign this role to users unless they need the most access to the DB instance.

The `rds_superuser` role can do the following:

- Add extensions that are available for use with Amazon RDS. For more information, see Supported PostgreSQL Features (p. 1348) and the PostgreSQL documentation.
- Manage tablespaces, including creating and deleting them. For more information, see the Tablespaces section in the PostgreSQL documentation.
- View all users not assigned the `rds_superuser` role using the `pg_stat_activity` command and kill their connections using the `pg_terminate_backend` and `pg_cancel_backend` commands.
- Grant and revoke the `rds_replication` role for all roles that are not the `rds_superuser` role. For more information, see the GRANT section in the PostgreSQL documentation.

The following example shows how to create a user and then grant the user the `rds_superuser` role. User-defined roles, such as `rds_superuser`, have to be granted.

```
create role testuser with password 'testuser' login;
CREATE ROLE
grant rds_superuser to testuser;
```

```
GRANT ROLE
```

Managing PostgreSQL Database Access

In Amazon RDS for PostgreSQL, you can manage which users have privileges to connect to which databases. In other PostgreSQL environments, you sometimes perform this kind of management by modifying the `pg_hba.conf` file. In Amazon RDS, you can use database grants instead.

New databases in PostgreSQL are always created with a default set of privileges. The default privileges allow `PUBLIC` (all users) to connect to the database and to create temporary tables while connected.

To control which users are allowed to connect to a given database in Amazon RDS, first revoke the default `PUBLIC` privileges. Then grant back the privileges on a more granular basis. The following example code shows how.

```
psql> revoke all on database <database-name> from public;
psql> grant connect, temporary on database <database-name> to <user/role name>;
```

For more information about privileges in PostgreSQL databases, see the `GRANT` command in the PostgreSQL documentation.

Working with PostgreSQL Parameters

PostgreSQL parameters that you set for a local PostgreSQL instance in the *postgresql.conf* file are maintained in the DB parameter group for your DB instance. If you create a DB instance using the default parameter group, the parameter settings are in the parameter group called *default.postgres9.6*.

When you create a DB instance, the parameters in the associated DB parameter group are loaded. You can modify parameter values by changing values in the parameter group. You can also change parameter values, if you have the security privileges to do so, by using the ALTER DATABASE, ALTER ROLE, and SET commands. You can't use the command line `postgres` command or the `env PGOPTIONS` command, because you have no access to the host.

Keeping track of PostgreSQL parameter settings can occasionally be difficult. Use the following command to list current parameter settings and the default value.

```
select name, setting, boot_val, reset_val, unit
from pg_settings
order by name;
```

For an explanation of the output values, see the `pg_settings` topic in the PostgreSQL documentation.

If you set the memory settings too large for `max_connections` or `shared_buffers`, you will prevent the PostgreSQL instance from starting up. Some parameters use units that you might not be familiar with; for example, `shared_buffers` sets the number of 8-KB shared memory buffers used by the server.

The following error is written to the *postgres.log* file when the instance is attempting to start up, but incorrect parameter settings are preventing it from starting.

```
2013-09-18 21:13:15 UTC::@:[8097]:FATAL:  could not map anonymous shared
memory: Cannot allocate memory
2013-09-18 21:13:15 UTC::@:[8097]:HINT:  This error usually means that
PostgreSQL's request for a shared memory segment exceeded available memory or
swap space. To reduce the request size (currently 3514134274048 bytes), reduce
PostgreSQL's shared memory usage, perhaps by reducing shared_buffers or
max_connections.
```

There are two types of PostgreSQL parameters, static and dynamic. Static parameters require that the DB instance be rebooted before they are applied. Dynamic parameters can be applied immediately. The following table shows parameters that you can modify for a PostgreSQL DB instance and each parameter's type.

Parameter Name	Apply_Type	Description
`application_name`	Dynamic	Sets the application name to be reported in statistics and logs.
`array_nulls`	Dynamic	Enables input of NULL elements in arrays.
`authentication_timeout`	Dynamic	Sets the maximum allowed time to complete client authentication.
`autovacuum`	Dynamic	Starts the autovacuum subprocess.
`autovacuum_analyze_scale_factor`	Dynamic	Number of tuple inserts, updates, or deletes before analyze as a fraction of reltuples.
`autovacuum_analyze_threshold`	Dynamic	Minimum number of tuple inserts, updates, or deletes before analyze.
`autovacuum_naptime`	Dynamic	Time to sleep between autovacuum runs.
`autovacuum_vacuum_cost_delay`	Dynamic	Vacuum cost delay, in milliseconds, for autovacuum.
`autovacuum_vacuum_cost_limit`	Dynamic	Vacuum cost amount available before napping, for autovacuum.
`autovacuum_vacuum_scale_factor`	Dynamic	Number of tuple updates or deletes before vacuum as a fraction of reltuples.
`autovacuum_vacuum_threshold`	Dynamic	Minimum number of tuple updates or deletes before vacuum.
`backslash_quote`	Dynamic	Sets whether a backslash (\) is allowed in string literals.
`bgwriter_delay`	Dynamic	Background writer sleep time between rounds.
`bgwriter_lru_maxpages`	Dynamic	Background writer maximum number of LRU pages to flush per round.
`bgwriter_lru_multiplier`	Dynamic	Multiple of the average buffer usage to free per round.
`bytea_output`	Dynamic	Sets the output format for bytes.
`check_function_bodies`	Dynamic	Checks function bodies during CREATE FUNCTION.
`checkpoint_completion_target`	Dynamic	Time spent flushing dirty buffers during checkpoint, as a fraction of the checkpoint interval.
`checkpoint_segments`	Dynamic	Sets the maximum distance in log segments between automatic write-ahead log (WAL) checkpoints.
`checkpoint_timeout`	Dynamic	Sets the maximum time between automatic WAL checkpoints.

Parameter Name	Apply_Type	Description
checkpoint_warning	Dynamic	Enables warnings if checkpoint segments are filled more frequently than this.
client_encoding	Dynamic	Sets the client's character set encoding.
client_min_messages	Dynamic	Sets the message levels that are sent to the client.
commit_delay	Dynamic	Sets the delay in microseconds between transaction commit and flushing WAL to disk.
commit_siblings	Dynamic	Sets the minimum concurrent open transactions before performing commit_delay.
constraint_exclusion	Dynamic	Enables the planner to use constraints to optimize queries.
cpu_index_tuple_cost	Dynamic	Sets the planner's estimate of the cost of processing each index entry during an index scan.
cpu_operator_cost	Dynamic	Sets the planner's estimate of the cost of processing each operator or function call.
cpu_tuple_cost	Dynamic	Sets the planner's estimate of the cost of processing each tuple (row).
cursor_tuple_fraction	Dynamic	Sets the planner's estimate of the fraction of a cursor's rows that will be retrieved.
datestyle	Dynamic	Sets the display format for date and time values.
deadlock_timeout	Dynamic	Sets the time to wait on a lock before checking for deadlock.
debug_pretty_print	Dynamic	Indents parse and plan tree displays.
debug_print_parse	Dynamic	Logs each query's parse tree.
debug_print_plan	Dynamic	Logs each query's execution plan.
debug_print_rewritten	Dynamic	Logs each query's rewritten parse tree.
default_statistics_target	Dynamic	Sets the default statistics target.
default_tablespace	Dynamic	Sets the default tablespace to create tables and indexes in.
default_transaction_deferrable	Dynamic	Sets the default deferrable status of new transactions.
default_transaction_isolation	Dynamic	Sets the transaction isolation level of each new transaction.
default_transaction_read_only	Dynamic	Sets the default read-only status of new transactions.
default_with_oids	Dynamic	Creates new tables with OIDs by default.
effective_cache_size	Dynamic	Sets the planner's assumption about the size of the disk cache.

Parameter Name	Apply_Type	Description
`effective_io_concurrency`	Dynamic	Number of simultaneous requests that can be handled efficiently by the disk subsystem.
`enable_bitmapscan`	Dynamic	Enables the planner's use of bitmap-scan plans.
`enable_hashagg`	Dynamic	Enables the planner's use of hashed aggregation plans.
`enable_hashjoin`	Dynamic	Enables the planner's use of hash join plans.
`enable_indexscan`	Dynamic	Enables the planner's use of index-scan plans.
`enable_material`	Dynamic	Enables the planner's use of materialization.
`enable_mergejoin`	Dynamic	Enables the planner's use of merge join plans.
`enable_nestloop`	Dynamic	Enables the planner's use of nested-loop join plans.
`enable_seqscan`	Dynamic	Enables the planner's use of sequential-scan plans.
`enable_sort`	Dynamic	Enables the planner's use of explicit sort steps.
`enable_tidscan`	Dynamic	Enables the planner's use of TID scan plans.
`escape_string_warning`	Dynamic	Warns about backslash (\) escapes in ordinary string literals.
`extra_float_digits`	Dynamic	Sets the number of digits displayed for floating-point values.
`from_collapse_limit`	Dynamic	Sets the FROM-list size beyond which subqueries are not collapsed.
`fsync`	Dynamic	Forces synchronization of updates to disk.
`full_page_writes`	Dynamic	Writes full pages to WAL when first modified after a checkpoint.
`geqo`	Dynamic	Enables genetic query optimization.
`geqo_effort`	Dynamic	GEQO: effort is used to set the default for other GEQO parameters.
`geqo_generations`	Dynamic	GEQO: number of iterations of the algorithm.
`geqo_pool_size`	Dynamic	GEQO: number of individuals in the population.
`geqo_seed`	Dynamic	GEQO: seed for random path selection.
`geqo_selection_bias`	Dynamic	GEQO: selective pressure within the population.
`geqo_threshold`	Dynamic	Sets the threshold of FROM items beyond which GEQO is used.
`gin_fuzzy_search_limit`	Dynamic	Sets the maximum allowed result for exact search by GIN.
`hot_standby_feedback`	Dynamic	Determines whether a hot standby sends feedback messages to the primary or upstream standby.

Parameter Name	Apply_Type	Description
intervalstyle	Dynamic	Sets the display format for interval values.
join_collapse_limit	Dynamic	Sets the FROM-list size beyond which JOIN constructs are not flattened.
lc_messages	Dynamic	Sets the language in which messages are displayed.
lc_monetary	Dynamic	Sets the locale for formatting monetary amounts.
lc_numeric	Dynamic	Sets the locale for formatting numbers.
lc_time	Dynamic	Sets the locale for formatting date and time values.
log_autovacuum_min_duration	Dynamic	Sets the minimum execution time above which autovacuum actions will be logged.
log_checkpoints	Dynamic	Logs each checkpoint.
log_connections	Dynamic	Logs each successful connection.
log_disconnections	Dynamic	Logs end of a session, including duration.
log_duration	Dynamic	Logs the duration of each completed SQL statement.
log_error_verbosity	Dynamic	Sets the verbosity of logged messages.
log_executor_stats	Dynamic	Writes executor performance statistics to the server log.
log_filename	Dynamic	Sets the file name pattern for log files.
log_hostname	Dynamic	Logs the host name in the connection logs.
log_lock_waits	Dynamic	Logs long lock waits.
log_min_duration_statement	Dynamic	Sets the minimum execution time above which statements will be logged.
log_min_error_statement	Dynamic	Causes all statements generating an error at or above this level to be logged.
log_min_messages	Dynamic	Sets the message levels that are logged.
log_parser_stats	Dynamic	Writes parser performance statistics to the server log.
log_planner_stats	Dynamic	Writes planner performance statistics to the server log.
log_rotation_age	Dynamic	Automatic log file rotation will occur after N minutes.
log_rotation_size	Dynamic	Automatic log file rotation will occur after N kilobytes.
log_statement	Dynamic	Sets the type of statements logged.
log_statement_stats	Dynamic	Writes cumulative performance statistics to the server log.
log_temp_files	Dynamic	Logs the use of temporary files larger than this number of kilobytes.

Parameter Name	Apply_Type	Description
maintenance_work_mem	Dynamic	Sets the maximum memory to be used for maintenance operations.
max_stack_depth	Dynamic	Sets the maximum stack depth, in kilobytes.
max_standby_archive_delay	Dynamic	Sets the maximum delay before canceling queries when a hot standby server is processing archived WAL data.
max_standby_streaming_delay	Dynamic	Sets the maximum delay before canceling queries when a hot standby server is processing streamed WAL data.
max_wal_size	Static	Sets the WAL size that triggers the checkpoint. For PostgreSQL version 9.6 and earlier, `max_wal_size` is in units of 16 MB. For PostgreSQL version 10 and later, `max_wal_size` is in units of 1 MB.
min_wal_size	Static	Sets the minimum size to shrink the WAL to. For PostgreSQL version 9.6 and earlier, `min_wal_size` is in units of 16 MB. For PostgreSQL version 10 and later, `min_wal_size` is in units of 1 MB.
quote_all_identifiers	Dynamic	Adds quotes (") to all identifiers when generating SQL fragments.
random_page_cost	Dynamic	Sets the planner's estimate of the cost of a non-sequentially fetched disk page.
rds.adaptive_autovacuum	Dynamic	Automatically tunes the autovacuum parameters whenever the transaction ID thresholds are exceeded.
rds.log_retention_period	Dynamic	Sets log retention such that Amazon RDS deletes PostgreSQL logs that are older than N minutes.
rds.restrict_password_commands	Static	Restricts who can manage passwords to users with the `rds_password` role. Set this parameter to 1 to enable password restriction. The default is 0.
search_path	Dynamic	Sets the schema search order for names that are not schema-qualified.
seq_page_cost	Dynamic	Sets the planner's estimate of the cost of a sequentially fetched disk page.
session_replication_role	Dynamic	Sets the sessions behavior for triggers and rewrite rules.
sql_inheritance	Dynamic	Causes subtables to be included by default in various commands.
ssl_renegotiation_limit	Dynamic	Sets the amount of traffic to send and receive before renegotiating the encryption keys.
standard_conforming_strings	Dynamic	Causes ... strings to treat backslashes literally.
statement_timeout	Dynamic	Sets the maximum allowed duration of any statement.

Parameter Name	Apply_Type	Description
synchronize_seqscans	Dynamic	Enables synchronized sequential scans.
synchronous_commit	Dynamic	Sets the current transactions synchronization level.
tcp_keepalives_count	Dynamic	Maximum number of TCP keepalive retransmits.
tcp_keepalives_idle	Dynamic	Time between issuing TCP keepalives.
tcp_keepalives_interval	Dynamic	Time between TCP keepalive retransmits.
temp_buffers	Dynamic	Sets the maximum number of temporary buffers used by each session.
temp_tablespaces	Dynamic	Sets the tablespaces to use for temporary tables and sort files.
timezone	Dynamic	Sets the time zone for displaying and interpreting time stamps.
track_activities	Dynamic	Collects information about executing commands.
track_counts	Dynamic	Collects statistics on database activity.
track_functions	Dynamic	Collects function-level statistics on database activity.
track_io_timing	Dynamic	Collects timing statistics on database I/O activity.
transaction_deferrable	Dynamic	Indicates whether to defer a read-only serializable transaction until it can be executed with no possible serialization failures.
transaction_isolation	Dynamic	Sets the current transactions isolation level.
transaction_read_only	Dynamic	Sets the current transactions read-only status.
transform_null_equals	Dynamic	Treats expr=NULL as expr IS NULL.
update_process_title	Dynamic	Updates the process title to show the active SQL command.
vacuum_cost_delay	Dynamic	Vacuum cost delay in milliseconds.
vacuum_cost_limit	Dynamic	Vacuum cost amount available before napping.
vacuum_cost_page_dirty	Dynamic	Vacuum cost for a page dirtied by vacuum.
vacuum_cost_page_hit	Dynamic	Vacuum cost for a page found in the buffer cache.
vacuum_cost_page_miss	Dynamic	Vacuum cost for a page not found in the buffer cache.
vacuum_defer_cleanup_age	Dynamic	Number of transactions by which vacuum and hot cleanup should be deferred, if any.
vacuum_freeze_min_age	Dynamic	Minimum age at which vacuum should freeze a table row.
vacuum_freeze_table_age	Dynamic	Age at which vacuum should scan a whole table to freeze tuples.
wal_writer_delay	Dynamic	WAL writer sleep time between WAL flushes.

Parameter Name	Apply_Type	Description
`work_mem`	Dynamic	Sets the maximum memory to be used for query workspaces.
`xmlbinary`	Dynamic	Sets how binary values are to be encoded in XML.
`xmloption`	Dynamic	Sets whether XML data in implicit parsing and serialization operations is to be considered as documents or content fragments.
`autovacuum_freeze_max_age`	Static	Age at which to autovacuum a table to prevent transaction ID wraparound.
`autovacuum_max_workers`	Static	Sets the maximum number of simultaneously running autovacuum worker processes.
`max_connections`	Static	Sets the maximum number of concurrent connections.
`max_files_per_process`	Static	Sets the maximum number of simultaneously open files for each server process.
`max_locks_per_transaction`	Static	Sets the maximum number of locks per transaction.
`max_pred_locks_per_transaction`	Static	Sets the maximum number of predicate locks per transaction.
`max_prepared_transactions`	Static	Sets the maximum number of simultaneously prepared transactions.
`shared_buffers`	Static	Sets the number of shared memory buffers used by the server.
`ssl`	Static	Enables SSL connections.
`temp_file_limit`	Static	Sets the maximum size in KB to which the temporary files can grow.
`track_activity_query_size`	Static	Sets the size reserved for pg_stat_activity.current_query, in bytes.
`wal_buffers`	Static	Sets the number of disk-page buffers in shared memory for WAL.

Amazon RDS uses the default PostgreSQL units for all parameters. The following table shows the PostgreSQL default unit and value for each parameter.

Parameter Name	Unit
`effective_cache_size`	8 KB
`segment_size`	8 KB
`shared_buffers`	8 KB
`temp_buffers`	8 KB
`wal_buffers`	8 KB

Parameter Name	Unit
wal_segment_size	8 KB
log_rotation_size	KB
log_temp_files	KB
maintenance_work_mem	KB
max_stack_depth	KB
ssl_renegotiation_limit	KB
temp_file_limit	KB
work_mem	KB
log_rotation_age	minutes
autovacuum_vacuum_cost_delay	ms
bgwriter_delay	ms
deadlock_timeout	ms
lock_timeout	ms
log_autovacuum_min_duration	ms
log_min_duration_statement	ms
max_standby_archive_delay	ms
max_standby_streaming_delay	ms
statement_timeout	ms
vacuum_cost_delay	ms
wal_receiver_timeout	ms
wal_sender_timeout	ms
wal_writer_delay	ms
archive_timeout	s
authentication_timeout	s
autovacuum_naptime	s
checkpoint_timeout	s
checkpoint_warning	s
post_auth_delay	s
pre_auth_delay	s
tcp_keepalives_idle	s
tcp_keepalives_interval	s

Parameter Name	Unit
wal_receiver_status_interval	s

Working with PostgreSQL Autovacuum on Amazon RDS

We strongly recommend that you use the autovacuum feature for PostgreSQL databases to maintain the health of your PostgreSQL DB instance. Autovacuum automates the execution of the VACUUM and the ANALYZE commands. Autovacuum checks for tables that have had a large number of inserted, updated, or deleted tuples. Autovacuum then reclaims storage by removing obsolete data or tuples from the PostgreSQL database.

Autovacuum is enabled by default for all new Amazon RDS PostgreSQL DB instances, and the related autovacuum configuration parameters are appropriately set by default. Because our defaults are somewhat generic, you can benefit from tuning parameters to your specific workload. The following section can help you perform the needed autovacuum tuning.

Topics

Allocating Memory for Autovacuum

One of the most important parameters influencing autovacuum performance is the `maintenance_work_mem` parameter. This parameter determines how much memory that you allocate for autovacuum to use to scan a database table and to hold all the row IDs that are going to be vacuumed. If you set the value of the `maintenance_work_mem` parameter too low, the vacuum process might have to scan the table multiple times to complete its work. Such multiple scans can have a negative impact on performance.

When doing calculations to determine the `maintenance_work_mem` parameter value, keep in mind two things:

- The default unit is kilobytes (KB) for this parameter.
- The `maintenance_work_mem` parameter works in conjunction with the `autovacuum_max_workers` parameter. If you have many small tables, allocate more `autovacuum_max_workers` and less `maintenance_work_mem`. If you have large tables (say, larger than 100 GB), allocate more memory and fewer worker processes. You need to have enough memory allocated to succeed on your biggest table. Each `autovacuum_max_workers` can use the memory you allocate. Thus, you should make sure the combination of worker processes and memory equal the total memory that you want to allocate.

In general terms, for large hosts set the `maintenance_work_mem` parameter to a value between one and two gigabytes (between 1,048,576 and 2,097,152 KB). For extremely large hosts, set the parameter to a value between two and four gigabytes (between 2,097,152 and 4,194,304 KB). The value you set for this parameter should depend on the workload. Amazon RDS has updated its default for this parameter to be kilobytes calculated as follows:

`GREATEST({DBInstanceClassMemory/63963136*1024},65536).`

Reducing the Likelihood of Transaction ID Wraparound

In some cases, parameter group settings related to autovacuum might not be aggressive enough to prevent transaction ID wraparound. To address this, Amazon RDS for PostgreSQL provides a mechanism that adapts the autovacuum parameter values automatically. *Adaptive autovacuum parameter tuning* is a feature for RDS for PostgreSQL versions 9.4 and newer. A detailed explanation of TransactionID wraparound is found in the PostgreSQL documentation.

Adaptive autovacuum parameter tuning is enabled by default for RDS PostgreSQL instances with the dynamic parameter `rds.adaptive_autovacuum` set to ON. We strongly recommend that you keep this enabled. However, to turn off adaptive autovacuum parameter tuning, set the `rds.adaptive_autovacuum` parameter to 0 or OFF.

Transaction ID wraparound is still possible even when RDS tunes the autovacuum parameters. We encourage you to implement an Amazon CloudWatch alarm for transaction ID wraparound. For more information, see the blog post Implement an Early Warning System for Transaction ID Wraparound in Amazon RDS for PostgreSQL.

With adaptive autovacuum parameter tuning enabled, RDS will begin adjusting autovacuum parameters when the CloudWatch metric `MaximumUsedTransactionIDs` reaches the value of the `autovacuum_freeze_max_age` parameter or 500,000,000, whichever is greater.

RDS continues to adjust parameters for autovacuum if a table continues to trend toward transaction ID wraparound. Each of these adjustments dedicates more resources to autovacuum to avoid wraparound. RDS updates the following autovacuum-related parameters:

- autovacuum_vacuum_cost_delay
- autovacuum_vacuum_cost_limit
- autovacuum_work_mem
- autovacuum_naptime

RDS modifies these parameters only if the new value makes autovacuum more aggressive. The parameters are modified in memory on the DB instance. The values in the parameter group aren't changed. To view the current in-memory settings, use the PostgreSQL SHOW SQL command.

Whenever RDS modifies any of these autovacuum parameters, it generates an event for the affected DB instance that is visible on the AWS Management Console (https://console.aws.amazon.com/rds/) and through the RDS API. After the `MaximumUsedTransactionIDs` CloudWatch metric returns below the threshold, RDS resets the autovacuum related parameters in memory back to the values specified in the parameter group and generates another event corresponding to this change.

Determining if the Tables in Your Database Need Vacuuming

You can use the following query to show the number of unvacuumed transactions in a database. The `datfrozenxid` column of a database's `pg_database` row is a lower bound on the normal transaction IDs appearing in that database. This column is the minimum of the per-table `relfrozenxid` values within the database.

```
SELECT datname, age(datfrozenxid) FROM pg_database ORDER BY age(datfrozenxid) desc limit
 20;
```

For example, the results of running the preceding query might be the following.

```
datname    | age
mydb       | 1771757888
template0  | 1721757888
template1  | 1721757888
rdsadmin   | 1694008527
postgres   | 1693881061
(5 rows)
```

When the age of a database reaches 2 billion transaction IDs, transaction ID (XID) wraparound occurs and the database becomes read-only. This query can be used to produce a metric and run a few times a day. By default, autovacuum is set to keep the age of transactions to no more than 200,000,000 (`autovacuum_freeze_max_age`).

A sample monitoring strategy might look like this:

- Set the `autovacuum_freeze_max_age` value to 200 million transactions.
- If a table reaches 500 million unvacuumed transactions, that triggers a low-severity alarm. This isn't an unreasonable value, but it can indicate that autovacuum isn't keeping up.
- If a table ages to 1 billion, this should be treated as an alarm to take action on. In general, you want to keep ages closer to `autovacuum_freeze_max_age` for performance reasons. We recommend you investigate using the recommendations that follow.
- If a table reaches 1.5 billion unvacuumed transactions, that triggers a high-severity alarm. Depending on how quickly your database uses transaction IDs, this alarm can indicate that the system is running out of time to run autovacuum. In this case, we recommend you resolve this immediately.

If a table is constantly breaching these thresholds, you need to modify your autovacuum parameters further. By default, using VACUUM manually (which has cost-based delays disabled) is more aggressive than using the default autovacuum, but it is also more intrusive to the system as a whole.

We recommend the following:

- Be aware and enable a monitoring mechanism so that you are aware of the age of your oldest transactions.

  For information on creating a process that warns you about transaction ID wraparound, see the AWS Database Blog post Implement an Early Warning System for Transaction ID Wraparound in Amazon RDS for PostgreSQL.
- For busier tables, perform a manual vacuum freeze regularly during a maintenance window, in addition to relying on autovacuum. For information on performing a manual vacuum freeze, see Performing a Manual Vacuum Freeze (p. 1283).

Determining Which Tables Are Currently Eligible for Autovacuum

Often, it is one or two tables in need of vacuuming. Tables whose `relfrozenxid` value is greater than the number of transactions in `autovacuum_freeze_max_age` are always targeted by autovacuum. Otherwise, if the number of tuples made obsolete since the last VACUUM exceeds the "vacuum threshold", the table is vacuumed.

The autovacuum threshold is defined as:

```
Vacuum-threshold = vacuum-base-threshold + vacuum-scale-factor * number-of-tuples
```

While you are connected to your database, run the following query to see a list of tables that autovacuum sees as eligible for vacuuming:

```
  WITH vbt AS (SELECT setting AS autovacuum_vacuum_threshold FROM
pg_settings WHERE name = 'autovacuum_vacuum_threshold')
    , vsf AS (SELECT setting AS autovacuum_vacuum_scale_factor FROM
pg_settings WHERE name = 'autovacuum_vacuum_scale_factor')
    , fma AS (SELECT setting AS autovacuum_freeze_max_age FROM
pg_settings WHERE name = 'autovacuum_freeze_max_age')
    , sto AS (select opt_oid, split_part(setting, '=', 1) as param,
split_part(setting, '=', 2) as value from (select oid opt_oid,
unnest(reloptions) setting from pg_class) opt)
SELECT
    '"'||ns.nspname||'"."'||c.relname||'"' as relation
    , pg_size_pretty(pg_table_size(c.oid)) as table_size
    , age(relfrozenxid) as xid_age
    , coalesce(cfma.value::float, autovacuum_freeze_max_age::float)
autovacuum_freeze_max_age
    , (coalesce(cvbt.value::float, autovacuum_vacuum_threshold::float)
+ coalesce(cvsf.value::float,autovacuum_vacuum_scale_factor::float) *
c.reltuples) as autovacuum_vacuum_tuples
    , n_dead_tup as dead_tuples
FROM pg_class c join pg_namespace ns on ns.oid = c.relnamespace
join pg_stat_all_tables stat on stat.relid = c.oid
join vbt on (1=1) join vsf on (1=1) join fma on (1=1)
left join sto cvbt on cvbt.param = 'autovacuum_vacuum_threshold' and
c.oid = cvbt.opt_oid
left join sto cvsf on cvsf.param = 'autovacuum_vacuum_scale_factor' and
c.oid = cvsf.opt_oid
left join sto cfma on cfma.param = 'autovacuum_freeze_max_age' and
c.oid = cfma.opt_oid
WHERE c.relkind = 'r' and nspname <> 'pg_catalog'
and (
    age(relfrozenxid) >= coalesce(cfma.value::float,
autovacuum_freeze_max_age::float)
    or
    coalesce(cvbt.value::float, autovacuum_vacuum_threshold::float) +
coalesce(cvsf.value::float,autovacuum_vacuum_scale_factor::float) *
c.reltuples <= n_dead_tup
   -- or 1 = 1
)
ORDER BY age(relfrozenxid) DESC LIMIT 50;
```

Determining if Autovacuum Is Currently Running and For How Long

If you need to manually vacuum a table, you need to determine if autovacuum is currently running. If it is, you might need to adjust parameters to make it run more efficiently, or terminate autovacuum so you can manually run VACUUM.

Use the following query to determine if autovacuum is running, how long it has been running, and if it is waiting on another session.

If you are using Amazon RDS PostgreSQL 9.6+ or higher, use this query:

```
SELECT datname, usename, pid, state, wait_event, current_timestamp - xact_start AS
 xact_runtime, query
FROM pg_stat_activity
```

```
WHERE upper(query) LIKE '%VACUUM%'
ORDER BY xact_start;
```

After running the query, you should see output similar to the following.

```
 datname | usename  |  pid  | state  | wait_event |      xact_runtime       | query
 --------+----------+-------+--------+------------+-------------------------
+-----------------------------------------------------------------------------------------------
 mydb    | rdsadmin | 16473 | active |            | 33 days 16:32:11.600656 | autovacuum:
 VACUUM ANALYZE public.mytable1 (to prevent wraparound)
 mydb    | rdsadmin | 22553 | active |            | 14 days 09:15:34.073141 | autovacuum:
 VACUUM ANALYZE public.mytable2 (to prevent wraparound)
 mydb    | rdsadmin | 41909 | active |            | 3 days 02:43:54.203349  | autovacuum:
 VACUUM ANALYZE public.mytable3
 mydb    | rdsadmin |   618 | active |            | 00:00:00                | SELECT
 datname, usename, pid, state, wait_event, current_timestamp - xact_start AS xact_runtime,
 query+
         |          |       |        |            |                         | FROM
 pg_stat_activity
       +
         |          |       |        |            |                         | WHERE query
 like '%VACUUM%'
 +
         |          |       |        |            |                         | ORDER BY
 xact_start;
   +
```

If you are using a version less than Amazon RDS PostgreSQL 9.6, but 9.4.7 or later, or 9.5.2 or later, use the following query.

```
SELECT datname, usename, pid, waiting, current_timestamp - xact_start AS xact_runtime,
 query
FROM pg_stat_activity
WHERE upper(query) LIKE '%VACUUM%'
ORDER BY xact_start;
```

After running the query, you should see output similar to the following.

```
 datname | usename  |  pid  | waiting |       xact_runtime      | query
 --------+----------+-------+---------+-------------------------
+---------------------------------------------------------------------------------------
 mydb    | rdsadmin | 16473 | f       | 33 days 16:32:11.600656 | autovacuum: VACUUM
 ANALYZE public.mytable1 (to prevent wraparound)
 mydb    | rdsadmin | 22553 | f       | 14 days 09:15:34.073141 | autovacuum: VACUUM
 ANALYZE public.mytable2 (to prevent wraparound)
 mydb    | rdsadmin | 41909 | f       | 3 days 02:43:54.203349  | autovacuum: VACUUM
 ANALYZE public.mytable3
 mydb    | rdsadmin |   618 | f       | 00:00:00                | SELECT datname, usename,
 pid, waiting, current_timestamp - xact_start AS xact_runtime, query+
         |          |       |         |                         | FROM pg_stat_activity
                                                                   +
         |          |       |         |                         | WHERE query like '%VACUUM
%'
                                                                   +
         |          |       |         |                         | ORDER BY xact_start;
                                                                   +
```

Several issues can cause a long-running autovacuum session (that is, multiple days long). The most common issue is that your `maintenance_work_mem` parameter value is set too low for the size of the table or rate of updates.

We recommend that you use the following formula to set the maintenance_work_mem parameter value.

```
GREATEST({DBInstanceClassMemory/63963136*1024},65536)
```

Short running autovacuum sessions can also indicate problems:

- It can indicate that there aren't enough autovacuum_max_workers for your workload. In this case, you need to indicate the number of workers.
- It can indicate that there is an index corruption (autovacuum crashes and restart on the same relation but make no progress). In this case, run a manual vacuum freeze verbose ___table___ to see the exact cause.

Performing a Manual Vacuum Freeze

You might want to perform a manual vacuum on a table that has a vacuum process already running. This is useful if you have identified a table with an age approaching 2 billion transactions (or above any threshold you are monitoring).

The following steps are a guideline, and there are several variations to the process. For example, during testing, suppose that you find that the maintenance_work_mem parameter value was set too small and that you need to take immediate action on a table. However, perhaps you don't want to bounce the instance at the moment. Using the queries in previous sections, you determine which table is the problem and notice a long running autovacuum session. You know that you need to change the maintenance_work_mem parameter setting, but you also need to take immediate action and vacuum the table in question. The following procedure shows what to do in this situation:

To manually perform a vacuum freeze

1. Open two sessions to the database containing the table you want to vacuum. For the second session, use "screen" or another utility that maintains the session if your connection is dropped.
2. In session one, get the PID of the autovacuum session running on the table. This action requires that you are running Amazon RDS PostgreSQL 9.4.7 or later, or 9.5.2 or later, to have full visibility into the running rdsadmin processes.

   Run the following query to get the PID of the autovacuum session.

   ```
   SELECT datname, usename, pid, current_timestamp - xact_start
   AS xact_runtime, query
   FROM pg_stat_activity WHERE upper(query) LIKE '%VACUUM%' ORDER BY
   xact_start;
   ```
3. In session two, calculate the amount of memory you need for this operation. In this example, we determine that we can afford to use up to 2 GB of memory for this operation, so we set maintenance_work_mem for the current session to 2 GB.

   ```
   set maintenance_work_mem='2 GB';
   SET
   ```
4. In session two, issue a `vacuum freeze verbose` command for the table. The verbose setting is useful because, although there is no progress report for this in PostgreSQL currently, you can see activity.

   ```
   \timing on
   Timing is on.
   vacuum freeze verbose pgbench_branches;
   ```

```
INFO:  vacuuming "public.pgbench_branches"
INFO:  index "pgbench_branches_pkey" now contains 50 row versions in 2 pages
DETAIL:  0 index row versions were removed.
0 index pages have been deleted, 0 are currently reusable.
CPU 0.00s/0.00u sec elapsed 0.00 sec.
INFO:  index "pgbench_branches_test_index" now contains 50 row versions in 2 pages
DETAIL:  0 index row versions were removed.
0 index pages have been deleted, 0 are currently reusable.
CPU 0.00s/0.00u sec elapsed 0.00 sec.
INFO:  "pgbench_branches": found 0 removable, 50 nonremovable row versions
     in 43 out of 43 pages
DETAIL:  0 dead row versions cannot be removed yet.
There were 9347 unused item pointers.
0 pages are entirely empty.
CPU 0.00s/0.00u sec elapsed 0.00 sec.
VACUUM
Time: 2.765 ms
```

5. In session one, if autovacuum was blocking, you see in `pg_stat_activity` that waiting is "T" for your vacuum session. In this case, you need to terminate the autovacuum process as follows.

```
SELECT pg_terminate_backend('the_pid');
```

6. At this point, your session begins. It's important to note that autovacuum restarts immediately because this table is probably the highest on its list of work. Initiate your `vacuum freeze verbose` command in session 2 and then terminate the autovacuum process in session 1.

Reindexing a Table When Autovacuum Is Running

If an index has become corrupt, autovacuum continues to process the table and fails. If you attempt a manual vacuum in this situation, you will receive an error message similar to the following:

```
mydb=# vacuum freeze pgbench_branches;
ERROR: index "pgbench_branches_test_index" contains unexpected
   zero page at block 30521
HINT: Please REINDEX it.
```

When the index is corrupted and autovacuum is attempting to run against the table, you contend with an already running autovacuum session. When you issue a "REINDEX " command, you take out an exclusive lock on the table. Write operations are blocked, and also reads that use that specific index.

To reindex a table when autovacuum is running on the table

1. Open two sessions to the database containing the table you want to vacuum. For the second session, use "screen" or another utility that maintains the session if your connection is dropped.
2. In session one, get the PID of the autovacuum session running on the table. This action requires that you are running Amazon RDS PostgreSQL 9.4.7 or later, or 9.5.2 or later, to have full visibility into the running rdsadmin processes.

   Run the following query to get the PID of the autovacuum session.

```
SELECT datname, usename, pid, current_timestamp - xact_start
AS xact_runtime, query
FROM pg_stat_activity WHERE upper(query) like '%VACUUM%' ORDER BY
xact_start;
```

3. In session two, issue the reindex command.

```
\timing on
Timing is on.
reindex index pgbench_branches_test_index;
REINDEX
Time: 9.966 ms
```

4. In session one, if autovacuum was blocking, you see in `pg_stat_activity` that waiting is "T" for your vacuum session. In this case, you will need to terminate the autovacuum process.

```
select pg_terminate_backend('the_pid');
```

5. At this point, your session begins. It's important to note that autovacuum restarts immediately because this table is probably the highest on its list of work. Initiate your command in session 2 and then terminate the autovacuum process in session 1.

Other Parameters That Affect Autovacuum

The following query shows the values of some of the parameters that directly affect autovacuum and its behavior. The autovacuum parameters are described fully in the PostgreSQL documentation.

```
SELECT name, setting, unit, short_desc
FROM pg_settings
WHERE name IN (
'autovacuum_max_workers',
'autovacuum_analyze_scale_factor',
'autovacuum_naptime',
'autovacuum_analyze_threshold',
'autovacuum_analyze_scale_factor',
'autovacuum_vacuum_threshold',
'autovacuum_vacuum_scale_factor',
'autovacuum_vacuum_threshold',
'autovacuum_vacuum_cost_delay',
'autovacuum_vacuum_cost_limit',
'vacuum_cost_limit',
'autovacuum_freeze_max_age',
'maintenance_work_mem',
'vacuum_freeze_min_age');
```

While these all affect autovacuum, some of the most important ones are:

- maintenance_work_mem
- autovacuum_freeze_max_age
- autovacuum_max_workers
- autovacuum_vacuum_cost_delay
- Autovacuum_vacuum_cost_limit

Setting Table-Level Autovacuum Parameters

Autovacuum-related storage parameters can be set at a table level, which can be better than altering the behavior of the entire database. For large tables, you might need to set aggressive settings and you might not want to make autovacuum behave that way for all tables.

The following query shows which tables currently have table-level options in place.

```
SELECT relname, reloptions
```

```
FROM pg_class
WHERE reloptions IS NOT null;
```

An example where this might be useful is on tables that are much larger than the rest of your tables. Suppose that you have one 300-GB table and 30 other tables less than 1 GB. In this case, you might set some specific parameters for your large table so you don't alter the behavior of your entire system.

```
ALTER TABLE mytable set (autovacuum_vacuum_cost_delay=0);
```

Doing this disables the cost-based autovacuum delay for this table at the expense of more resource usage on your system. Normally, autovacuum pauses for autovacuum_vacuum_cost_delay each time autovacuum_cost_limit is reached. You can find more details in the PostgreSQL documentation about cost-based vacuuming.

Autovacuum Logging

By default, the *postgresql.log* doesn't contain information about the autovacuum process. If you are using PostgreSQL 9.4.5 or later, you can see output in the PostgreSQL error log from the autovacuum worker operations by setting the `rds.force_autovacuum_logging_level` parameter. Allowed values are `disabled, debug5, debug4, debug3, debug2, debug1, info, notice, warning, error, log, fatal,` and `panic`. The default value is `disabled` because the other allowable values can add significant amount of information to your logs.

We recommend that you set the value of the `rds.force_autovacuum_logging_level` parameter to `log` and that you set the `log_autovacuum_min_duration` parameter to a value from 1,000 to 5,000 milliseconds. If you set this value to 5,000, Amazon RDS writes any activity to the log that takes more than five seconds. It also shows "vacuum skipped" messages when application locking is causing autovacuum to intentionally skip tables. If you are troubleshooting a problem and need more detail, you can use a different logging level value, such as `debug1` or `debug3`. Use these debug parameters for a short period of time because these settings produce extremely verbose content written to the error log file. For more information about these debug settings, see the PostgreSQL documentation.

> **Note**
> PostgreSQL version 9.4.7 and later includes improved visibility of autovacuum sessions by allowing the `rds_superuser` account to view autovacuum sessions in `pg_stat_activity`. For example, you can identify and terminate an autovacuum session that is blocking a command from running, or executing slower than a manually issued vacuum command.

Audit Logging for a PostgreSQL DB Instance

There are several parameters you can set to log activity that occurs on your PostgreSQL DB instance. These parameters include the following:

- The `log_statement` parameter can be used to log user activity in your PostgreSQL database. For more information, see PostgreSQL Database Log Files (p. 482).
- The `rds.force_admin_logging_level` parameter logs actions by the RDS internal user (rdsadmin) in the databases on the DB instance, and writes the output to the PostgreSQL error log. Allowed values are disabled, debug5, debug4, debug3, debug2, debug1, info, notice, warning, error, log, fatal, and panic. The default value is disabled.
- The `rds.force_autovacuum_logging_level` parameter logs autovacuum worker operations in all databases on the DB instance, and writes the output to the PostgreSQL error log. Allowed values are disabled, debug5, debug4, debug3, debug2, debug1, info, notice, warning, error, log, fatal, and panic. The default value is disabled. The Amazon RDS recommended setting for rds.force_autovacuum_logging_level: is LOG. Set log_autovacuum_min_duration to a value from 1000 or 5000. Setting this value to 5,000 writes activity to the log that takes more than 5 seconds and shows "vacuum skipped" messages. For more information on this parameter, see Best Practices for Working with PostgreSQL (p. 132).

Working with the pgaudit Extension

The `pgaudit` extension provides detailed session and object audit logging for Amazon RDS for PostgreSQL version 9.6.3 and later and version 9.5.7 and later. You can enable session auditing or object auditing using this extension.

With session auditing, you can log audit events from various sources and includes the fully qualified command text when available. For example, you can use session auditing to log all READ statements that connect to a database by setting pgaudit.log to 'READ'.

With object auditing, you can refine the audit logging to work with specific commands. For example, you can specify that you want audit logging for READ operations on a specific number of tables.

To use object based logging with the `pgaudit` extension

1. Create a specific database role called `rds_pgaudit`. Use the following command to create the role.

```
CREATE ROLE rds_pgaudit;
CREATE ROLE
```

2. Modify the parameter group that is associated with your DB instance to use the shared preload libraries that contain `pgaudit` and set the parameter `pgaudit.role`. The `pgaudit.role` must be set to the role `rds_pgaudit`.

   The following command modifies a custom parameter group.

```
aws rds modify-db-parameter-group
   --db-parameter-group-name rds-parameter-group-96
   --parameters
 "ParameterName=pgaudit.role,ParameterValue=rds_pgaudit,ApplyMethod=pending-reboot"
   --parameters
 "ParameterName=shared_preload_libraries,ParameterValue=pgaudit,ApplyMethod=pending-
reboot"
   --region us-west-2
```

3. Reboot the instance so that the DB instance picks up the changes to the parameter group. The following command reboots a DB instance.

```
aws rds reboot-db-instance --db-instance-identifier rds-test-instance --region us-
west-2
```

4. Run the following command to confirm that `pgaudit` has been initialized.

```
show shared_preload_libraries;
shared_preload_libraries
--------------------------
rdsutils,pgaudit
(1 row)
```

5. Run the following command to create the `pgaudit` extension.

```
CREATE EXTENSION pgaudit;
CREATE EXTENSION
```

6. Run the following command to confirm `pgaudit.role` is set to *rds_pgaudit*.

```
show pgaudit.role;
pgaudit.role
------------------
rds_pgaudit
```

To test the audit logging, run several commands that you have chosen to audit. For example, you might run the following commands.

```
CREATE TABLE t1 (id int);
CREATE TABLE
GRANT SELECT ON t1 TO rds_pgaudit;
GRANT
select * from t1;
id
----
(0 rows)
```

The database logs should contain an entry similar to the following.

```
...
2017-06-12 19:09:49 UTC:…:rds_test@postgres:[11701]:LOG: AUDIT:
OBJECT,1,1,READ,SELECT,TABLE,public.t1,select * from t1;
...
```

For information on viewing the logs, see Amazon RDS Database Log Files (p. 453).

Working with the pg_repack Extension

You can use the `pg_repack` extension to remove bloat from tables and indexes. This extension is supported on Amazon RDS for PostgreSQL versions 9.6.3 and later. For more information on the `pg_repack` extension, see the GitHub project documentation.

To use the pg_repack extension

1. Install the `pg_repack` extension on your Amazon RDS for PostgreSQL DB instance by running the following command.

```
CREATE EXTENSION pg_repack;
```

2. Use the pg_repack client utility to connect to a database. Use a database role that has *rds_superuser* privileges to connect to the database. In the following connection example, the *rds_test* role has *rds_superuser* privileges, and the database endpoint used is *rds-test-instance.cw7jjfgdr4on8.us-west-2.rds.amazonaws.com*.

```
pg_repack -h rds-test-instance.cw7jjfgdr4on8.us-west-2.rds.amazonaws.com -U rds_test -k
 postgres
```

Connect using the -k option. The -a option is not supported.

3. The response from the pg_repack client provides information on the tables on the DB instance that are repacked.

```
INFO: repacking table "pgbench_tellers"
INFO: repacking table "pgbench_accounts"
INFO: repacking table "pgbench_branches"
```

Working with PostGIS

PostGIS is an extension to PostgreSQL for storing and managing spatial information. If you are not familiar with PostGIS, you can get a good general overview at PostGIS Introduction.

You need to perform a bit of setup before you can use the PostGIS extension. The following list shows what you need to do; each step is described in greater detail later in this section.

- Connect to the DB instance using the master user name used to create the DB instance.
- Load the PostGIS extensions.
- Transfer ownership of the extensions to the `rds_superuser` role.
- Transfer ownership of the objects to the `rds_superuser` role.
- Test the extensions.

Step 1: Connect to the DB Instance Using the Master User Name Used to Create the DB Instance

First, you connect to the DB instance using the master user name that was used to create the DB instance. That name is automatically assigned the `rds_superuser` role. You need the `rds_superuser` role that is needed to do the remaining steps.

The following example uses SELECT to show you the current user; in this case, the current user should be the master username you chose when creating the DB instance.

```
select current_user;
 current_user
 -------------
  myawsuser
 (1 row)
```

Step 2: Load the PostGIS Extensions

Use the CREATE EXTENSION statements to load the PostGIS extensions. You must also load the extension. You can then use the `\dn` *psql* command to list the owners of the PostGIS schemas.

```
create extension postgis;
CREATE EXTENSION
```

```
create extension fuzzystrmatch;
CREATE EXTENSION
create extension postgis_tiger_geocoder;
CREATE EXTENSION
create extension postgis_topology;
CREATE EXTENSION
\dn
     List of schemas
     Name     |   Owner
--------------+-----------
 public       | myawsuser
 tiger        | rdsadmin
 tiger_data   | rdsadmin
 topology     | rdsadmin
(4 rows)
```

Step 3: Transfer Ownership of the Extensions to the rds_superuser Role

Use the ALTER SCHEMA statements to transfer ownership of the schemas to the `rds_superuser` role.

```
alter schema tiger owner to rds_superuser;
ALTER SCHEMA
alter schema tiger_data owner to rds_superuser;
ALTER SCHEMA
alter schema topology owner to rds_superuser;
ALTER SCHEMA
\dn
       List of schemas
     Name     |     Owner
--------------+---------------
 public       | myawsuser
 tiger        | rds_superuser
tiger_data    | rds_superuser
 topology     | rds_superuser
(4 rows)
```

Step 4: Transfer Ownership of the Objects to the rds_superuser Role

Use the following function to transfer ownership of the PostGIS objects to the `rds_superuser` role. Run the following statement from the psql prompt to create the function.

```
CREATE FUNCTION exec(text) returns text language plpgsql volatile AS $f$ BEGIN EXECUTE $1;
 RETURN $1; END; $f$;
```

Next, run this query to run the exec function that in turn executes the statements and alters the permissions.

```
SELECT exec('ALTER TABLE ' || quote_ident(s.nspname) || '.' || quote_ident(s.relname) || '
 OWNER TO rds_superuser;')
  FROM (
    SELECT nspname, relname
    FROM pg_class c JOIN pg_namespace n ON (c.relnamespace = n.oid)
    WHERE nspname in ('tiger','topology') AND
    relkind IN ('r','S','v') ORDER BY relkind = 'S')
```

```
s;
```

Step 5: Test the Extensions

Add `tiger` to your search path using the following command.

```
SET search_path=public,tiger;
```

Test `tiger` by using the following SELECT statement.

```
select na.address, na.streetname, na.streettypeabbrev, na.zip
from normalize_address('1 Devonshire Place, Boston, MA 02109') as na;
 address | streetname | streettypeabbrev |  zip
---------+------------+------------------+-------
       1 | Devonshire | Pl               | 02109
(1 row)
```

Test `topology` by using the following SELECT statement.

```
select topology.createtopology('my_new_topo',26986,0.5);
 createtopology
----------------
              1
(1 row)
```

Using pgBadger for Log Analysis with PostgreSQL

You can use a log analyzer such as pgbadger to analyze PostgreSQL logs. The *pgbadger* documentation states that the %l pattern (log line for session/process) should be a part of the prefix. However, if you provide the current rds log_line_prefix as a parameter to *pgbadger* it should still produce a report.

For example, the following command correctly formats an Amazon RDS PostgreSQL log file dated 2014-02-04 using *pgbadger*.

```
./pgbadger -p '%t:%r:%u@%d:[%p]:' postgresql.log.2014-02-04-00
```

Viewing the Contents of pg_config

In PostgreSQL version 9.6.1, you can see the compile-time configuration parameters of the currently installed version of PostgreSQL using the new view pg_config. You can use the view by calling the pg_config function as shown in the following sample.

```
select * from pg_config();
       name         |             setting

-------------------
+-----------------------------------------------------------------------
------------------------------------------------------------------------------------------
 BINDIR             | /rdsdbbin/postgres-9.6.1.R1/bin
 DOCDIR             | /rdsdbbin/postgres-9.6.1.R1/share/doc
 HTMLDIR            | /rdsdbbin/postgres-9.6.1.R1/share/doc
 INCLUDEDIR         | /rdsdbbin/postgres-9.6.1.R1/include
 PKGINCLUDEDIR      | /rdsdbbin/postgres-9.6.1.R1/include
```

```
 INCLUDEDIR-SERVER | /rdsdbbin/postgres-9.6.1.R1/include/server
 LIBDIR            | /rdsdbbin/postgres-9.6.1.R1/lib
 PKGLIBDIR         | /rdsdbbin/postgres-9.6.1.R1/lib
 LOCALEDIR         | /rdsdbbin/postgres-9.6.1.R1/share/locale
 MANDIR            | /rdsdbbin/postgres-9.6.1.R1/share/man
 SHAREDIR          | /rdsdbbin/postgres-9.6.1.R1/share
 SYSCONFDIR        | /rdsdbbin/postgres-9.6.1.R1/etc
 PGXS              | /rdsdbbin/postgres-9.6.1.R1/lib/pgxs/src/makefiles/pgxs.mk
 CONFIGURE         | '--prefix=/rdsdbbin/postgres-9.6.1.R1' '--with-openssl' '--with-perl'
 '--with-tcl' '--with-ossp-uuid' '--with-libxml' '--with-libraries=/rdsdbbin
/postgres-9.6.1.R1/lib' '--with-includes=/rdsdbbin/postgres-9.6.1.R1/include' '--enable-
debug'
 CC                | gcc
 CPPFLAGS          | -D_GNU_SOURCE -I/usr/include/libxml2 -I/rdsdbbin/postgres-9.6.1.R1/
include
 CFLAGS            | -Wall -Wmissing-prototypes -Wpointer-arith -Wdeclaration-after-
statement
 -Wendif-labels -Wmissing-format-attribute -Wformat-security -fno-strict-
aliasing -fwrapv -fexcess-precision=standard -g -O2
 CFLAGS_SL         | -fpic
 LDFLAGS           | -L../../src/common -L/rdsdbbin/postgres-9.6.1.R1/lib -Wl,--as-needed -
Wl,
 -rpath,'/rdsdbbin/postgres-9.6.1.R1/lib',--enable-new-dtags
 LDFLAGS_EX        |
 LDFLAGS_SL        |
 LIBS              | -lpgcommon -lpgport -lxml2 -lssl -lcrypto -lz -lreadline -lrt -lcrypt
 -ldl -lm
 VERSION           | PostgreSQL 9.6.1
(23 rows)
```

If you attempt to access the view directly, the request fails.

```
select * from pg_config;
ERROR:  permission denied for relation pg_config
```

Working with the orafce Extension

The `orafce` extension provides functions that are common in commercial databases, and can make it easier for you to port a commercial database to PostgreSQL. Amazon RDS for PostgreSQL versions 9.6.6 and later support this extension. For more information about `orafce`, see the orafce project on GitHub.

> **Note**
> Amazon RDS for PostgreSQL doesn't support the `utl_file` package that is part of the `orafce` extension. This is because the `utl_file` schema functions provide read and write operations on operating-system text files, which requires superuser access to the underlying host.

To use the orafce extension

1. Connect to the DB instance with the master user name that you used to create the DB instance.

   > **Note**
   > If you want to enable `orafce` on a different database in the same instance, use the `/c dbname` psql command to change from the master database after initiating the connection.

2. Enable the orafce extension with the `CREATE EXTENSION` statement.

   ```
   CREATE EXTENSION orafce;
   ```

3. Transfer ownership of the oracle schema to the rds_superuser role with the `ALTER SCHEMA` statement.

```
ALTER SCHEMA oracle OWNER TO rds_superuser;
```

Note
If you want to see the list of owners for the oracle schema, use the `\dn` psql command.

Accessing External Data with the postgres_fdw Extension

You can access data in a table on a remote database server with the postgres_fdw extension. If you set up a remote connection from your PostgreSQL DB instance, access is also available to your read replica.

To use postgres_fdw to access a remote database server

1. Install the postgres_fdw extension.

```
CREATE EXTENSION postgres_fdw;
```

2. Create a foreign data server using CREATE SERVER.

```
CREATE SERVER foreign_server
FOREIGN DATA WRAPPER postgres_fdw
OPTIONS (host 'xxx.xx.xxx.xx', port '5432', dbname 'foreign_db');
```

3. Create a user mapping to identify the role to be used on the remote server.

```
CREATE USER MAPPING FOR local_user
SERVER foreign_server
OPTIONS (user 'foreign_user', password 'password');
```

4. Create a table that maps to the table on the remote server.

```
CREATE FOREIGN TABLE foreign_table (
        id integer NOT NULL,
        data text)
SERVER foreign_server
OPTIONS (schema_name 'some_schema', table_name 'some_table');
```

Using a Custom DNS Server for Outbound Network Access

Amazon RDS for PostgreSQL supports outbound network access on your DB instances and allows Domain Name Service (DNS) resolution from a custom DNS server owned by the customer. You can resolve only fully qualified domain names from your Amazon RDS DB instance through your custom DNS server.

Topics

Enabling Custom DNS Resolution

To enable DNS resolution in your customer VPC, associate a custom DB parameter group to your RDS PostgreSQL instance, turn on the `rds.custom_dns_resolution` parameter by setting it to 1, and then restart the DB instance for the changes to take place.

Disabling Custom DNS Resolution

To disable DNS resolution in your customer VPC, turn off the `rds.custom_dns_resolution` parameter of your custom DB parameter group by setting it to 0, then restart the DB instance for the changes to take place.

Setting Up a Custom DNS Server

After you set up your custom DNS name server, it takes up to 30 minutes to propagate the changes to your DB instance. After the changes are propagated to your DB instance, all outbound network traffic requiring a DNS lookup queries your DNS server over port 53.

> **Note**
> If you don't set up a custom DNS server, and `rds.custom_dns_resolution` is set to 1, hosts are resolved using a Route 53 private zone. For more information, see Working with Private Hosted Zones.

To set up a custom DNS server for your Amazon RDS PostgreSQL DB instance

1. From the DHCP options set attached to your VPC, set the `domain-name-servers` option to the IP address of your DNS name server. For more information, see DHCP Options Sets.

   > **Note**
   > The `domain-name-servers` option accepts up to four values, but your Amazon RDS DB instance uses only the first value.
2. Ensure that your DNS server can resolve all lookup queries, including public DNS names, Amazon EC2 private DNS names, and customer-specific DNS names. If the outbound network traffic contains any DNS lookups that your DNS server can't handle, your DNS server must have appropriate upstream DNS providers configured.
3. Configure your DNS server to produce User Datagram Protocol (UDP) responses of 512 bytes or less.
4. Configure your DNS server to produce Transmission Control Protocol (TCP) responses of 1024 bytes or less.
5. Configure your DNS server to allow inbound traffic from your Amazon RDS DB instances over port 53. If your DNS server is in an Amazon VPC, the VPC must have a security group that contains inbound rules that allow UDP and TCP traffic on port 53. If your DNS server is not in an Amazon VPC, it must have appropriate firewall whitelisting to allow UDP and TCP inbound traffic on port 53.

   For more information, see Security Groups for Your VPC and Adding and Removing Rules.
6. Configure the VPC of your Amazon RDS DB instance to allow outbound traffic over port 53. Your VPC must have a security group that contains outbound rules that allow UDP and TCP traffic on port 53.

For more information, see Security Groups for Your VPC and Adding and Removing Rules.

7. The routing path between the Amazon RDS DB instance and the DNS server has to be configured correctly to allow DNS traffic.

   If the Amazon RDS DB instance and the DNS server are not in the same VPC, a peering connection has to be set up between them. For more information, see What is VPC Peering?

Restricting Password Management

You can restrict who can manage database user passwords to a special role. By doing this, you can have more control over password management on the client side.

You enable restricted password management with the static parameter `rds.restrict_password_commands` and use a role called `rds_password`. When the parameter `rds.restrict_password_commands` is set to 1, only users that are members of the `rds_password` role can run certain SQL commands. The restricted SQL commands are commands that modify database user passwords and password expiration time.

To use restricted password management, your DB instance must be running Amazon RDS for PostgreSQL 10.6 or higher. Because the `rds.restrict_password_commands` parameter is static, changing this parameter requires a database restart.

When a database has restricted password management enabled, if you try to run restricted SQL commands you get the following error: ERROR: must be a member of rds_password to alter passwords.

Following are some examples of SQL commands that are restricted when restricted password management is enabled.

```
postgres=> CREATE ROLE myrole WITH PASSWORD 'mypassword';
postgres=> CREATE ROLE myrole WITH PASSWORD 'mypassword' VALID UNTIL '2020-01-01';
postgres=> ALTER ROLE myrole WITH PASSWORD 'mypassword' VALID UNTIL '2020-01-01';
postgres=> ALTER ROLE myrole WITH PASSWORD 'mypassword';
postgres=> ALTER ROLE myrole VALID UNTIL '2020-01-01';
postgres=> ALTER ROLE myrole RENAME TO myrole2;
```

Some `ALTER ROLE` commands that include `RENAME TO` might also be restricted. They might be restricted because renaming a PostgreSQL role that has an MD5 password clears the password.

The `rds_superuser` role has membership for the `rds_password` role by default, and you can't change this. You can give other roles membership for the `rds_password` role by using the `GRANT` SQL command. We recommend that you give membership to `rds_password` to only a few roles that you use solely for password management. These roles require the `CREATEROLE` attribute to modify other roles.

Make sure that you verify password requirements such as expiration and needed complexity on the client side. We recommend that you restrict password-related changes by using your own client-side utility. This utility should have a role that is a member of `rds_password` and has the `CREATEROLE` role attribute.

Using Kerberos Authentication with Amazon RDS for PostgreSQL

You can use Kerberos authentication to authenticate users when they connect to your DB instance running PostgreSQL. In this case, your DB instance works with AWS Directory Service for Microsoft Active Directory to enable Kerberos authentication. AWS Directory Service for Microsoft Active Directory is also called AWS Managed Microsoft AD.

You create an AWS Managed Microsoft AD directory to store user credentials. You then provide to your PostgreSQL DB instance the Active Directory's domain and other information. When users authenticate with the PostgreSQL DB instance, authentication requests are forwarded to the AWS Managed Microsoft AD directory.

Keeping all of your credentials in the same directory can save you time and effort. You have a centralized place for storing and managing credentials for multiple DB instances. Using a directory can also improve your overall security profile.

Kerberos provides a different authentication method than AWS Identity and Access Management (IAM). A database can use either Kerberos or IAM authentication but not both. For more information about IAM authentication, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).

Amazon RDS supports Kerberos authentication for PostgreSQL DB instances in the following AWS Regions:

- US East (Ohio)
- US East (N. Virginia)
- US West (N. California)
- US West (Oregon)
- Asia Pacific (Mumbai)
- Asia Pacific (Seoul)
- Asia Pacific (Singapore)
- Asia Pacific (Sydney)
- Asia Pacific (Tokyo)
- Canada (Central)
- Europe (Frankfurt)
- Europe (Ireland)
- Europe (London)
- Europe (Stockholm)
- South America (São Paulo)
- China (Beijing)
- China (Ningxia)

Topics

Overview of Kerberos Authentication for PostgreSQL DB Instances

To set up Kerberos authentication for a PostgreSQL DB instance, take the following steps, described in more detail later:

1. Use AWS Managed Microsoft AD to create an AWS Managed Microsoft AD directory. You can use the AWS Management Console, the AWS CLI, or the AWS Directory Service API to create the directory.
2. Create a role that provides Amazon RDS access to make calls to your AWS Managed Microsoft AD directory. To do so, create an AWS Identity and Access Management (IAM) role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`.

   For the IAM role to allow access, the AWS Security Token Service (AWS STS) endpoint must be activated in the correct AWS Region for your AWS account. AWS STS endpoints are active by default in all AWS Regions, and you can use them without any further actions. For more information, see Activating and Deactivating AWS STS in an AWS Region in the *IAM User Guide*.
3. Create and configure users in the AWS Managed Microsoft AD directory using the Microsoft Active Directory tools. For more information about creating users in your Active Directory, see Manage Users and Groups in AWS Managed Microsoft AD in the *AWS Directory Service Administration Guide*.
4. If you plan to locate the directory and the DB instance in different virtual private clouds (VPCs), configure VPC peering. For more information, see What Is VPC Peering? in the *Amazon VPC Peering Guide*.
5. Create or modify a PostgreSQL DB instance either from the console, CLI, or RDS API using one of the following methods:
   - Creating an Amazon RDS DB Instance (p. 136)
   - Modifying an Amazon RDS DB Instance (p. 220)
   - Restoring from a DB Snapshot (p. 303)
   - Restoring a DB Instance to a Specified Time (p. 336)

   When you create or modify the DB instance, provide the domain identifier (`d-*` identifier) that was generated when you created your directory. Also provide the name of the IAM role that you created. You can locate the DB instance in the same VPC as the directory or in a different VPC.
6. Use the RDS master user credentials to connect to the PostgreSQL DB instance. Create the user in PostgreSQL to be identified externally. Externally identified users can log in to the PostgreSQL DB instance using Kerberos authentication.

Setting Up Kerberos Authentication for PostgreSQL DB Instances

You use AWS Directory Service for Microsoft Active Directory (AWS Managed Microsoft AD) to set up Kerberos authentication for a PostgreSQL DB instance. To set up Kerberos authentication, take the following steps.

Topics

- Step 7: Configure a PostgreSQL Client (p. 1305)

Step 1: Create a Directory Using AWS Managed Microsoft AD

AWS Directory Service creates a fully managed Active Directory in the AWS Cloud. When you create an AWS Managed Microsoft AD directory, AWS Directory Service creates two domain controllers and DNS servers for you. The directory servers are created in different subnets in a VPC. This redundancy helps make sure that your directory remains accessible even if a failure occurs.

When you create an AWS Managed Microsoft AD directory, AWS Directory Service performs the following tasks on your behalf:

- Sets up an Active Directory within your VPC.
- Creates a directory administrator account with the user name `Admin` and the specified password. You use this account to manage your directory.

  Important
  Make sure to save this password. AWS Directory Service doesn't store this password, and it can't be retrieved or reset.
- Creates a security group for the directory controllers.

When you launch AWS Directory Service for Microsoft Active Directory, AWS creates an Organizational Unit (OU) that contains all of your directory's objects. This OU, which has the NetBIOS name that you entered when you created your directory, is located in the domain root. The domain root is owned and managed by AWS.

The `Admin` account that was created with your AWS Managed Microsoft AD directory has permissions for the most common administrative activities for your OU:

- Create, update, or delete users
- Add resources to your domain such as file or print servers, and then assign permissions for those resources to users in your OU
- Create additional OUs and containers
- Delegate authority
- Restore deleted objects from the Active Directory Recycle Bin
- Run Active Directory and Domain Name Service (DNS) modules for Windows PowerShell on the Active Directory Web Service

The `Admin` account also has rights to perform the following domain-wide activities:

- Manage DNS configurations (add, remove, or update records, zones, and forwarders)
- View DNS event logs
- View security event logs

To create a directory with AWS Managed Microsoft AD

1. In the AWS Directory Service console navigation pane, choose **Directories**, and then choose **Set up directory**.
2. Choose **AWS Managed Microsoft AD**. AWS Managed Microsoft AD is the only option currently supported for use with Amazon RDS.
3. Choose **Next**.
4. On the **Enter directory information** page, provide the following information:

Edition

Choose the edition that meets your requirements.

Directory DNS name

The fully qualified name for the directory, such as **`corp.example.com`**.

Directory NetBIOS name

An optional short name for the directory, such as `CORP`.

Directory description

An optional description for the directory.

Admin password

The password for the directory administrator. The directory creation process creates an administrator account with the user name `Admin` and this password.

The directory administrator password can't include the word "admin." The password is case-sensitive and must be 8–64 characters in length. It must also contain at least one character from three of the following four categories:

- Lowercase letters (a–z)
- Uppercase letters (A–Z)
- Numbers (0–9)
- Nonalphanumeric characters (~!@#$%^&*_-+=`|\(){}[]:;"'<>,.?/)

Confirm password

Retype the administrator password.

> **Important**
> Make sure that you save this password. AWS Directory Service doesn't store this password, and it can't be retrieved or reset.

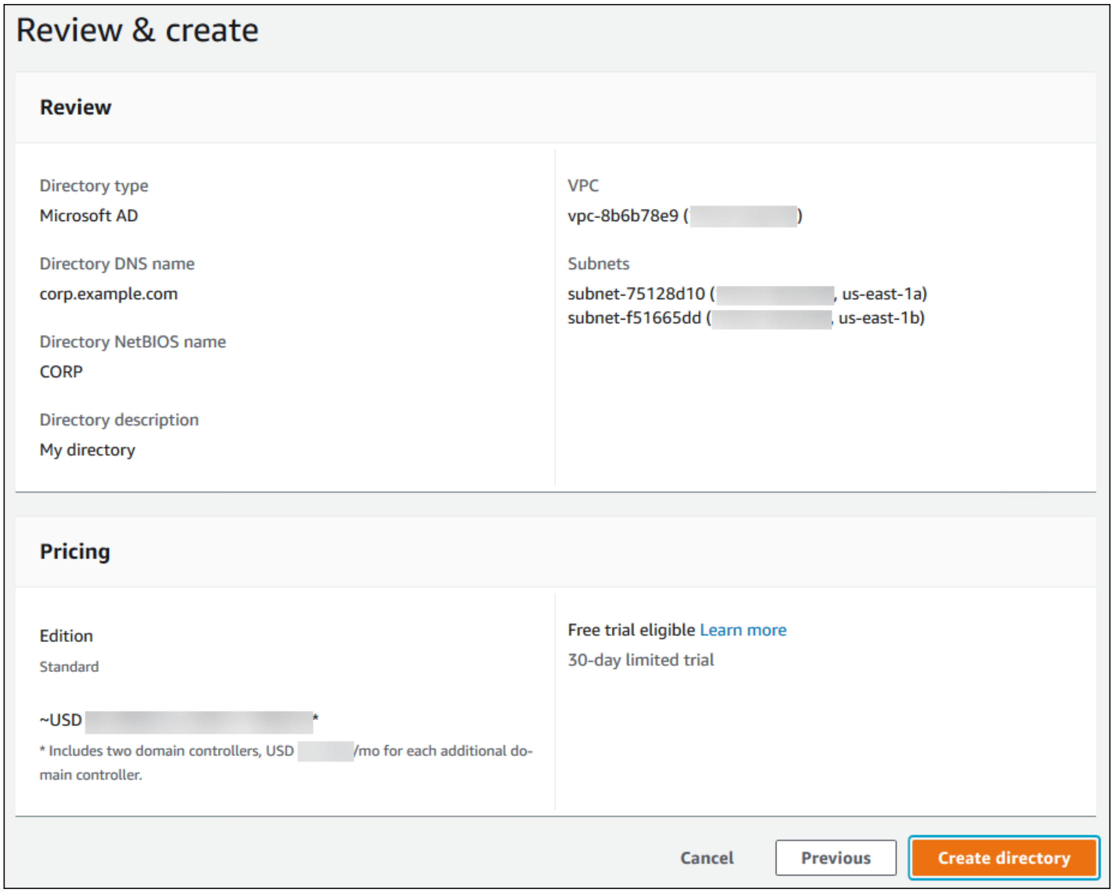
5. Choose **Next**.
6. On the **Choose VPC and subnets** page, provide the following information:

   VPC

   Choose the VPC for the directory. You can create the PostgreSQL DB instance in this same VPC or in a different VPC.

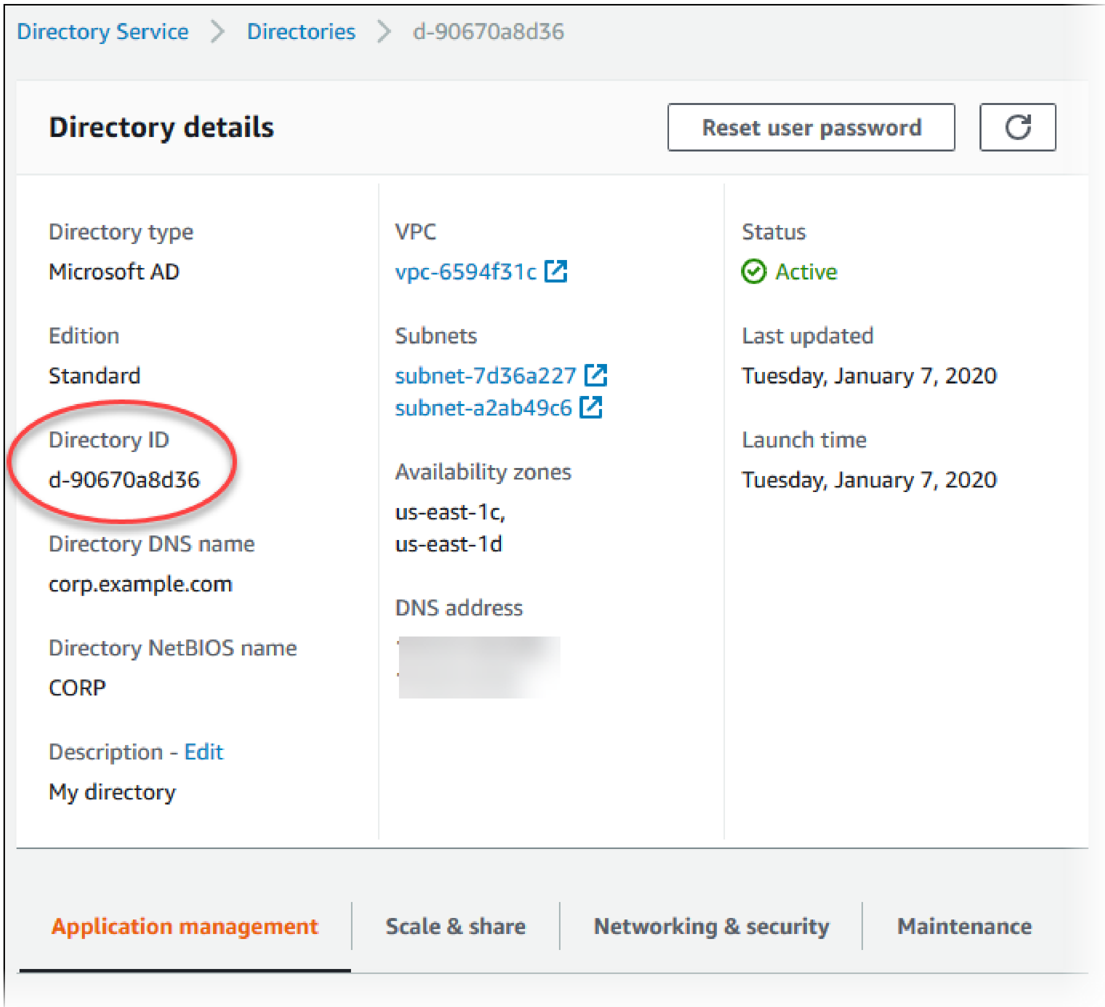
   Subnets

   Choose the subnets for the directory servers. The two subnets must be in different Availability Zones.
7. Choose **Next**.
8. Review the directory information. If changes are needed, choose **Previous** and make the changes. When the information is correct, choose **Create directory**.



It takes several minutes for the directory to be created. When it has been successfully created, the **Status** value changes to **Active**.

To see information about your directory, choose the directory ID in the directory listing. Make a note of the **Directory ID** value. You need this value when you create or modify your PostgreSQL DB instance.



Step 2: Create an IAM Role for Amazon RDS to Access the AWS Directory Service

For Amazon RDS to call AWS Directory Service for you, an IAM role that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess` is required. This role allows Amazon RDS to make calls to AWS Directory Service.

When a DB instance is created using the AWS Management Console and the console user has the `iam:CreateRole` permission, the console creates this role automatically. In this case, the role name is `rds-directoryservice-kerberos-access-role`. Otherwise, create the IAM role manually. When you create this IAM role, choose `Directory Service`, and attach the AWS managed policy `AmazonRDSDirectoryServiceAccess` to it.

For more information about creating IAM roles for a service, see Creating a Role to Delegate Permissions to an AWS Service in the *IAM User Guide*.

> **Note**
> The IAM role used for Windows Authentication for RDS for Microsoft SQL Server can't be used for Amazon RDS for PostgreSQL.

Optionally, you can create policies with the required permissions instead of using the managed IAM policy `AmazonRDSDirectoryServiceAccess`. In this case, the IAM role must have the following IAM trust policy.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": [
          "directoryservice.rds.amazonaws.com",
          "rds.amazonaws.com"
        ]
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

The role must also have the following IAM role policy.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "ds:DescribeDirectories",
        "ds:AuthorizeApplication",
        "ds:UnauthorizeApplication",
        "ds:GetAuthorizedApplicationDetails"
      ],
    "Effect": "Allow",
    "Resource": "*"
    }
  ]
}
```

Step 3: Create and Configure Users

You can create users by using the Active Directory Users and Computers tool, which is one of the Active Directory Domain Services and Active Directory Lightweight Directory Services tools. In this case, *users* are individual people or entities that have access to your directory.

To create users in an AWS Directory Service directory, you must be connected to a Windows-based Amazon EC2 instance. Also, this EC2 instance must be a member of the AWS Directory Service directory. At the same time, you must be logged in as a user that has privileges to create users. For more information, see Create a User in the *AWS Directory Service Administration Guide*.

Step 4: Configure VPC Peering

If you plan to locate the directory and the DB instance in the same VPC, skip this step and move on to Step 5: Create or Modify a PostgreSQL DB Instance (p. 1303). If you plan to locate the directory and the DB instance in different VPCs, configure VPC peering by following the instructions in this step.

If the same AWS account owns both VPCs, follow the instructions in What Is VPC Peering? in the *Amazon VPC Peering Guide*. Specifically, complete the following steps:

1. Set up appropriate VPC routing rules to make sure that the network traffic can flow both ways.

2. Ensure the DB instance's security group can receive ingress traffic from this security group.
3. Ensure that there is no network access control list (ACL) rule to block traffic.

If different AWS accounts own the VPCs, complete the following steps:

1. Configure VPC peering by following the instructions in What Is VPC Peering? Specifically, complete the following steps:
   a. Set up appropriate VPC routing rules to make sure that the network traffic can flow both ways.
   b. Make sure that there is no ACL rule to block traffic.
2. Start sharing the directory with the AWS account where you plan to create the DB instance. To do this, follow the instructions in Tutorial: Sharing Your AWS Managed Microsoft AD Directory for Seamless EC2 Domain-Join in the *AWS Directory Service Administration Guide*.
3. Sign in to the AWS Directory Service console using the account for the DB instance, and make sure that the domain has the `SHARED` status before proceeding.
4. While logged into the AWS Directory Service console using the account for the DB instance, make a note of the **Directory ID** value for the directory.

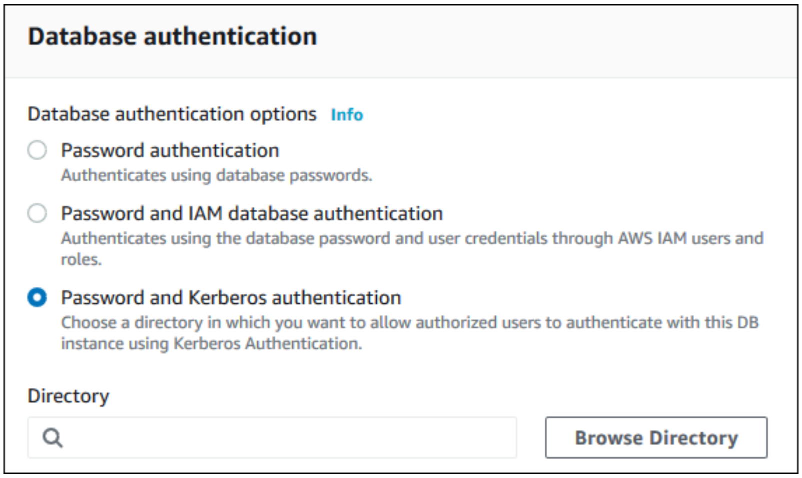
Step 5: Create or Modify a PostgreSQL DB Instance

Create or modify a PostgreSQL DB instance for use with your directory. You can use the console, CLI, or RDS API to associate a DB instance with a directory. You can do this in one of the following ways:

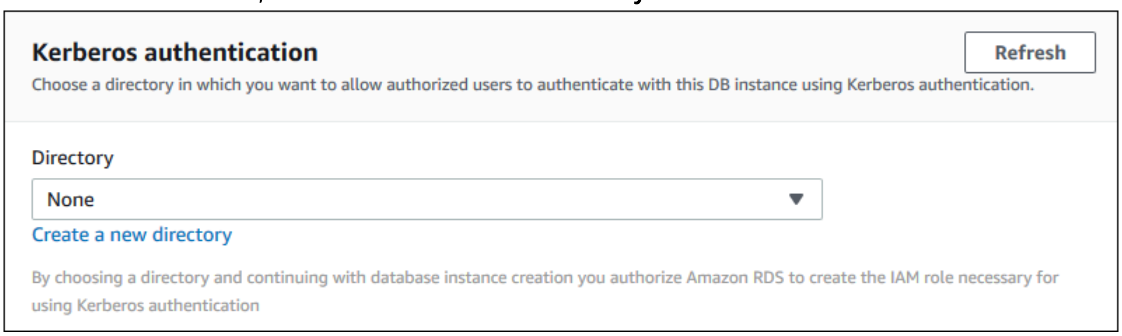
- Create a new PostgreSQL DB instance using the console, the create-db-instance CLI command, or the CreateDBInstance RDS API operation. For instructions, see Creating an Amazon RDS DB Instance (p. 136).
- Modify an existing PostgreSQL DB instance using the console, the modify-db-instance CLI command, or the ModifyDBInstance RDS API operation. For instructions, see Modifying an Amazon RDS DB Instance (p. 220).
- Restore a PostgreSQL DB instance from a DB snapshot using the console, the restore-db-instance-from-db-snapshot CLI command, or the RestoreDBInstanceFromDBSnapshot RDS API operation. For instructions, see Restoring from a DB Snapshot (p. 303).
- Restore a PostgreSQL DB instance to a point-in-time using the console, the restore-db-instance-to-point-in-time CLI command, or the RestoreDBInstanceToPointInTime RDS API operation. For instructions, see Restoring a DB Instance to a Specified Time (p. 336).

Kerberos authentication is only supported for PostgreSQL DB instancesin a VPC. The DB instance can be in the same VPC as the directory, or in a different VPC. The DB instance must use a security group that allows egress within the directory's VPC so the DB instance can communicate with the directory.

When you use the console to create a DB instance, choose **Password and Kerberos authentication** in the **Database authentication** section. Choose **Browse Directory** and then select the directory, or choose **Create a new directory**.



When you use the console to modify or restore a DB instance, choose the directory in the **Kerberos authentication** section, or choose **Create a new directory**.



When you use the AWS CLI, the following parameters are required for the DB instance to be able to use the directory that you created:

- For the `--domain` parameter, use the domain identifier ("d-*" identifier) generated when you created the directory.
- For the `--domain-iam-role-name` parameter, use the role you created that uses the managed IAM policy `AmazonRDSDirectoryServiceAccess`.

For example, the following CLI command modifies a DB instance to use a directory.

```
aws rds modify-db-instance --db-instance-identifier mydbinstance --domain d-Directory-ID --
domain-iam-role-name role-name
```

> **Important**
> If you modify a DB instance to enable Kerberos authentication, reboot the DB instance after making the change.

Step 6: Create Kerberos Authentication PostgreSQL Logins

Next, use the RDS master user credentials to connect to the PostgreSQL DB instance as you do with any other DB instance. The DB instance is joined to the AWS Managed Microsoft AD domain. Thus, you can provision PostgreSQL logins and users from the Microsoft Active Directory users and groups in your domain. To manage database permissions, you grant and revoke standard PostgreSQL permissions to these logins.

To allow an Active Directory user to authenticate with PostgreSQL, use the RDS master user credentials. You use these credentials to connect to the PostgreSQL DB instance as you do with any other DB instance. After you're logged in, create an externally authenticated user in PostgreSQL and grant the `rds_ad` role to this user.

```
CREATE USER "username@CORP.EXAMPLE.COM" WITH LOGIN;
GRANT rds_ad TO "username@CORP.EXAMPLE.COM";
```

Replace *username* with the user name and include the domain name in uppercase. Users (both humans and applications) from your domain can now connect to the RDS PostgreSQL instance from a domain-joined client machine using Kerberos authentication.

Step 7: Configure a PostgreSQL Client

To configure a PostgreSQL client, take the following steps:

- Create a krb5.conf file (or equivalent) to point to the domain.
- Verify that traffic can flow between the client host and AWS Directory Service. Use a network utility such as Netcat for the following:
  - Verify traffic over DNS for port 53.
  - Verify traffic over TCP/UDP for port 53 and for Kerberos, which includes ports 88 and 464 for AWS Directory Service.
- Verify that traffic can flow between the client host and the DB instance over the database port. For example, use psql to connect and access the database.

The following is sample krb5.conf content for AWS Managed Microsoft AD.

```
[libdefaults]
 default_realm = EXAMPLE.COM
 default_ccache_name = /tmp/kerbcache
[realms]
 EXAMPLE.COM = {
  kdc = example.com
  admin_server = example.com
 }
[domain_realm]
 .example.com = EXAMPLE.COM
 example.com = EXAMPLE.COM
```

Managing a DB Instance in a Domain

You can use the console, the CLI, or the RDS API to manage your DB instance and its relationship with your Microsoft Active Directory. For example, you can associate an Active Directory to enable Kerberos authentication. You can also remove the association for an Active Directory to disable Kerberos authentication. You can also move a DB instance to be externally authenticated by one Microsoft Active Directory to another.

For example, using the CLI, you can do the following:

- To reattempt enabling Kerberos authentication for a failed membership, use the modify-db-instance CLI command. Specify the current membership's directory ID for the `--domain` option.
- To disable Kerberos authentication on a DB instance, use the modify-db-instance CLI command. Specify `none` for the `--domain` option.
- To move a DB instance from one domain to another, use the modify-db-instance CLI command. Specify the domain identifier of the new domain for the `--domain` option.

Understanding Domain Membership

After you create or modify your DB instance, it becomes a member of the domain. You can view the status of the domain membership in the console or by running the describe-db-instances CLI command. The status of the DB instance can be one of the following:

- `kerberos-enabled` – The DB instance has Kerberos authentication enabled.
- `enabling-kerberos` – AWS is in the process of enabling Kerberos authentication on this DB instance.
- `pending-enable-kerberos` – Enabling Kerberos authentication is pending on this DB instance.
- `pending-maintenance-enable-kerberos` – AWS will attempt to enable Kerberos authentication on the DB instance during the next scheduled maintenance window.
- `pending-disable-kerberos` – Disabling Kerberos authentication is pending on this DB instance.
- `pending-maintenance-disable-kerberos` – AWS will attempt to disable Kerberos authentication on the DB instance during the next scheduled maintenance window.
- `enable-kerberos-failed` – A configuration problem prevented AWS from enabling Kerberos authentication on the DB instance. Correct the configuration problem before reissuing the command to modify the DB instance.
- `disabling-kerberos` – AWS is in the process of disabling Kerberos authentication on this DB instance.

A request to enable Kerberos authentication can fail because of a network connectivity issue or an incorrect IAM role. In some cases, the attempt to enable Kerberos authentication might fail when you create or modify a DB instance. If so, make sure that you are using the correct IAM role, then modify the DB instance to join the domain.

> **Note**
> Only Kerberos authentication with RDS for PostgreSQL sends traffic to the domain's DNS servers. All other DNS requests are treated as outbound network access on your DB instances running PostgreSQL. For more information about outbound network access with RDS for PostgreSQL, see Using a Custom DNS Server for Outbound Network Access (p. 1293).

Connecting to PostgreSQL with Kerberos Authentication

You can connect to PostgreSQL with Kerberos authentication with the pgAdmin interface or with a command line interface such as psql. For more information about connecting, see Connecting to a DB Instance Running the PostgreSQL Database Engine (p. 1226) .

pgAdmin

To use pgAdmin to connect to PostgreSQL with Kerberos authentication, take the following steps:

1. Launch the pgAdmin application on your client computer.
2. On the **Dashboard** tab, choose **Add New Server**.
3. In the **Create - Server** dialog box, enter a name on the **General** tab to identify the server in pgAdmin.
4. On the **Connection** tab, enter the following information from your RDS for PostgreSQL database:
   - For **Host**, enter the endpoint. Use a format such as *`PostgreSQL-endpoint`*`.`*`AWS-Region`***`.rds.amazonaws.com`**.
   - For **Port**, enter the assigned port.
   - For **Maintenance database**, enter the name of the initial database to which the client will connect.

- For **Username**, enter the user name that you entered for Kerberos authentication in Step 6: Create Kerberos Authentication PostgreSQL Logins (p. 1304).

5. Choose **Save**.

psql

To use psql to connect to PostgreSQL with Kerberos authentication, take the following steps:

1. At a command prompt, run the following command.

```
kinit username
```

   Replace *username* with the user name. At the prompt, enter the password stored in the Microsoft Active Directory for the user.

2. If the PostgreSQL DB instance is using a publicly accessible VPC, put a private IP address for your DB instance endpoint in your `/etc/hosts` file on the EC2 client. For example, the following commands obtain the private IP address and then put it in the `/etc/hosts` file.

```
% dig +short PostgreSQL-endpoint.AWS-Region.rds.amazonaws.com
;; Truncated, retrying in TCP mode.
ec2-34-210-197-118.AWS-Region.compute.amazonaws.com.
34.210.197.118

% echo " 34.210.197.118  PostgreSQL-endpoint.AWS-Region.rds.amazonaws.com" >> /etc/hosts
```

3. Use the following psql command to log in to a PostgreSQL DB instance that is integrated with Active Directory.

```
psql -U username@CORP.EXAMPLE.COM -p 5432 -h PostgreSQL-instance-endpoint.AWS-
Region.rds.amazonaws.com postgres
```

Working with the Database Preview Environment

When you create a DB instance in Amazon RDS, you know that the PostgreSQL version it's based on has been tested and is fully supported by Amazon. The PostgreSQL community releases new versions and new extensions continuously. You can try out new PostgreSQL versions and extensions before they are fully supported. To do that, you can create a new DB instance in the Database Preview Environment.

DB instances in the Database Preview Environment are similar to DB instances in a production environment. However, keep in mind several important factors:

- All DB instances are deleted 60 days after you create them, along with any backups and snapshots.
- You can only create a DB instance in a virtual private cloud (VPC) based on the Amazon VPC service.
- You can only create M4, T2, and R4 instance types. For more information about RDS instance classes, see DB Instance Classes (p. 7).
- You can't get help from AWS Support with DB instances. You can post your questions in the RDS Database Preview Environment Forum.
- You can only use General Purpose SSD and Provisioned IOPS SSD storage.
- You can't copy a snapshot of a DB instance to a production environment.
- Some Amazon RDS features aren't available in the preview environment, as described following.

Topics

Features Not Supported in the Preview Environment

The following features are not available in the preview environment:

- Cross-region snapshot copy
- Cross-region read replicas
- Extensions not in the following table of supported extensions

PostgreSQL Extensions Supported in the Preview Environment

The PostgreSQL extensions supported in the Database Preview Environment are listed in the following table.

Extension	Version
amcheck	1.1
bloom	1.0
btree_gin	1.3
btree_gist	1.5
citext	1.5
cube	1.4
dblink	1.2
dict_int	1.0
dict_xsyn	1.0
earthdistance	1.1
fuzzystrmatch	1.1
hstore	1.5
hstore_plper	1.0
intagg	1.1
intarray	1.2
isn	1.2
log_fdw	1.0

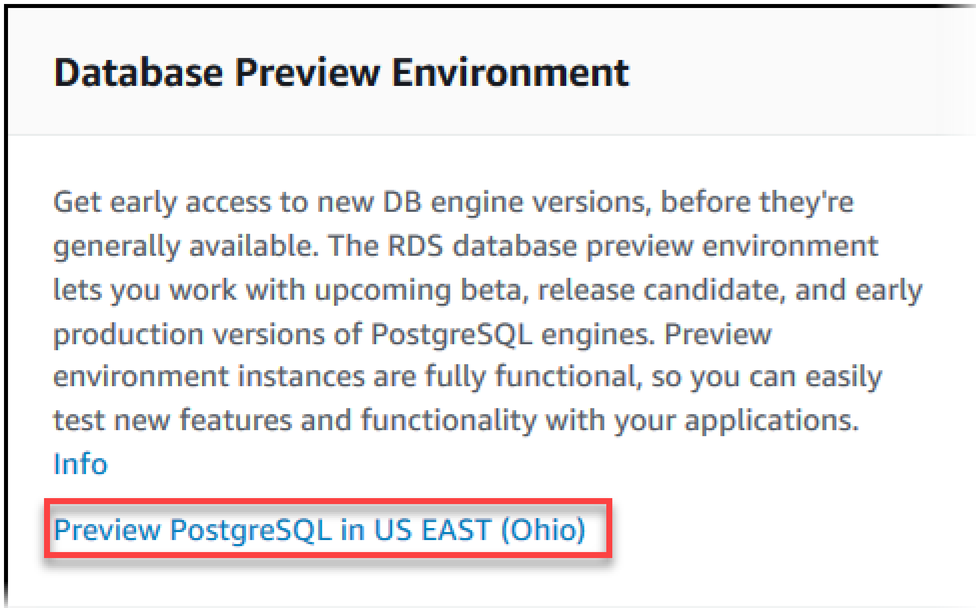
Extension	Version
ltree	1.1
pg_buffercache	1.3
pg_freespacemap	1.2
pg_prewarm	1.2
pg_stat_statements	1.5
pg_trgm	1.4
pg_visibility	1.2
pgcrypto	1.3
pgrowlocks	1.2
pgstattuple	1.5
plperl	1.0
plpgsql	1.0
pltcl	1.0
postgres_fdw	1.0
sslinfo	1.2
tablefunc	1.0
test_parser	1.0
tsm_system_rows	1.0
tsm_system_time	1.0
unaccent	1.1
uuid_ossp	1.1

Creating a New DB Instance in the Preview Environment

Use the following procedure to create a DB instance in the preview environment.

To create a DB instance in the preview environment

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. Choose **Dashboard** from the navigation pane.
3. Choose **Switch to database preview environment**.



You also can navigate directly to the Database Preview Environment.

> **Note**
> If you want to create an instance in the Database Preview Environment with the API or CLI, the endpoint is `rds-preview.us-east-2.amazonaws.com`.

4. Continue with the procedure as described in Console (p. 136).

Amazon RDS for PostgreSQL Versions and Extensions

Amazon RDS supports DB instances running several editions of PostgreSQL. Use this section to see how to work with PostgreSQL on Amazon RDS. You should also be aware of the limits for PostgreSQL DB instances.

You can specify any currently supported PostgreSQL version when creating a new DB instance. You can specify the major version (such as PostgreSQL 10), and any supported minor version for the specified major version. If no version is specified, Amazon RDS defaults to a supported version, typically the most recent version. If a major version is specified but a minor version is not, Amazon RDS defaults to a recent release of the major version you have specified. To see a list of supported versions, as well as defaults for newly created DB instances, use the `describe-db-engine-versions` AWS CLI command.

For information about importing PostgreSQL data into a DB instance, see Importing Data into PostgreSQL on Amazon RDS (p. 1248).

Topics

Supported PostgreSQL Database Versions

Amazon RDS supports the following PostgreSQL versions.

Topics

PostgreSQL 12 Versions

Minor Versions

PostgreSQL Version 12.2 on Amazon RDS

PostgreSQL version 12.2 is now available on Amazon RDS. PostgreSQL version 12.2 contains several improvements that were announced for PostgreSQL releases 12.0, 12.1, and 12.2.

For information on extensions and modules, see PostgreSQL Version 12 Extensions and Modules Supported on Amazon RDS (p. 1329).

PostgreSQL 11 Versions

Minor Versions

PostgreSQL Version 11.7 on Amazon RDS

PostgreSQL version 11.7 contains several bug fixes for issues in release 11.6. For more information on the fixes in PostgreSQL 11.7, see the PostgreSQL 11.7 documentation.

PostgreSQL Version 11.6 on Amazon RDS

PostgreSQL version 11.6 contains several bug fixes for issues in release 11.5. For more information on the fixes in PostgreSQL 11.6, see the PostgreSQL documentation.

This version also includes the following changes:

1. Upgraded the `pgTAP` extension to version 1.1.0.
2. Added the `plprofiler` extension.
3. Added to `shared_preload_libraries` support for `pg_prewarm` to start automatically.

PostgreSQL Version 11.5 on Amazon RDS

PostgreSQL version 11.5 contains several bug fixes for issues in release 11.4. For more information on the fixes in PostgreSQL 11.5, see the PostgreSQL documentation.

This version also includes the following changes:

- A new extension `pg_transport` is added.
- The extension `aws_s3` has been updated to support virtual-hosted style requests. For more information, see Amazon S3 Path Deprecation Plan – The Rest of the Story.
- The `PostGIS` extension is updated to version 2.5.2.

PostgreSQL Version 11.4 on Amazon RDS

This release contains an important security fix and also bug fixes and improvements done by the PostgreSQL community. For more information on the security fix, see the PostgreSQL community announcement and the security fix CVE-2019-10164.

With this release, the `pg_hint_plan` extension has been updated to version 1.3.4.

For more information on the fixes in PostgreSQL 11.4, see the PostgreSQL documentation.

PostgreSQL Version 11.2 on Amazon RDS

PostgreSQL version 11.2 contains several bug fixes for issues in release 11.1. For more information on the fixes in PostgreSQL 11.2, see the PostgreSQL documentation.

This version also includes the following changes:

- A new pgTAP extension version 1.0.
- Support for Amazon S3 import. For more information, see Importing Amazon S3 Data into an RDS for PostgreSQL DB Instance (p. 1251).
- Multiple major version upgrade is available to PostgreSQL 11.2 from certain previous PostgreSQL versions. For more information, see Major Version Upgrades for PostgreSQL (p. 1236).

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 11.1 on Amazon RDS

PostgreSQL version 11.1 contains several improvements that were announced in PostgreSQL 11.1 Released! This version includes SQL stored procedures that enable embedded transactions within a procedure. This version also includes major improvements to partitioning and parallelism and many useful performance improvements. For example, by using a non-null constant for a column default, you can now use an ALTER TABLE command to add a column without causing a table rewrite.

PostgreSQL version 11.1 contains several bug fixes for issues in release 11. For complete details, see the PostgreSQL Release 11.1 documentation. Some changes in this version include the following:

- Partitioning – Partitioning improvements include support for hash partitioning, enabling creation of a default partition, and dynamic row movement to another partition based on the key column update.
- Performance – Performance improvements include parallelism while creating indexes, materialized views, hash joins, and sequential scans to make the operations perform better.

- Stored procedures – SQL stored procedures now added support embedded transactions.
- Support for Just-In-Time (JIT) capability – RDS PostgreSQL 11 instances are created with JIT capability, speeding evaluation of expressions. To enable JIT capability, set the `jit` parameter to 1 in the PostgreSQL parameter group for the database.
- Segment size – The write-ahead logging (WAL) segment size has been changed from 16 MB to 64 MB.
- Autovacuum improvements – To provide valuable logging, the parameter `rds.force_autovacuum_logging` is ON by default in conjunction with the `log_autovacuum_min_duration` parameter set to 10 seconds. To increase autovacuum effectiveness, the values for the `autovacuum_max_workers` and `autovacuum_vacuum_cost_limit` parameters are computed based on host memory capacity to provide larger default values.
- Improved transaction timeout – The parameter `idle_in_transaction_session_timeout` is set to 12 hours. Any session that has been idle more than 12 hours is terminated.
- Performance metrics – The `pg_stat_statements` module is included in `shared_preload_libraries` by default. This avoids having to reboot the instance immediately after creation. However, this functionality still requires you to run the statement `CREATE EXTENSION pg_stat_statements;`. Also, `track_io_timing` is enabled by default to add more granular data to `pg_stat_statements`.
- The tsearch2 module is no longer supported – If your application uses `tsearch2` functions, update it to use the equivalent functions provided by the core PostgreSQL engine. For more information about the tsearch2 module, see PostgreSQL tsearch2.
- The chkpass module is no longer supported – For more information about the `chkpass` module, see PostgreSQL chkpass.
- Extension updates for RDS PostgreSQL 11.1 include the following:
  - `pgaudit` is updated to 1.3.0.
  - `pg_hint_plan` is updated to 1.3.2.
  - `pglogical` is updated to 2.2.1.
  - `plcoffee` is updated to 2.3.8.
  - `plv8` is updated to 2.3.8.
  - `PostGIS` is updated to 2.5.1.
  - `prefix` is updated to 1.2.8.
  - `wal2json` is updated to hash 9e962bad.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 11 on Amazon RDS in the Database Preview Environment

> **Note**
> PostgreSQL Version 11 on Amazon RDS has been released in the production environment. It is no longer supported in the Database Preview Environment.

PostgreSQL version 11 contains several improvements that are described in PostgreSQL 11 Released!

For information on the Database Preview Environment, see the section called "Working with the Database Preview Environment" (p. 1307). To access the Preview Environment from the console, select https://console.aws.amazon.com/rds-preview/.

PostgreSQL 10 Versions

Minor Versions

PostgreSQL Version 10.12 on Amazon RDS

PostgreSQL version 10.12 contains several bug fixes for issues in release 10.11. For more information on the fixes in PostgreSQL 10.12, see the PostgreSQL 10.12 documentation.

PostgreSQL Version 10.11 on Amazon RDS

PostgreSQL version 10.11 contains several bug fixes for issues in release 10.10. For more information on the fixes in PostgreSQL 10.11, see the PostgreSQL documentation. Changes in this version include the following:

1. Added the `plprofiler` extension.
2. Added to `shared_preload_libraries` support for `pg_prewarm` to start automatically.

PostgreSQL Version 10.10 on Amazon RDS

PostgreSQL version 10.10 contains several bug fixes for issues in release 10.9. For more information on the fixes in PostgreSQL 10.10, see the PostgreSQL documentation. Changes in this version include the following:

1. The `aws_s3` extension is updated to support virtual-hosted style requests. For more information, see Amazon S3 Path Deprecation Plan – The Rest of the Story.
2. The `PostGIS` extension is updated to version 2.5.2.

PostgreSQL Version 10.9 on Amazon RDS

This release contains an important security fix and also bug fixes and improvements done by the PostgreSQL community. For more information on the security fix, see the PostgreSQL community announcement and security fix CVE-2019-10164.

With this release, the `pg_hint_plan` extension has been updated to version 1.3.3.

For more information on the fixes in PostgreSQL 10.9, see the PostgreSQL documentation.

PostgreSQL Version 10.7 on Amazon RDS

PostgreSQL version 10.7 contains several bug fixes for issues in release 10.6. For more information on the fixes in 10.7, see the PostgreSQL documentation.

This version also includes the following changes:

- Support for Amazon S3 import. For more information, see Importing Amazon S3 Data into an RDS for PostgreSQL DB Instance (p. 1251).

- Multiple major version upgrade is available to PostgreSQL 10.7 from certain previous PostgreSQL versions. For more information, see Major Version Upgrades for PostgreSQL (p. 1236).

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 10.6 on Amazon RDS

PostgreSQL version 10.6 contains several bug fixes for issues in release 10.5. For more information on the fixes in PostgreSQL 10.6, see the PostgreSQL documentation.

This version also includes the following changes:

- A new `rds.restrict_password_commands` parameter and a new `rds_password` role have been introduced. When the `rds.restrict_password_commands` parameter is enabled, only users who have the `rds_password` role can make user password and password expiration changes. By restricting password-related operations to a limited set of roles, you can implement policies such as password complexity requirements from the client side. The `rds.restrict_password_commands` parameter is static, so it requires a database restart to change it. For more information, see Restricting Password Management (p. 1295).
- The logical decoding plugin `wal2json` has been updated to commit `9e962ba`.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

> **Note**
> Amazon RDS for PostgreSQL has announced the removal of the `tsearch2` extension in the next major release. We encourage customers still using pre-8.3 text search to migrate to the equivalent built-in features. For more information about migrating, see the PostgreSQL documentation.

PostgreSQL Version 10.5 on Amazon RDS

PostgreSQL version 10.5 contains several bug fixes for issues in release 10.4. For more information on the fixes in 10.5, see the PostgreSQL documentation.

This version also includes the following changes:

- Support for the `pglogical` extension version 2.2.0. Prerequisites for using this extension are the same as the prerequisites for using logical replication for PostgreSQL as described in Logical Replication for PostgreSQL on Amazon RDS (p. 1349).
- Support for the `pg_similarity` extension version 1.0.
- Support for the `pageinspect` extension version 1.6.
- Support for the `libprotobuf` extension version 1.3.0 for the PostGIS component.
- An update for the `pg_hint_plan` extension to version 1.3.1.
- An update for the `wal2json` extension to version 01c5c1e.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 10.4 on Amazon RDS

PostgreSQL version 10.4 contains several bug fixes for issues in release 10.3. For more information on the fixes in 10.4, see the PostgreSQL documentation.

This version also includes the following changes:

- Support for PostgreSQL 10 Logical Replication using the native publication and subscription framework. RDS PostgreSQL databases can function as both publishers and subscribers. You can specify replication to other PostgreSQL databases at the database-level or at the table-level. With logical replication, the publisher and subscriber databases need not be physically identical (block-to-block) to each other. This allows for use cases such as data consolidation, data distribution, and data replication across different database versions for 10.4 and above. For more details, refer to Logical Replication for PostgreSQL on Amazon RDS (p. 1349).
- The temporary file size limitation is user-configurable. You require the **rds_superuser** role to modify the `temp_file_limit` parameter.
- Update of the `GDAL` library, which is used by the PostGIS extension. See Working with PostGIS (p. 1289).
- Update of the `ip4r` extension to version 2.1.1.
- Update of the `pg_repack` extension to version 1.4.3. See Working with the pg_repack Extension (p. 1288).
- Update of the `plv8` extension to version 2.1.2.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

> **Note**
> The `tsearch2` extension is to be removed in the next major release. We encourage customers still using pre-8.3 text search to migrate to the equivalent built-in features. For more information about migrating, see the PostgreSQL documentation.

PostgreSQL Version 10.3 on Amazon RDS

PostgreSQL version 10.3 contains several bug fixes for issues in release 10. For more information on the fixes in 10.3, see the PostgreSQL documentation.

Version 2.1.0 of PL/v8 is now available. If you use PL/v8 and upgrade PostgreSQL to a new PL/v8 version, you immediately take advantage of the new extension but the catalog metadata doesn't reflect this fact. For the steps to synchronize your catalog metadata with the new version of PL/v8, see Upgrade PL/v8 (p. 1346).

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 10.1 on Amazon RDS

PostgreSQL version 10.1 contains several bug fixes for issues in release 10. For more information on the fixes in 10.1, see the PostgreSQL documentation and the PostgreSQL 10 community announcement.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL version 10.1 includes the following changes:

- **Declarative table partitioning** – PostgreSQL 10 adds table partitioning to SQL syntax and native tuple routing.
- **Parallel queries** – When you create a new PostgreSQL 10.1 instance, parallel queries are enabled for the `default.postgres10` parameter group. The parameter max_parallel_workers_per_gather is set to 2 by default, but you can modify it to support your specific workload requirements.
- **Support for the International Components for Unicode (ICU)** – You can use the ICU library to provide explicitly versioned collations. Amazon RDS for PostgreSQL 10.1 is compiled with ICU version 60.2. For more information about ICU implementation in PostgreSQL, see Collation Support.
- **Huge pages** – Huge pages is a feature of the Linux kernel that uses multiple page size capabilities of modern hardware architectures. Amazon RDS for PostgreSQL supports huge pages with a global configuration parameter. When you create a new PostgreSQL 10.1 instance with RDS, the `huge_pages` parameter is set to `"on"` for the `default.postgres10` parameter group. You can modify this setting to support your specific workload requirements.
- **PL/v8 update** – PL/v8 is a procedural language that allows you to write functions in JavaScript that you can then call from SQL. This release of PostgreSQL supports version 2.1.0 of PL/v8.
- **Renaming of xlog and location** – In PostgreSQL version 10 the abbreviation "xlog" has changed to "wal", and the term "location" has changed to "lsn". For more information, see https://www.postgresql.org/docs/10/static/release-10.html#id-1.11.6.8.4.
- **tsearch2 module** – Amazon RDS continues to provide the `tsearch2` module in PostgreSQL version 10, but is to remove it in the next major version release. If your application uses tsearch2 functions update it to use the equivalent functions the core engine provides. For more information about using `tsearch2`, see tsearch2 module.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL 9.6 Versions

Minor Versions

PostgreSQL Version 9.6.17 on Amazon RDS

PostgreSQL version 9.6.17 contains several bug fixes for issues in release 9.6.16. For more information on the fixes in PostgreSQL 9.6.17, see the PostgreSQL 9.6.17 documentation.

PostgreSQL Version 9.6.16 on Amazon RDS

PostgreSQL version 9.6.16 contains several bug fixes for issues in release 9.6.15. For more information on the fixes in PostgreSQL 9.6.16, see the PostgreSQL documentation. Changes in this version include the following:

1. Added to `shared_preload_libraries` support for `pg_prewarm` to start automatically.

PostgreSQL Version 9.6.15 on Amazon RDS

PostgreSQL version 9.6.15 contains several bug fixes for issues in release 9.6.14. For more information on the fixes in PostgreSQL 9.6.15, see the PostgreSQL documentation.

The `PostGIS` extension is updated to version 2.5.2.

PostgreSQL Version 9.6.14 on Amazon RDS

This release contains bug fixes and improvements done by the PostgreSQL community.

With this release, the `pg_hint_plan` extension has been updated to version 1.2.5.

For more information on the fixes in PostgreSQL 9.6.14, see the PostgreSQL documentation.

PostgreSQL Version 9.6.12 on Amazon RDS

PostgreSQL version 9.6.12 contains several bug fixes for issues in release 9.6.11. For more information on the fixes in 9.6.12, see the PostgreSQL documentation.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.6.11 on Amazon RDS

PostgreSQL version 9.6.11 contains several bug fixes for issues in release 9.6.10. For more information on the fixes in PostgreSQL 9.6.11, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

With this version, the logical decoding plugin `wal2json` has been updated to commit `9e962ba`.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.10 on Amazon RDS

PostgreSQL version 9.6.10 contains several bug fixes for issues in release 9.6.9. For more information on the fixes in 9.6.10, see the PostgreSQL documentation.

This version includes the following changes:

- Support for the `pglogical` extension version 2.2.0. Prerequisites for using this extension are the same as the prerequisites for using logical replication for PostgreSQL as described in Logical Replication for PostgreSQL on Amazon RDS (p. 1349).
- Support for the `pg_similarity` extension version 2.2.0.
- An update for the `wal2json` extension to version 01c5c1e.
- An update for the `pg_hint_plan` extension to version 1.2.3.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.9 on Amazon RDS

PostgreSQL version 9.6.9 contains several bug fixes for issues in release 9.6.8. For more information on the fixes in 9.6.9, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

This version includes the following changes:

- The temporary file size limitation is user-configurable. You require the **rds_superuser** role to modify the `temp_file_limit` parameter.
- Update of the `GDAL` library, which is used by the PostGIS extension. See Working with PostGIS (p. 1289).
- Update of the `ip4r` extension to version 2.1.1.
- Update of the `pgaudit` extension to version 1.1.1. See Working with the pgaudit Extension (p. 1287).

  Update of the `pg_repack` extension to version 1.4.3. See Working with the pg_repack Extension (p. 1288).
- Update of the `plv8` extension to version 2.1.2.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.8 on Amazon RDS

PostgreSQL version 9.6.8 contains several bug fixes for issues in release 9.6.6. For more information on the fixes in 9.6.8, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.6 on Amazon RDS

PostgreSQL version 9.6.6 contains several bug fixes for issues in release 9.6.5. For more information on the fixes in 9.6.6, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

This version includes the following features:

- Supports the `orafce` extension, version 3.6.1. This extension contains functions that are native to commercial databases, and can be helpful if you are porting a commercial database to PostgreSQL. For more information about using `orafce` with Amazon RDS, see Working with the orafce Extension (p. 1292).
- Supports the `prefix` extension, version 1.2.6. This extension provides an operator for text prefix searches. For more information about `prefix`, see the prefix project on GitHub.
- Supports version 2.3.4 of PostGIS, version 2.4.2 of pgrouting, and an updated version of wal2json.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.5 on Amazon RDS

PostgreSQL version 9.6.5 contains several bug fixes for issues in release 9.6.4. For more information on the fixes in 9.6.5, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

This version also includes support for the pgrouting and postgresql-hll extensions, and the decoder_raw optional module.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.6.3 on Amazon RDS

PostgreSQL version 9.6.3 contains several new features and bug fixes. This version includes the following features:

- Supports the extension `pg_repack` version 1.4.0. You can use this extension to remove bloat from tables and indexes. For more information on using `pg_repack` with Amazon RDS, see Working with the pg_repack Extension (p. 1288).
- Supports the extension `pgaudit` version 1.1.0. This extension provides detailed session and object audit logging. For more information on using pgaudit with Amazon RDS, see Working with the pgaudit Extension (p. 1287).
- Supports `wal2json`, an output plugin for logical decoding.
- Supports the `auto_explain` module. You can use this module to log execution plans of slow statements automatically. The following example shows how to use `auto_explain` from within an Amazon RDS PostgreSQL session:

```
LOAD '$libdir/plugins/auto_explain';
```

  For more information on using `auto_explain`, see the PostgreSQL documentation.

PostgreSQL Version 9.6.2 on Amazon RDS

PostgreSQL version 9.6.2 contains several new features and bug fixes. The new version also includes the following extension versions:

- PostGIS version 2.3.2
- pg_freespacemap version 1.1–Provides a way to examine the free space map (FSM). This extension provides an overloaded function called pg_freespace. The functions show the value recorded in the free space map for a given page, or for all pages in the relation.
- pg_hint_plan version 1.1.3– Provides control of execution plans by using hinting phrases at the beginning of SQL statements.
- log_fdw version 1.0–Using this extension from Amazon RDS, you can load and query your database engine log from within the database. For more information, see Using the log_fdw Extension (p. 1345).
- With this version release, you can now edit the `max_worker_processes` parameter in a DB parameter group.

PostgreSQL version 9.6.2 on Amazon RDS also supports altering enum values. For more information, see ALTER ENUM for PostgreSQL (p. 1352).

For more information on the fixes in 9.6.2, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.6.1 on Amazon RDS

PostgreSQL version 9.6.1 contains several new features and improvements. For more information about the fixes and improvements in PostgreSQL 9.6.1, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353). For information about performing parallel queries and phrase searching using Amazon RDS for PostgreSQL 9.6.1, see the AWS Database Blog.

PostgreSQL version 9.6.1 includes the following changes:

- **Parallel query execution**: Supports parallel execution of large read-only queries, allowing sequential scans, hash joins, nested loops, and aggregates to be run in parallel. By default, parallel query execution is not enabled. To enable parallel query execution, set the parameter `max_parallel_workers_per_gather` to a value larger than zero.
- **Updated postgres_fdw extension**: Supports remote JOINs, SORTs, UPDATEs, and DELETE operations.
- **PL/v8 update**: Provides version 1.5.3 of the PL/v8 language.
- **PostGIS version update**: Supports POSTGIS="2.3.0 r15146" GEOS="3.5.0-CAPI-1.9.0 r4084" PROJ="Rel. 4.9.2, 08 September 2015" GDAL="GDAL 2.1.1, released 2016/07/07" LIBXML="2.9.1" LIBJSON="0.12" RASTER
- **Vacuum improvement**: Avoids scanning pages unnecessarily during vacuum freeze operations.
- **Full-text search support for phrases**: Supports the ability to specify a phrase-search query in tsquery input using the new operators <-> and <N>.
- **Two new extensions are supported**:
  - `bloom`, an index access method based on Bloom filters
  - `pg_visibility`, which provides a means for examining the visibility map and page-level visibility information of a table.
- With the release of version 9.6.2, you can now edit the `max_worker_processes` parameter in a PostgreSQL version 9.6.1 DB parameter group.

You can create a new PostgreSQL 9.6.1 database instance using the AWS Management Console, AWS CLI, or RDS API. You can also upgrade an existing PostgreSQL 9.5 instance to version 9.6.1 using major version upgrade. If you want to upgrade a DB instance from version 9.4 to 9.6, you must perform a point-and-click upgrade to the next major version first. Each upgrade operation involves a short period of unavailability for your DB instance.

PostgreSQL 9.5 Versions

Minor Versions

PostgreSQL Version 9.5.21 on Amazon RDS

PostgreSQL version 9.5.21 contains several bug fixes for issues in release 9.5.20. For more information on the fixes in PostgreSQL 9.5.21, see the PostgreSQL 9.5.21 documentation.

PostgreSQL Version 9.5.20 on Amazon RDS

PostgreSQL version 9.5.20 contains several bug fixes for issues in release 9.6.19. For more information on the fixes in PostgreSQL 9.5.20, see the PostgreSQL documentation. Changes in this version include the following:

1. Added to `shared_preload_libraries` support for `pg_prewarm` to start automatically.

PostgreSQL Version 9.5.19 on Amazon RDS

PostgreSQL version 9.5.19 contains several bug fixes for issues in release 9.6.18. For more information on the fixes in PostgreSQL 9.5.19, see the PostgreSQL documentation.

The `PostGIS` extension is updated to version 2.5.2.

PostgreSQL Version 9.5.18 on Amazon RDS

This release contains bug fixes and improvements done by the PostgreSQL community.

With this release, the `pg_hint_plan` extension has been updated to version 1.1.8.

For more information on the fixes in PostgreSQL 9.5.18, see the PostgreSQL documentation.

PostgreSQL Version 9.5.16 on Amazon RDS

PostgreSQL version 9.5.16 contains several bug fixes for issues in release 9.5.15. For more information on the fixes in 9.5.16, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.5.15 on Amazon RDS

PostgreSQL version 9.5.15 contains several bug fixes for issues in release 9.5.14. For more information on the fixes in 9.5.15, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.5.14 on Amazon RDS

PostgreSQL version 9.5.14 contains several bug fixes for issues in release 9.5.13. For more information on the fixes in 9.5.14, see the PostgreSQL documentation.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.5.13 on Amazon RDS

PostgreSQL version 9.5.13 contains several bug fixes for issues in release 9.5.12. For more information on the fixes in 9.5.13, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

This version includes the following extension updates:

- Update of the `pgaudit` extension to version 1.0.6. See Working with the pgaudit Extension (p. 1287).
- Update of the `pg_hint_plan` extension to version 1.1.5.
- Update of the `plv8` extension to version 2.1.2.

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.5.12 on Amazon RDS

PostgreSQL version 9.5.12 contains several bug fixes for issues in release 9.5.10 For more information on the fixes in 9.5.12, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.5.10 on Amazon RDS

PostgreSQL version 9.5.10 contains several bug fixes for issues in version 9.5.9. For more information on the fixes in 9.5.10, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.5.9 on Amazon RDS

PostgreSQL version 9.5.9 contains several bug fixes for issues in version 9.5.8. For more information on the fixes in 9.5.9, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.5.7 on Amazon RDS

PostgreSQL version 9.5.7 contains several new features and bug fixes. This version includes the following features:

- Supports the extension `pgaudit` version 1.0.5. This extension provides detailed session and object audit logging. For more information on using `pgaudit` with Amazon RDS, see Working with the pgaudit Extension (p. 1287).
- Supports `wal2json`, an output plugin for logical decoding.
- Supports the `auto_explain` module. You can use this module to log execution plans of slow statements automatically. The following example shows how to use `auto_explain` from within an Amazon RDS PostgreSQL session.

  ```
  LOAD '$libdir/plugins/auto_explain';
  ```

  For more information on using `auto_explain`, see the PostgreSQL documentation.

PostgreSQL Version 9.5.6 on Amazon RDS

PostgreSQL version 9.5.6 contains several new features and bug fixes. The new version also includes the following extension versions:

- PostGIS version 2.2.5
- pg_freespacemap version 1.1–Provides a way to examine the free space map (FSM). This extension provides an overloaded function called pg_freespace. This function shows the value recorded in the free space map for a given page, or for all pages in the relation.
- pg_hint_plan version 1.1.3– Provides control of execution plans by using hinting phrases at the beginning of SQL statements.

PostgreSQL version 9.5.6 on Amazon RDS also supports altering enum values. For more information, see ALTER ENUM for PostgreSQL (p. 1352).

For more information on the fixes in 9.5.6, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.5.4 on Amazon RDS

PostgreSQL version 9.5.4 contains several fixes to issue found in previous versions. For more information on the fixes in 9.5.4, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

Beginning with PostgreSQL version 9.4, PostgreSQL supports the streaming of WAL changes using logical replication decoding. Amazon RDS supports logical replication for PostgreSQL version 9.4.9 and higher and 9.5.4 and higher. For more information about PostgreSQL logical replication on Amazon RDS, see Logical Replication for PostgreSQL on Amazon RDS (p. 1349).

Beginning with PostgreSQL version 9.5.4 for Amazon RDS, the command ALTER USER WITH BYPASSRLS is supported.

PostgreSQL versions 9.4.9 and later and version 9.5.4 and later support event triggers, and Amazon RDS supports event triggers for these versions. You can use the master user account can be used to create, modify, rename, and delete event triggers. Event triggers are at the DB instance level, so they can apply to all databases on an instance. For more information about PostgreSQL event triggers on Amazon RDS, see Event Triggers for PostgreSQL on Amazon RDS (p. 1350).

PostgreSQL Version 9.5.2 on Amazon RDS

PostgreSQL version 9.5.2 contains several fixes to issues found in previous versions. For more information on the features in 9.5.2, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL version 9.5.2 doesn't support the db.m1 or db.m2 DB instance classes. If you need to upgrade a DB instance running PostgreSQL version 9.4 to version 9.5.2 to one of these instance classes, you need to scale compute. To do that, you need a comparable db.t2 or db.m3 DB instance class before you can upgrade a DB instance running PostgreSQL version 9.4 to version 9.5.2. For more information on DB instance classes, see DB Instance Classes (p. 7).

Native PostgreSQL version 9.5.2 introduced the command ALTER USER WITH BYPASSRLS.

This release includes updates from previous versions, including the following:

- **CVE-2016-2193:** Fixes an issue where a query plan might be reused for more than one ROLE in the same session. Reusing a query plan can cause the query to use the wrong set of Row Level Security (RLS) policies.

- **CVE-2016-3065:** Fixes a server crash bug triggered by using `pageinspect` with BRIN index pages. Because an attacker might be able to expose a few bytes of server memory, this crash is being treated as a security issue.

Major enhancements in RDS PostgreSQL 9.5 include the following:

- UPSERT: Allow INSERTs that would generate constraint conflicts to be turned into UPDATEs or ignored
- Add the GROUP BY analysis features GROUPING SETS, CUBE, and ROLLUP
- Add row-level security control
- Create mechanisms for tracking the progress of replication, including methods for identifying the origin of individual changes during logical replication
- Add Block Range Indexes (BRIN)
- Add substantial performance improvements for sorting
- Add substantial performance improvements for multi-CPU machines
- PostGIS 2.2.2 - To use this latest version of PostGIS, use the ALTER EXTENSION UPDATE statement to update after you upgrade to version 9.5.2. Example:

  ALTER EXTENSION POSTGIS UPDATE TO '2.2.2'
- Improved visibility of autovacuum sessions by allowing the rds_superuser account to view autovacuum sessions in pg_stat_activity. For example, you can identify and terminate an autovacuum session that is blocking a command from running, or executing slower than a manually issued vacuum command.

RDS PostgreSQL version 9.5.2 includes the following new extensions:

- **address_standardizer** – A single-line address parser that takes an input address and normalizes it based on a set of rules stored in a table, helper lex, and gaz tables.
- hstore_plperl – Provides transforms for the `hstore` type for PL/Perl.
- tsm_system_rows – Provides the table sampling method `SYSTEM_ROWS`, which can be used in the `TABLESAMPLE` clause of a `SELECT` command.
- tsm_system_time – Provides the table sampling method `SYSTEM_TIME`, which can be used in the `TABLESAMPLE` clause of a `SELECT` command.

PostgreSQL 9.4 Versions

Minor Versions

PostgreSQL Version 9.4.25 on Amazon RDS

PostgreSQL version 9.4.25 contains several bug fixes for issues in release 9.4.24. For more information on the fixes in PostgreSQL 9.4.25, see the PostgreSQL documentation. Changes in this version include the following:

1. Added to `shared_preload_libraries` support for `pg_prewarm` to start automatically.

PostgreSQL Version 9.4.24 on Amazon RDS

PostgreSQL version 9.4.24 contains several bug fixes for issues in release 9.4.23. For more information on the fixes in PostgreSQL 9.4.24, see the PostgreSQL documentation.

The `PostGIS` extension is updated to version 2.5.2.

PostgreSQL Version 9.4.23 on Amazon RDS

This release contains bug fixes and improvements done by the PostgreSQL community. For more information on the fixes in PostgreSQL 9.4.23, see the PostgreSQL documentation.

PostgreSQL Version 9.4.21 on Amazon RDS

PostgreSQL version 9.4.21 contains several bug fixes for issues in release 9.4.20. For more information on the fixes in 9.4.21, the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.4.20 on Amazon RDS

PostgreSQL version 9.4.20 contains several bug fixes for issues in release 9.4.19. For more information on the fixes in 9.4.20, the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.4.19 on Amazon RDS

PostgreSQL version 9.4.19 contains several bug fixes for issues in release 9.4.18. For more information on the fixes in 9.4.19, see the PostgreSQL documentation.

For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.4.18 on Amazon RDS

PostgreSQL version 9.4.18 contains several bug fixes for issues in release 9.4.17. For more information on the fixes in 9.4.18, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

The `plv8` extension has been updated to version 2.1.2. For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.4.17 on Amazon RDS

PostgreSQL version 9.4.17 contains several bug fixes for issues in release 9.4.15. For more information on the fixes in 9.4.17, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

For the complete list of extensions supported by Amazon RDS for PostgreSQL, see Supported PostgreSQL Features and Extensions (p. 1328).

PostgreSQL Version 9.4.15 on Amazon RDS

PostgreSQL version 9.4.15 contains several bug fixes for issues in release 9.4.14. For more information on the fixes in 9.4.15, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.4.14 on Amazon RDS

PostgreSQL version 9.4.14 contains several bug fixes for issues in release 9.4.12. For more information on the fixes in 9.4.14, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.4.12 on Amazon RDS

PostgreSQL version 9.4.12 contains several fixes to issue found in previous versions.

For more information on the fixes in 9.4.12, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL Version 9.4.11 on Amazon RDS

PostgreSQL version 9.4.11 contains several fixes to issue found in previous versions.

For more information on the fixes in 9.4.11, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

Beginning with PostgreSQL version 9.4, PostgreSQL supports the streaming of WAL changes using logical replication decoding. Amazon RDS supports logical replication for PostgreSQL version 9.4.9 and higher and 9.5.4 and higher. For more information about PostgreSQL logical replication on Amazon RDS, see Logical Replication for PostgreSQL on Amazon RDS (p. 1349).

PostgreSQL versions 9.4.9 and later and version 9.5.4 and later support event triggers, and Amazon RDS supports event triggers for these versions. The master user account can be used to create, modify, rename, and delete event triggers. Event triggers are at the DB instance level, so they can apply to all databases on an instance. For more information about PostgreSQL event triggers on Amazon RDS, see Event Triggers for PostgreSQL on Amazon RDS (p. 1350).

PostgreSQL Version 9.4.9 on Amazon RDS

PostgreSQL version 9.4.9 contains several fixes to issue found in previous versions. For more information on the fixes in 9.4.9, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

Beginning with PostgreSQL version 9.4, PostgreSQL supports the streaming of WAL changes using logical replication decoding. Amazon RDS supports logical replication for PostgreSQL version 9.4.9 and higher and 9.5.4 and higher. For more information about PostgreSQL logical replication on Amazon RDS, see Logical Replication for PostgreSQL on Amazon RDS (p. 1349).

PostgreSQL versions 9.4.9 and later and version 9.5.4 and later support event triggers, and Amazon RDS supports event triggers for these versions. The master user account can be used to create, modify, rename, and delete event triggers. Event triggers are at the DB instance level, so they can apply to all databases on an instance. For more information about PostgreSQL event triggers on Amazon RDS, see Event Triggers for PostgreSQL on Amazon RDS (p. 1350).

PostgreSQL Version 9.4.7 on Amazon RDS

PostgreSQL version 9.4.7 contains several fixes to issue found in previous versions. For more information on the fixes in 9.4.7, see the PostgreSQL documentation. For information on upgrading the engine version for your PostgreSQL DB instance, see Upgrading a PostgreSQL DB Instance (p. 1353).

PostgreSQL version 9.4.7 includes improved visibility of autovacuum sessions by allowing the rds_superuser account to view autovacuum sessions in pg_stat_activity. For example, you can identify and terminate an autovacuum session that is blocking a command from running, or executing slower than a manually issued vacuum command.

Supported PostgreSQL Features and Extensions

Amazon RDS supports many of the most common PostgreSQL extensions and features.

Topics

PostgreSQL Extensions and Modules Supported on Amazon RDS

PostgreSQL supports many PostgreSQL extensions and modules. Extensions and modules expand on the functionality provided by the PostgreSQL engine. The following sections show the extensions and modules supported by Amazon RDS for the major PostgreSQL versions.

Topics

You can find a list of extensions supported by Amazon RDS in the default DB parameter group for that PostgreSQL version. You can also see the current extensions list using `psql` by showing the `rds.extensions` parameter as in the following example.

```
SHOW rds.extensions;
```

> **Note**
> Parameters added in a minor version release might display inaccurately when using the `rds.extensions` parameter in `psql`.

PostgreSQL Version 12 Extensions and Modules Supported on Amazon RDS

The following table shows PostgreSQL extensions and modules for PostgreSQL version 12 that are currently supported on Amazon RDS. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extensions and Modules	Version 12.2
address_standardizer	3.0.0
address_standardizer_data_us	3.0.0
amcheck module	1.2
aws_commons —see Importing Data into PostgreSQL on Amazon RDS	1.0
aws_s3 —see Importing Data into PostgreSQL on Amazon RDS	1.0
bloom	1.0
btree_gin	1.3
btree_gist	1.5
citext	1.6
cube	1.4
dblink	1.2
dict_int	1.0
dict_xsyn	1.0
earthdistance	1.1
fuzzystrmatch	1.1
hll	2.14
hstore	1.6
hstore_plperl	1.0
intagg	1.1
intarray	1.2
ip4r	2.4
isn	1.2
jsonb_plperl	1.0
log_fdw—see Using the log_fdw Extension (p. 1345)	1.1
ltree	1.1
orafce	3.8
pageinspect	1.7

Extensions and Modules	Version 12.2
pg_buffercache	1.3
pg_freespacemap	1.2
pg_hint_plan	1.3.4
pg_prewarm	1.2
pg_repack	1.4.5
pg_similarity	1.0
pg_stat_statements	1.7
pg_transport — see Transporting PostgreSQL Databases Between DB Instances (p. 1262)	1.0
pg_trgm	1.4
pg_visibility	1.2
pgaudit	1.4
pgcrypto	1.3
pglogical	2.3.0
pgrouting	3.0.0
pgrowlocks	1.2
pgstattuple	1.5
pgTAP	1.1.0
plcoffee	2.3.14
plls	2.3.14
plperl	1.0
plpgsql	1.0
plprofiler	4.1
pltcl	1.0
plv8	2.3.14
PostGIS	3.0.0
postgis_raster	3.0.0
postgis_tiger_geocoder	3.0.0
postgis_topology	3.0.0
postgres_fdw	1.0
prefix	1.2.0

Extensions and Modules	Version 12.2
sslinfo	1.2
tablefunc	1.0
test_parser	1.0
tsm_system_rows	1.0
tsm_system_time	1.0
unaccent	1.1
uuid-ossp	1.1
`wal2json` module	2.1

PostgreSQL Version 11.x Extensions and Modules Supported on Amazon RDS

The following tables show PostgreSQL extensions and modules for PostgreSQL version 11.x that are currently supported by PostgreSQL on Amazon RDS. "N/A" indicates that the extension or module is not available for that PostgreSQL version. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extension	Version 11.1	Version 11.2	Version 11.4	Version 11.5	Version 11.6	Version 11.7
address_standardizer	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1
address_standardizer_data_us	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1
bloom	1.0	1.0	1.0	1.0	1.0	1.0
btree_gin	1.3	1.3	1.3	1.3	1.3	1.3
btree_gist	1.5	1.5	1.5	1.5	1.5	1.5
citext	1.5	1.5	1.5	1.5	1.5	1.5
cube	1.4	1.4	1.4	1.4	1.4	1.4
dblink	1.2	1.2	1.2	1.2	1.2	1.2
dict_int	1.0	1.0	1.0	1.0	1.0	1.0
dict_xsyn	1.0	1.0	1.0	1.0	1.0	1.0
earthdistance	1.1	1.1	1.1	1.1	1.1	1.1
fuzzystrmatch	1.1	1.1	1.1	1.1	1.1	1.1
hstore	1.5	1.5	1.5	1.5	1.5	1.5
hstore_plperl	1.0	1.0	1.0	1.0	1.0	1.0
intagg	1.1	1.1	1.1	1.1	1.1	1.1
intarray	1.2	1.2	1.2	1.2	1.2	1.2

Extension	Version 11.1	Version 11.2	Version 11.4	Version 11.5	Version 11.6	Version 11.7
ip4r	2.3	2.3	2.3	2.3	2.3	2.3
isn	1.2	1.2	1.2	1.2	1.2	1.2
log_fdw—see Using the log_fdw Extension (p. 1345)	1.0	1.0	1.0	1.0	1.0	1.0
libprotobuf	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0
ltree	1.1	1.1	1.1	1.1	1.1	1.1
orafce	3.7	3.7	3.7	3.7	3.7	**3.8**
pageinspect	1.6	1.6	1.6	1.6	1.6	1.6
pg_buffercache	1.3	1.3	1.3	1.3	1.3	1.3
pg_freespacemap	1.2	1.2	1.2	1.2	1.2	1.2
pg_hint_plan	1.3.2	1.3.2	**1.3.4**	1.3.4	1.3.4	1.3.4
pg_prewarm	1.2	1.2	1.2	1.2	1.2	1.2
pg_repack	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4
pg_similarity	1.0	1.0	1.0	1.0	1.0	1.0
pg_stat_statements	1.5	1.5	1.5	1.5	1.5	1.5
pg_transport	N/A	N/A	N/A	1.0	1.0	1.0
pg_trgm	1.4	1.4	1.4	1.4	1.4	1.4
pg_visibility	1.2	1.2	1.2	1.2	1.2	1.2
pgaudit	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0
pgcrypto	1.3	1.3	1.3	1.3	1.3	1.3
pglogical	2.2.1	2.2.1	2.2.1	2.2.1	2.2.1	2.2.1
pgrowlocks	1.2	1.2	1.2	1.2	1.2	1.2
pgrouting	2.6.1	2.6.1	2.6.1	2.6.1	2.6.1	2.6.1
pgstattuple	1.5	1.5	1.5	1.5	1.5	1.5
pgTAP	N/A	1.0	1.0	1.0	**1.1.0**	1.1.0
plcoffee	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8
plls	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8
plperl	1.0	1.0	1.0	1.0	1.0	1.0
plpgsql	1.0	1.0	1.0	1.0	1.0	1.0
plprofiler	N/A	N/A	N/A	N/A	**4.1**	4.1

Extension	Version 11.1	Version 11.2	Version 11.4	Version 11.5	Version 11.6	Version 11.7
pltcl	1.0	1.0	1.0	1.0	1.0	1.0
plv8	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8	2.3.8
PostGIS	2.5.1	2.5.1	2.5.1	**2.5.2**	2.5.2	2.5.2
postgis_tiger_geocoder	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1
postgis_topology	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1	2.5.1
postgres_fdw	1.0	1.0	1.0	1.0	1.0	1.0
postgresql-hll	2.11	2.11	2.11	2.11	2.11	2.11
prefix	1.2.8	1.2.8	1.2.8	1.2.8	1.2.8	1.2.8
sslinfo	1.2	1.2	1.2	1.2	1.2	1.2
tablefunc	1.0	1.0	1.0	1.0	1.0	1.0
test_parser	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_rows	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_time	1.0	1.0	1.0	1.0	1.0	1.0
unaccent	1.1	1.1	1.1	1.1	1.1	1.1
uuid-ossp	1.1	1.1	1.1	1.1	1.1	1.1

The following modules are supported as shown for PostgreSQL version 11.x.

Module	Version 11.1	Version 11.2	Version 11.4	Version 11.5	Version 11.6	Version 11.7
amcheck	Supported	Supported	Supported	Supported	Supported	Supported
auto_explain	Supported	Supported	Supported	Supported	Supported	Supported
decoder_raw	Supported	Supported	Supported	Supported	Supported	Supported
ICU	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported
test_decoding	Supported	Supported	Supported	Supported	Supported	Supported
wal2json	Commit hash 9e962bad	Commit hash 9e962bad	Commit hash 9e962bad	Commit hash 9e962bad	Commit hash 9e962bad	**version 2.1**

PostgreSQL Version 10.x Extensions and Modules Supported on Amazon RDS

The following tables show PostgreSQL extensions and modules for PostgreSQL version 10 that are currently supported by PostgreSQL on Amazon RDS. "N/A" indicates that the extension or module is not available for that PostgreSQL version. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extension	10.1	10.3	10.4	10.5	10.6	10.7	10.9	10.10	10.11	10.12
address_standardizer	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2
address_standardizer_data_us	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2
bloom	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
btree_gin	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
btree_gist	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
chkpass	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
citext	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
cube	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
dblink	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
dict_int	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dict_xsyn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
earthdistance	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
fuzzystrmatch	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
hstore	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
hstore_plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
intagg	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
intarray	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
ip4r	2.0	2.0	**2.1.1**	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1
isn	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
log_fdw—see Using the log_fdw Extension (p. 1345)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
libprotobuf	N/A	N/A	N/A	**1.3.0**	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0	1.3.0
ltree	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
orafce	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	**3.8**
pgaudit	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0
pg_buffercache	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pg_freespacemap	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pg_hint_plan	1.3.0	1.3.0	1.3.0	**1.3.1**	1.3.1	1.3.1	**1.3.3**	1.3.3	1.3.3	1.3.3
pg_prewarm	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Extension	10.1	10.3	10.4	10.5	10.6	10.7	10.9	10.10	10.11	10.12
pg_repack	1.4.2	1.4.2	**1.4.3**	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3
pg_similarity	N/A	N/A	N/A	**1.0**	1.0	1.0	1.0	1.0	1.0	1.0
pg_stat_statements	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
pg_trgm	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pg_visibility	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pgcrypto	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pageinspect	N/A	N/A	N/A	**1.6**	1.6	1.6	1.6	1.6	1.6	1.6
pglogical	N/A	N/A	N/A	**2.2.0**	2.2.0	2.2.0	2.2.0	2.2.0	2.2.0	2.2.0
pgrowlocks	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pgrouting	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2	2.5.2
pgstattuple	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
plcoffee	2.1.0	2.1.0	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
plls	2.1.0	2.1.0	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plpgsql	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plprofiler	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**4.1**	4.1
pltcl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plv8	2.1.0	2.1.0	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
PostGIS	2.4.2	2.4.2	**2.4.4**	2.4.4	2.4.4	2.4.4	2.4.4	**2.5.2**	2.5.2	2.5.2
postgis_tiger_geocoder	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2
postgis_topology	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2
postgres_fdw	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
postgresql-hll	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2
prefix	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0	1.2.0
sslinfo	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
tablefunc	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
test_parser	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsearch2 (deprecated in version 10)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Extension	10.1	10.3	10.4	10.5	10.6	10.7	10.9	10.10	10.11	10.12
tsm_system_rows	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_time	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
unaccent	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
uuid-ossp	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

The `tsearch2` extension is deprecated in version 10. The PostgreSQL team plans to remove `tsearch2` from the next major release of PostgreSQL.

The following modules are supported as shown for versions of PostgreSQL 10.

Module	Version 10.1	10.3	10.4	10.5	10.6	10.7	10.9	10.10	10.11	10.12
amcheck	Not supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
auto_explain	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
decoder_raw	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
ICU	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported	Version 60.2 supported
test_decoding	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
wal2json	Commit hash 5352cc4	Commit hash 5352cc4	Commit hash 5352cc4	**Commit hash 01c5c1e**	**Commit hash 9e962ba**	**Commit hash 9e962ba**	**Commit hash 9e962ba**	Commit hash 9e962ba	Commit hash 9e962ba	**version 2.1**

PostgreSQL Version 9.6.x Extensions and Modules Supported on Amazon RDS

The following tables show PostgreSQL extensions and modules for PostgreSQL version 9.6.x that are currently supported by PostgreSQL on Amazon RDS. "N/A" indicates that the extension or module is not available for that PostgreSQL version. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extension	9.6.1	9.6.2	9.6.3	9.6.5	9.6.6	9.6.8	9.6.9	9.6.10	9.6.11	9.6.12	9.6.14	9.6.15	9.6.16	9.6.17
address_standardizer	2.3.0	**2.3.2**	2.3.2	2.3.2	**2.3.4**	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4
address_standardizer_data_us	2.3.0	**2.3.2**	2.3.2	2.3.2	**2.3.4**	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4
bloom	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
btree_gin	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
btree_gist	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
chkpass	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Extension	9.6.1	9.6.2	9.6.3	9.6.5	9.6.6	9.6.8	9.6.9	9.6.10	9.6.11	9.6.12	9.6.14	9.6.15	9.6.16	9.6.17
citext	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
cube	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
dblink	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
dict_int	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dict_xsyn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
earthdistance	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
fuzzystrmatch	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
hstore	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
hstore_plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
intagg	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
intarray	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
ip4r	2.0	2.0	2.0	2.0	2.0	2.0	**2.1.1**	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1	2.1.1
isn	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
log_fdw — see Using the log_fdw Extension (p. 1345)	N/A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ltree	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
orafce	N/A	N/A	N/A	N/A	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	3.6.1	**3.8**
pgaudit	N/A	N/A	1.1	1.1	1.1	1.1	**1.1.1**	1.1.1	1.1.1	1.1.1	1.1.1	1.1.1	1.1.1	1.1.1
pg_buffercache	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pg_freespacemap	N/A	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pg_hint_plan	N/A	1.1.3	1.1.3	1.1.3	1.1.3	**1.2.2**	1.2.2	**1.2.3**	1.2.3	1.2.3	**1.2.5**	1.2.5	1.2.5	1.2.5
pg_prewarm	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pg_repack	N/A	N/A	1.4.0	1.4.1	1.4.2	1.4.2	**1.4.3**	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3	1.4.3
pg_similarity	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**1.0**	1.0	1.0	1.0	1.0	1.0	1.0
pg_stat_statements	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
pg_trgm	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pg_visibility	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pgcrypto	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pglogical	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**2.2.0**	2.2.0	2.2.0	2.2.0	2.2.0	2.2.0	2.2.0

Extension	9.6.1	9.6.2	9.6.3	9.6.5	9.6.6	9.6.8	9.6.9	9.6.10	9.6.11	9.6.12	9.6.14	9.6.15	9.6.16	9.6.17
pgrowlocks	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pgrouting	N/A	N/A	N/A	2.3.2	**2.4.2**	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2	2.4.2
pgstattuple	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
plcoffee	1.5.3	1.5.3	1.5.3	1.5.3	1.5.3	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
plls	1.5.3	1.5.3	1.5.3	1.5.3	1.5.3	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plpgsql	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pltcl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plv8	1.5.3	1.5.3	1.5.3	1.5.3	1.5.3	2.1.0	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
PostGIS	2.3.0	2.3.2	2.3.2	2.3.2	**2.3.4**	2.3.4	**2.3.7**	2.3.7	2.3.7	2.3.7	2.3.7	**2.5.2**	2.5.2	2.5.2
postgis_tiger_geocoder	2.3.0	2.3.2	2.3.2	2.3.2	**2.3.4**	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4
postgis_topology	2.3.0	2.3.2	2.3.2	2.3.2	**2.3.4**	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4	2.3.4
postgres_fdw	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
postgresql-hll	N/A	N/A	N/A	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2	2.10.2
prefix	N/A	N/A	N/A	N/A	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6	1.2.6
sslinfo	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
tablefunc	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
test_parser	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsearch2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_rows	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_time	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
unaccent	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
uuid-ossp	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

The following modules are supported as shown for versions of PostgreSQL 9.6.

Module	9.6.1	9.6.2	9.6.3	9.6.5	9.6.8	9.6.9	9.6.10	9.6.11	9.6.12	9.6.14	9.6.15	9.6.16	9.6.17
auto_explain	N/A	N/A	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
decoder_raw	N/A	N/A	N/A	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
test_decoding	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported

Module	9.6.1	9.6.2	9.6.3	9.6.5	9.6.8	9.6.9	9.6.10	9.6.11	9.6.12	9.6.14	9.6.15	9.6.16	9.6.17
wal2json	N/A	N/a	Commit hash 2828409	Commit hash 645ab69	Commit hash 5352cc4	Commit hash 5352cc4	**Commit hash 01c5c1e**	**Commit hash 9e962ba**	Commit hash 9e962ba	Commit hash 9e962ba	Commit hash 9e962ba	Commit hash 9e962ba	**version 2.1**

PostgreSQL Version 9.5.x Extensions Supported on Amazon RDS

The following tables show PostgreSQL extensions and modules for PostgreSQL version 9.5.x that are currently supported by PostgreSQL on Amazon RDS. "N/A" indicates that the extension or module is not available for that PostgreSQL version. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extension	9.5.2	9.5.4	9.5.6	9.5.7	9.5.9	9.5.10	9.5.12	9.5.13	9.5.14	9.5.15	9.5.16	9.5.18	9.5.19	9.5.20	9.5.21
address_standardizer	2.2.2	2.2.2	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5
address_standardizer_data_us	2.2.2	2.2.2	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5
bloom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
btree_gin	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
btree_gist	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
chkpass	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
citext	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
cube	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dblink	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
dict_int	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dict_xsyn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
earthdistance	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
fuzzystrmatch	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
hstore	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
hstore_plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
intagg	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
intarray	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ip4r	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
isn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
log_fdw — see Using the	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Extension	9.5.2	9.5.4	9.5.6	9.5.7	9.5.9	9.5.10	9.5.12	9.5.13	9.5.14	9.5.15	9.5.16	9.5.18	9.5.19	9.5.20	9.5.21
log_fdw Extension (p. 1345)															
ltree	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pgaudit	N/A	N/A	N/A	1.0.5	1.0.5	1.0.5	1.0.5	**1.0.6**	1.0.6	1.0.6	1.0.6	1.0.6	1.0.6	1.0.6	1.0.6
pg_buffercache	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pg_freespacemap	N/A	N/A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pg_hint_plan	N/A	N/A	1.1.3	1.1.3	1.1.3	1.1.3	1.1.3	**1.1.5**	1.1.5	1.1.5	1.1.5	**1.1.8**	1.1.8	1.1.8	1.1.8
pg_prewarm	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pg_stat_statements	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
pg_trgm	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pg_visibility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pgcrypto	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pgrowlocks	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pgstattuple	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
plcoffee	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	**2.1.0**	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0
plls	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	**2.1.0**	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0	2.1.0
plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plpgsql	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pltcl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plv8	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	**2.1.0**	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
PostGIS	2.2.2	2.2.2	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	**2.5.2**	2.5.2	2.5.2
postgis_tiger_geocoder	2.2.2	2.2.2	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5
postgis_topology	2.2.2	2.2.2	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5	2.2.5
postgres_fdw	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
sslinfo	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tablefunc	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
test_parser	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsearch2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_rows	N/A	N/A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_time	N/A	N/A	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
unaccent	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Extension	9.5.2	9.5.4	9.5.6	9.5.7	9.5.9	9.5.10	9.5.12	9.5.13	9.5.14	9.5.15	9.5.16	9.5.18	9.5.19	9.5.20	9.5.21
uuid-ossp	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

The following modules are supported as shown for versions of PostgreSQL 9.5.

Module	9.5.2	9.5.4	9.5.6	9.5.7	9.5.9	9.5.12	9.5.13	9.5.14	9.5.15	9.5.16	9.5.18	9.5.19	9.5.20	9.5.21
auto_explain	N/A	N/A	N/A	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
test_decoding	N/A	N/A	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported	Supported
wal2json	N/A	N/a	N/A	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	Commit hash 2828409	**version 2.1**

PostgreSQL Version 9.4.x Extensions and Modules Supported on Amazon RDS

The following tables show the PostgreSQL extensions and modules for PostgreSQL version 9.4.x that are currently supported by PostgreSQL on Amazon RDS. "N/A" indicates that the extension or module is not available for that PostgreSQL version. For more information on PostgreSQL extensions, see Packaging Related Objects into an Extension.

Extension	9.4.7	9.4.9	9.4.11	9.4.12	9.4.14	9.4.15	9.4.17	9.4.18	9.4.19	9.4.20	9.4.21	9.4.23	9.4.24
address_standardizer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
address_standardizer_data_us	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
bloom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
btree_gin	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
btree_gist	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
chkpass	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
citext	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
cube	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dblink	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
dict_int	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dict_xsyn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
earthdistance	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
fuzzystrmatch	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
hstore	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
hstore_plperl	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
intagg	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Extension	9.4.7	9.4.9	9.4.11	9.4.12	9.4.14	9.4.15	9.4.17	9.4.18	9.4.19	9.4.20	9.4.21	9.4.23	9.4.24
intarray	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ip4r	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
isn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
log_fdw — see Using the log_fdw Extension (p. 1345)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ltree	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pg_buffercache	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pg_freespacemap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pg_hint_plan	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pg_prewarm	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pg_stat_statements	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
pg_trgm	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pg_visibility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pgcrypto	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pgrowlocks	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
pgstattuple	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
plcoffee	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4
plls	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4
plperl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plpgsql	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
pltcl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
plv8	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	1.4.4	**2.1.0**	**2.1.2**	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
PostGIS	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	**2.5.2**
postgis_tiger_geocoder	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8
postgis_topology	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8	2.1.8
postgres_fdw	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
sslinfo	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tablefunc	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
test_parser	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Extension	9.4.7	9.4.9	9.4.11	9.4.12	9.4.14	9.4.15	9.4.17	9.4.18	9.4.19	9.4.20	9.4.21	9.4.23	9.4.24
tsearch2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
tsm_system_rows	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
tsm_system_time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
unaccent	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
uuid-ossp	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

The following modules are supported as shown for versions of PostgreSQL 9.4.

Module	9.4.7	9.4.9	9.4.11	9.4.12	9.4.14	9.4.17
test_decoding	N/A	N/A	N/A	Supported	Supported	Supported

PostgreSQL Extension Support for PostGIS on Amazon RDS

Before you can use the PostGIS extension, you must create it by running the following command.

```
CREATE EXTENSION POSTGIS;
```

The following table shows the PostGIS component versions that ship with the Amazon RDS for PostgreSQL versions.

PostgreSQL	PostGIS	GEOS	GDAL	PROJ
9.4.7	2.1.8 r13780	3.5.0-CAPI-1.9.0 r4084	1.11.4, released 2016/01/25	Rel. 4.9.2, September 8th, 2015
9.4.9	2.1.8 r13780	3.5.0-CAPI-1.9.0 r4084	1.11.5, released 2016/07/01	Rel. 4.9.2, September 8th, 2015
9.4.11	2.1.8 r13780	3.5.0-CAPI-1.9.0 r4084	1.11.5, released 2016/07/01	Rel. 4.9.2, September 8th, 2015
9.4.12	2.1.8 r13780	3.5.0-CAPI-1.9.0 r4084	1.11.5, released 2016/07/01	Rel. 4.9.2, September 8th, 2015
9.5.2	2.2.2 r14797	3.5.0-CAPI-1.9.0 r4084	2.0.2, released 2016/01/26	Rel. 4.9.2, September 8th, 2015
9.5.4	2.2.2 r14797	3.5.0-CAPI-1.9.0 r4084	2.0.3, released 2016/07/01	Rel. 4.9.2, September 8th, 2015

PostgreSQL	PostGIS	GEOS	GDAL	PROJ
9.5.6	2.2.5 r15298	3.5.1-CAPI-1.9.1 r4246	2.0.3, released 2016/07/01	Rel. 4.9.3, September 15th, 2016
9.5.7	2.2.5 r15298	3.5.1-CAPI-1.9.1 r4246	2.0.3, released 2016/07/01	Rel. 4.9.3, September 15th, 2016
9.6.1	2.3.0 r15146	3.5.0-CAPI-1.9.0 r4084	2.1.1, released 2016/07/07	Rel. 4.9.2, September 8th, 2016
9.6.2	2.3.2 r15302	3.5.1-CAPI-1.9.1 r4246	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
9.6.3	2.3.2 r15302	3.5.1-CAPI-1.9.1 r4246	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
9.6.6	2.3.4 r16009	3.6.2-CAPI-1.10.2 4d2925d6	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
9.6.8	2.3.4 r16009	3.6.2-CAPI-1.10.2 4d2925d6	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
9.6.9	2.3.7 r16523	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016
9.6.10	2.3.7 r16523	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016
9.6.11	2.3.7 r16523	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016
10.1	2.4.2	3.6.2-CAPI-1.10.2 4d2925d6	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
10.3	2.4.2	3.6.2-CAPI-1.10.2 4d2925d6	2.1.3, released 2017/20/01	Rel. 4.9.3, September 15th, 2016
10.4	2.4.4 r16526	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016
10.5	2.4.4 r16526	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016

PostgreSQL	PostGIS	GEOS	GDAL	PROJ
10.6	2.4.4 r16526	3.6.2-CAPI-1.10.2 4d2925d6	2.1.4, released 2017/06/23	Rel. 4.9.3, September 15th, 2016
11.1	2.5.1 r17027	3.7.0-CAPI-1.11.0 673b9939	2.3.1, released 2018/06/22	Rel. 5.2.0, September 15th, 2018

> **Note**
> PostgreSQL 10.5 added support for the `libprotobuf` extension version 1.3.0 to the PostGIS component.

Using the log_fdw Extension

The `log_fdw` extension is new for Amazon RDS for PostgreSQL version 9.6.2 and later. Using this extension, you can access your database engine log using a SQL interface. In addition to viewing the *stderr* log files that are generated by default on RDS, you can view CSV logs (set the `log_destination` parameter to `csvlog`) and build foreign tables with the data neatly split into several columns.

This extension introduces two new functions that make it easy to create foreign tables for database logs:

- `list_postgres_log_files()` – Lists the files in the database log directory and the file size in bytes.
- `create_foreign_table_for_log_file(table_name text, server_name text, log_file_name text)` – Builds a foreign table for the specified file in the current database.

All functions created by `log_fdw` are owned by `rds_superuser`. Members of the `rds_superuser` role can grant access to these functions to other database users.

The following example shows how to use the `log_fdw` extension.

To use the log_fdw extension

1. Get the `log_fdw` extension.

```
postgres=> CREATE EXTENSION log_fdw;
CREATE EXTENSION
```

2. Create the log server as a foreign data wrapper.

```
postgres=> CREATE SERVER log_server FOREIGN DATA WRAPPER log_fdw;
CREATE SERVER
```

3. Select all from a list of log files.

```
postgres=> SELECT * from list_postgres_log_files() order by 1;
```

A sample response is as follows.

```
           file_name              | file_size_bytes
----------------------------------+-----------------
 postgresql.log.2016-08-09-22.csv |           1111
 postgresql.log.2016-08-09-23.csv |           1172
 postgresql.log.2016-08-10-00.csv |           1744
 postgresql.log.2016-08-10-01.csv |           1102
(4 rows)
```

4. Create a table with a single 'log_entry' column for non-CSV files.

```
postgres=> SELECT create_foreign_table_for_log_file('my_postgres_error_log',
     'log_server', 'postgresql.log.2016-08-09-22.csv');
```

   A sample response is as follows.

```
-----------------------------------

(1 row)
```

5. Select a sample of the log file. The following code retrieves the log time and error message description.

```
postgres=> SELECT log_time, message from my_postgres_error_log order by 1;
```

   A sample response is as follows.

```
             log_time             |                                  message

----------------------------------
+---------------------------------------------------------------------------
Tue Aug 09 15:45:18.172 2016 PDT | ending log output to stderr
Tue Aug 09 15:45:18.175 2016 PDT | database system was interrupted; last known up at
 2016-08-09 22:43:34 UTC
Tue Aug 09 15:45:18.223 2016 PDT | checkpoint record is at 0/90002E0
Tue Aug 09 15:45:18.223 2016 PDT | redo record is at 0/90002A8; shutdown FALSE
Tue Aug 09 15:45:18.223 2016 PDT | next transaction ID: 0/1879; next OID: 24578
Tue Aug 09 15:45:18.223 2016 PDT | next MultiXactId: 1; next MultiXactOffset: 0
Tue Aug 09 15:45:18.223 2016 PDT | oldest unfrozen transaction ID: 1822, in database 1
(7 rows)
```

Upgrade PL/v8

If you use PL/v8 and upgrade PostgreSQL to a new PL/v8 version, you immediately take advantage of the new extension but the catalog metadata doesn't reflect this fact. The following steps synchronize your catalog metadata with the new version of PL/v8. These steps are optional but we highly recommended you complete them to avoid metadata mismatch warnings.

1. Verify that you need to update.

Run the following command while connected to your instance.

```
select * from pg_available_extensions where name in
('plv8','plls','plcoffee');
```

If your results contain values for an installed version that is a lower number than the default version, you should continue with this procedure to update your extensions.

For example, the following result set indicates you should update:

```
name     | default_version | installed_version |                     comment
--------+-----------------+-------------------
+--------------------------------------------------
plls     | 2.1.0           | 1.5.3             | PL/LiveScript (v8) trusted procedural
 language
plcoffee| 2.1.0            | 1.5.3             | PL/CoffeeScript (v8) trusted procedural
 language
plv8     | 2.1.0           | 1.5.3             | PL/JavaScript (v8) trusted procedural
 language
(3 rows)
```

2. Take a snapshot of your instance.

   The upgrade drops all your PL/v8 functions. Take a snapshot of your instance as a precaution. You can continue with the following steps while the snapshot is being created.

   For steps to create a snapshot see, Creating a DB Snapshot (p. 301)

3. Get a count of the functions you need to drop and recreate.

   Obtain the count of the number of PL/v8 functions in your instance so you can validate that they are all in place after the upgrade.

   The following code returns the number of functions written in PL/v8, plcoffee, or plls:

```
select proname, nspname, lanname
from pg_proc p, pg_language l, pg_namespace n
where p.prolang = l.oid
and n.oid = p.pronamespace
and lanname in ('plv8','plcoffee','plls');
```

4. Use pg_dump to create a schema-only dump file.

   The following code creates a file on your client machine in the /tmp directory.

```
./pg_dump -Fc --schema-only -U master postgres > /tmp/test.dmp
```

   This example uses the following flags:

   - -FC "format custom"
   - --schema-only "will only dump commands necessary to create schema (functions in our case)"
   - -U "rds master username"
   - database "the database name in our instance"

   For more information on pg_dump see, pg_dump.

5. Extract the "CREATE FUNCTION" DDL statement that is present in the dump file.

The following code extracts the DDL statement needed to create the functions. You use this in subsequent steps to recreate the functions. The code uses the `grep` command to extract the statements to a file.

```
./pg_restore -l /tmp/test.dmp | grep FUNCTION > /tmp/function_list/
```

For more information on pg_restore see, pg_restore.

6. Drop the functions and extensions.

   The following code drops any PL/v8 based objects. The cascade option ensures that any dependent are dropped.

   ```
   drop extension plv8 cascade;
   ```

   If your PostgreSQL instance contains objects based on plcoffee or plls, repeat this step for those extensions.

7. Create the extensions.

   The following code creates the PL/v8, plcoffee, and plls extensions:

   ```
   create extension plv8;
   ```

   ```
   create extension plcoffee;
   ```

   ```
   create extension plls;
   ```

8. Create the functions using the dump file and "driver" file.

   The following code re-creates the functions that you extracted previously.

   ```
   ./pg_restore -U master -d postgres -Fc -L /tmp/function_list /tmp/test.dmp
   ```

9. Verify your functions count.

   Validate that your functions have all been re-creating by re-running the following code:

   ```
   select * from pg_available_extensions where name in
   ('plv8','plls','plcoffee');
   ```

   Note
   PL/v8 version 2 adds the following extra row to your result set:

   ```
       proname    |  nspname    | lanname
   ---------------+-------------+----------
    plv8_version  | pg_catalog | plv8
   ```

Supported PostgreSQL Features

Amazon RDS supports many of the most common PostgreSQL features. These include:

Topics

- ALTER ENUM for PostgreSQL (p. 1352)

Logical Replication for PostgreSQL on Amazon RDS

Beginning with PostgreSQL version 10.4, RDS supports the publication and subscription SQL Syntax for PostgreSQL 10 Logical Replication.

To enable logical replication for an Amazon RDS for PostgreSQL DB instance

1. The AWS user account requires the **rds_superuser** role to perform logical replication for the PostgreSQL database on Amazon RDS.
2. Set the `rds.logical_replication` static parameter to 1.
3. Modify the inbound rules of the security group for the publisher instance (production) to allow the subscriber instance (replica) to connect. This is usually done by including the IP address of the subscriber in the security group.
4. Restart the DB instance for the changes to the static parameter `rds.logical_replication` to take effect.

For more information on PostgreSQL logical replication, see the PostgreSQL documentation.

Logical Decoding and Logical Replication

Beginning with PostgreSQL version 9.4, RDS supports the streaming of WAL changes using logical replication slots. Amazon RDS supports logical decoding for a PostgreSQL DB instance version 9.4.9 and higher and 9.5.4 and higher. You can set up logical replication slots on your instance and stream database changes through these slots to a client such as `pg_recvlogical`. Logical replication slots are created at the database level and support replication connections to a single database.

The most common clients for PostgreSQL logical replication are the AWS Database Migration Service or a custom-managed host on an AWS EC2 instance. The logical replication slot knows nothing about the receiver of the stream, and there is no requirement that the target be a replica database. If you set up a logical replication slot and don't read from the slot, data can be written and quickly fill up your DB instance's storage.

PostgreSQL logical replication and logical decoding on Amazon RDS are enabled with a parameter, a replication connection type, and a security role. The client for logical decoding can be any client that is capable of establishing a replication connection to a database on a PostgreSQL DB instance.

To enable logical decoding for an Amazon RDS for PostgreSQL DB instance

1. The user account requires the **rds_superuser** role to enable logical replication. The user account also requires the **rds_replication** role to grant permissions to manage logical slots and to stream data using logical slots.
2. Set the `rds.logical_replication` static parameter to 1. As part of applying this parameter, we also set the parameters `wal_level`, `max_wal_senders`, `max_replication_slots`, and `max_connections`. These parameter changes can increase WAL generation, so you should only set the `rds.logical_replication` parameter when you are using logical slots.
3. Reboot the DB instance for the static `rds.logical_replication` parameter to take effect.
4. Create a logical replication slot as explained in the next section. This process requires that you specify a decoding plugin. Currently we support the `test_decoding` output plugin that ships with PostgreSQL.

For more information on PostgreSQL logical decoding, see the PostgreSQL documentation.

Working with Logical Replication Slots

You can use SQL commands to work with logical slots. For example, the following command creates a logical slot named test_slot using the default PostgreSQL output plugin test_decoding.

```
SELECT * FROM pg_create_logical_replication_slot('test_slot', 'test_decoding');
```

The output should be similar to the following.

```
slot_name     | xlog_position
-----------------+---------------
regression_slot | 0/16B1970
(1 row)
```

To list logical slots, use the following command.

```
SELECT * FROM pg_replication_slots;
```

To drop a logical slot, use the following command.

```
SELECT pg_drop_replication_slot('test_slot');
```

The output should be similar to the following.

```
pg_drop_replication_slot
-----------------------

(1 row)
```

For more examples on working with logical replication slots, see Logical Decoding Examples in the PostgreSQL documentation.

Once you create the logical replication slot, you can start streaming. The following example shows how logical decoding is controlled over the streaming replication protocol, using the program pg_recvlogical included in the PostgreSQL distribution. This requires that client authentication is set up to allow replication connections.

```
pg_recvlogical -d postgres --slot test_slot -U master
    --host sg-postgresql1.c6c8mresaghgv0.us-west-2.rds.amazonaws.com
    -f -  --start
```

Event Triggers for PostgreSQL on Amazon RDS

PostgreSQL versions 9.4.9 and later and version 9.5.4 and later support event triggers, and Amazon RDS supports event triggers for these versions. The master user account can be used to create, modify, rename, and delete event triggers. Event triggers are at the DB instance level, so they can apply to all databases on an instance.

For example, the following code creates an event trigger that prints the current user at the end of every DDL command.

```
CREATE OR REPLACE FUNCTION raise_notice_func()
                RETURNS event_trigger
                LANGUAGE plpgsql AS
$$
BEGIN
                RAISE NOTICE 'In trigger function: %', current_user;
END;
$$;

CREATE EVENT TRIGGER event_trigger_1
                ON ddl_command_end
EXECUTE PROCEDURE raise_notice_func();
```

For more information about PostgreSQL event triggers, see Event Triggers in the PostgreSQL documentation.

There are several limitations to using PostgreSQL event triggers on Amazon RDS. These include:

- You cannot create event triggers on read replicas. You can, however, create event triggers on a read replica master. The event triggers are then copied to the read replica. The event triggers on the read replica don't fire on the read replica when changes are pushed from the master. However, if the read replica is promoted, the existing event triggers fire when database operations occur.
- To perform a major version upgrade to a PostgreSQL DB instance that uses event triggers, you must delete the event triggers before you upgrade the instance.

Huge Pages for Amazon RDS for PostgreSQL

Amazon RDS for PostgreSQL supports multiple page sizes for PostgreSQL versions 9.4.11 and later, 9.5.6 and later, and 9.6.2 and later. This support includes 4 K and 2 MB page sizes.

Huge pages reduce overhead when using large contiguous chunks of memory. You allocate huge pages for your application by using calls to *mmap* or *SYSV* shared memory. You enable huge pages on an Amazon RDS for PostgreSQL database by using the `huge_pages` parameter. Set this parameter to "on" to enable huge pages.

For PostgreSQL versions 10 and above, huge pages are enabled for all instance classes. For PostgreSQL versions below 10, huge pages are enabled by default for db.r4.*, db.m4.16xlarge, and db.m5.* instance classes. For other instance classes, huge pages are disabled by default.

When you set the `huge_pages` parameter to "on," Amazon RDS uses huge pages based on the available shared memory. If the DB instance is unable to use huge pages due to shared memory constraints, Amazon RDS prevents the instance from starting and sets the status of the DB instance to an incompatible parameters state. In this case, you can set the `huge_pages` parameter to "off" to allow Amazon RDS to start the DB instance.

The `shared_buffers` parameter is key to setting the shared memory pool that is required for using huge pages. The default value for the `shared_buffers` parameter is set to a percentage of the total 8K pages available for that instance's memory. When you use huge pages, those pages are allocated in the huge pages collocated together. Amazon RDS puts a DB instance into an incompatible parameters state if the shared memory parameters are set to require more than 90 percent of the DB instance memory. For more information about setting shared memory for PostgreSQL, see the PostgreSQL documentation.

Note
Huge pages are not supported for the db.m1, db.m2, and db.m3 DB instance classes.

Tablespaces for PostgreSQL on Amazon RDS

Tablespaces are supported in PostgreSQL on Amazon RDS for compatibility; since all storage is on a single logical volume, tablespaces cannot be used for IO splitting or isolation. We have benchmarks and practical experience that shows that a single logical volume is the best setup for most use cases.

Autovacuum for PostgreSQL on Amazon RDS

The PostgreSQL autovacuum feature is turned on by default for new PostgreSQL DB instances. Autovacuum is optional, but we highly recommend that you do not turn autovacuum off. For more information on using autovacuum with Amazon RDS for PostgreSQL, see Working with PostgreSQL Autovacuum on Amazon RDS (p. 1278).

RAM Disk for the stats_temp_directory

The Amazon RDS for PostgreSQL parameter, `rds.pg_stat_ramdisk_size`, can be used to specify the system memory allocated to a RAM disk for storing the PostgreSQL `stats_temp_directory`. The RAM disk parameter is available for all PostgreSQL versions on Amazon RDS.

Under certain workloads, setting this parameter can improve performance and decrease IO requirements. For more information about the `stats_temp_directory`, see the PostgreSQL documentation..

To enable a RAM disk for your `stats_temp_directory`, set the `rds.pg_stat_ramdisk_size` parameter to a non-zero value in the parameter group used by your DB instance. The parameter value is in MB. You must reboot the DB instance before the change takes effect.

For example, the following AWS CLI command sets the RAM disk parameter to 256 MB.

```
aws rds modify-db-parameter-group \
    --db-parameter-group-name pg-95-ramdisk-testing \
    --parameters "ParameterName=rds.pg_stat_ramdisk_size, ParameterValue=256,
 ApplyMethod=pending-reboot"
```

After you reboot, run the following command to see the status of the `stats_temp_directory`:

```
postgres=>show stats_temp_directory;
```

The command should return the following:

```
stats_temp_directory
---------------------------
/rdsdbramdisk/pg_stat_tmp
(1 row)
```

ALTER ENUM for PostgreSQL

Amazon RDS for PostgreSQL versions 9.6.2 and 9.5.6 and later support the ability to alter enumerations. This feature is not available in other versions on Amazon RDS.

The following code shows an example of altering an enum value.

```
postgres=> CREATE TYPE rainbow AS ENUM ('red', 'orange', 'yellow', 'green', 'blue',
 'purple');
CREATE TYPE
postgres=> CREATE TABLE t1 (colors rainbow);
CREATE TABLE
postgres=> INSERT INTO t1 VALUES ('red'), ( 'orange');
INSERT 0 2
postgres=> SELECT * from t1;
colors
--------
red
orange
(2 rows)
postgres=> ALTER TYPE rainbow RENAME VALUE 'red' TO 'crimson';
ALTER TYPE
postgres=> SELECT * from t1;
colors
---------
crimson
orange
(2 rows)
```

Limits for PostgreSQL DB Instances

The following is a list of limitations for PostgreSQL on Amazon RDS:

- You can have up to 40 PostgreSQL DB instances.
- For storage limits, see Amazon RDS DB Instance Storage (p. 29).
- Amazon RDS reserves up to 3 connections for system maintenance. If you specify a value for the user connections parameter, you need to add 3 to the number of connections that you expect to use.

Upgrading a PostgreSQL DB Instance

There are two types of upgrades you can manage for your PostgreSQL DB instance:

- OS Updates – Occasionally, Amazon RDS might need to update the underlying operating system of your DB instance to apply security fixes or OS changes. You can decide when Amazon RDS applies OS updates by using the RDS console, AWS Command Line Interface (AWS CLI), or RDS API.

  For more information about OS updates, see Applying Updates for a DB Instance (p. 236).
- Database Engine Upgrades – When Amazon RDS supports a new version of a database engine, you can upgrade your DB instances to the new version. There are two kinds of upgrades: major version upgrades and minor version upgrades. Amazon RDS supports both major and minor version upgrades for PostgreSQL DB instances.

  For more information about PostgreSQL DB engine upgrades, see Upgrading the PostgreSQL DB Engine for Amazon RDS (p. 1235).

Using SSL with a PostgreSQL DB Instance

Amazon RDS supports Secure Socket Layer (SSL) encryption for PostgreSQL DB instances. Using SSL, you can encrypt a PostgreSQL connection between your applications and your PostgreSQL DB instances. You can also force all connections to your PostgreSQL DB instance to use SSL.

For general information about SSL support and PostgreSQL databases, see SSL Support in the PostgreSQL documentation. For information about using an SSL connection over JDBC, see Configuring the Client in the PostgreSQL documentation.

Topics

SSL support is available in all AWS regions for PostgreSQL. Amazon RDS creates an SSL certificate for your PostgreSQL DB instance when the instance is created. If you enable SSL certificate verification, then the SSL certificate includes the DB instance endpoint as the Common Name (CN) for the SSL certificate to guard against spoofing attacks.

To connect to a PostgreSQL DB instance over SSL

1. Download the certificate.

   For information about downloading certificates, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Import the certificate into your operating system.
3. Connect to your PostgreSQL DB instance over SSL.

   When you connect using SSL, your client can choose whether to verify the certificate chain. If your connection parameters specify `sslmode=verify-ca` or `sslmode=verify-full`, then your client requires the RDS CA certificates to be in their trust store or referenced in the connection URL. This requirement is to verify the certificate chain that signs your database certificate.

   When a client, such as psql or JDBC, is configured with SSL support, the client first tries to connect to the database with SSL by default. If the client can't connect with SSL, it reverts to connecting without SSL. The default `sslmode` mode used is different between libpq-based clients (such as psql) and JDBC. The libpq-based clients default to `prefer`, and JDBC clients default to `verify-full`.

   Use the `sslrootcert` parameter to reference the certificate, for example `sslrootcert=rds-ssl-ca-cert.pem`.

The following is an example of using psql to connect to a PostgreSQL DB instance.

```
$ psql -h testpg.cdhmuqifdpib.us-east-1.rds.amazonaws.com -p 5432 \
    "dbname=testpg user=testuser sslrootcert=rds-ca-2015-root.pem sslmode=verify-full"
```

Requiring an SSL Connection to a PostgreSQL DB Instance

You can require that connections to your PostgreSQL DB instance use SSL by using the `rds.force_ssl` parameter. By default, the `rds.force_ssl` parameter is set to 0 (off). You can set the `rds.force_ssl` parameter to 1 (on) to require SSL for connections to your DB instance. Updating the `rds.force_ssl` parameter also sets the PostgreSQL `ssl` parameter to 1 (on) and modifies your DB instance's `pg_hba.conf` file to support the new SSL configuration.

You can set the `rds.force_ssl` parameter value by updating the parameter group for your DB instance. If the parameter group for your DB instance isn't the default one, and the `ssl` parameter is already set to 1 when you set `rds.force_ssl` to 1, you don't need to reboot your DB instance. Otherwise, you must reboot your DB instance for the change to take effect. For more information on parameter groups, see Working with DB Parameter Groups (p. 202).

When the `rds.force_ssl` parameter is set to 1 for a DB instance, you see output similar to the following when you connect, indicating that SSL is now required:

```
$ psql postgres -h SOMEHOST.amazonaws.com -p 8192 -U someuser
. . .
SSL connection (cipher: DHE-RSA-AES256-SHA, bits: 256)
Type "help" for help.

postgres=>
```

Determining the SSL Connection Status

The encrypted status of your connection is shown in the logon banner when you connect to the DB instance:

```
Password for user master:
psql (10.3)
SSL connection (cipher: DHE-RSA-AES256-SHA, bits: 256)
Type "help" for help.

postgres=>
```

You can also load the `sslinfo` extension and then call the `ssl_is_used()` function to determine if SSL is being used. The function returns `t` if the connection is using SSL, otherwise it returns `f`.

```
postgres=> create extension sslinfo;
CREATE EXTENSION

postgres=> select ssl_is_used();
 ssl_is_used
---------
t
(1 row)
```

You can use the `select ssl_cipher()` command to determine the SSL cipher:

```
postgres=> select ssl_cipher();
ssl_cipher
--------------------
DHE-RSA-AES256-SHA
(1 row)
```

If you enable `set rds.force_ssl` and restart your instance, non-SSL connections are refused with the following message:

```
$ export PGSSLMODE=disable
$ psql postgres -h SOMEHOST.amazonaws.com -p 8192 -U someuser
psql: FATAL: no pg_hba.conf entry for host "host.ip", user "someuser", database "postgres",
 SSL off
$
```

For information about the `sslmode` option, see Database Connection Control Functions in the PostgreSQL documentation.

Security in Amazon RDS

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that are built to meet the requirements of the most security-sensitive organizations.

Security is a shared responsibility between AWS and you. The shared responsibility model describes this as security *of* the cloud and security *in* the cloud:

- **Security of the cloud** – AWS is responsible for protecting the infrastructure that runs AWS services in the AWS Cloud. AWS also provides you with services that you can use securely. Third-party auditors regularly test and verify the effectiveness of our security as part of the AWS compliance programs. To learn about the compliance programs that apply to Amazon RDS, see AWS Services in Scope by Compliance Program.
- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your organization's requirements, and applicable laws and regulations.

This documentation helps you understand how to apply the shared responsibility model when using Amazon RDS. The following topics show you how to configure Amazon RDS to meet your security and compliance objectives. You also learn how to use other AWS services that help you monitor and secure your Amazon RDS resources.

You can manage access to your Amazon RDS resources and your databases on a DB instance. The method you use to manage access depends on what type of task the user needs to perform with Amazon RDS:

- Run your DB instance in a virtual private cloud (VPC) based on the Amazon VPC service for the greatest possible network access control. For more information about creating a DB instance in a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
- Use AWS Identity and Access Management (IAM) policies to assign permissions that determine who is allowed to manage Amazon RDS resources. For example, you can use IAM to determine who is allowed to create, describe, modify, and delete DB instances, tag resources, or modify security groups.
- Use security groups to control what IP addresses or Amazon EC2 instances can connect to your databases on a DB instance. When you first create a DB instance, its firewall prevents any database access except through rules specified by an associated security group.
- Use Secure Socket Layer (SSL) or Transport Layer Security (TLS) connections with DB instances running the MySQL, MariaDB, PostgreSQL, Oracle, or Microsoft SQL Server database engines. For more information on using SSL/TLS with a DB instance, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
- Use Amazon RDS encryption to secure your DB instances and snapshots at rest. Amazon RDS encryption uses the industry standard AES-256 encryption algorithm to encrypt your data on the server that hosts your DB instance. For more information, see Encrypting Amazon RDS Resources (p. 1358).
- Use network encryption and transparent data encryption with Oracle DB instances; for more information, see Oracle Native Network Encryption (p. 963) and Oracle Transparent Data Encryption (p. 990)
- Use the security features of your DB engine to control who can log in to the databases on a DB instance. These features work just as if the database was on your local network.

Note
You only have to configure security for your use cases. You don't have to configure security access for processes that Amazon RDS manages. These include creating backups, replicating data between a master and a read replica, and other processes.

For more information on managing access to Amazon RDS resources and your databases on a DB instance, see the following topics.

Topics

Data Protection in Amazon RDS

Amazon RDS conforms to the AWS shared responsibility model, which includes regulations and guidelines for data protection. AWS is responsible for protecting the global infrastructure that runs all the AWS services. AWS maintains control over data hosted on this infrastructure, including the security configuration controls for handling customer content and personal data. AWS customers and APN partners, acting either as data controllers or data processors, are responsible for any personal data that they put in the AWS Cloud.

For data protection, we recommend that you protect AWS account credentials and set up principals with AWS Identity and Access Management (IAM). Doing this means that each user is given only the permissions necessary to fulfill their job duties. We also recommend that you secure your data in the following ways:

- Use multi-factor authentication (MFA) with each account.
- Use SSL/TLS to communicate with AWS resources.
- Set up API and user activity logging with AWS CloudTrail.
- Use AWS encryption solutions, along with all default security controls within AWS services.
- Use advanced managed security services such as Amazon Macie, which assists in discovering and securing personal data that is stored in Amazon S3.

We strongly recommend that you never put sensitive identifying information, such as your customers' account numbers, into free-form fields such as a **Name** field. This recommendation includes when you work with Amazon RDS or other AWS services using the console, API, AWS CLI, or AWS SDKs. Any data that you enter into Amazon RDS or other services might get picked up for inclusion in diagnostic logs. When you provide a URL to an external server, don't include credentials information in the URL to validate your request to that server.

For more information about data protection, see the AWS Shared Responsibility Model and GDPR blog post on the *AWS Security Blog*.

Topics

Protecting Data Using Encryption

You can enable encryption for database resources. You can also encrypt connections to DB instances.

Topics

Encrypting Amazon RDS Resources

You can encrypt your Amazon RDS DB instances and snapshots at rest by enabling the encryption option for your Amazon RDS DB instances. Data that is encrypted at rest includes the underlying storage for DB instances, its automated backups, read replicas, and snapshots.

Amazon RDS encrypted DB instances use the industry standard AES-256 encryption algorithm to encrypt your data on the server that hosts your Amazon RDS DB instances. After your data is encrypted, Amazon RDS handles authentication of access and decryption of your data transparently with a minimal impact on performance. You don't need to modify your database client applications to use encryption.

> **Note**
> For encrypted and unencrypted DB instances, data that is in transit between the source and the read replicas is encrypted, even when replicating across AWS Regions.

Topics

Overview of Encrypting Amazon RDS Resources

Amazon RDS encrypted DB instances provide an additional layer of data protection by securing your data from unauthorized access to the underlying storage. You can use Amazon RDS encryption to increase data protection of your applications deployed in the cloud, and to fulfill compliance requirements for data-at-rest encryption.

Amazon RDS also supports encrypting an Oracle or SQL Server DB instance with Transparent Data Encryption (TDE). TDE can be used with encryption at rest, although using TDE and encryption at rest simultaneously might slightly affect the performance of your database. You must manage different keys for each encryption method. For more information on TDE, see Oracle Transparent Data Encryption (p. 990) or Support for Transparent Data Encryption in SQL Server (p. 640).

To manage the keys used for encrypting and decrypting your Amazon RDS resources, you use the AWS Key Management Service (AWS KMS). AWS KMS combines secure, highly available hardware and software to provide a key management system scaled for the cloud. Using AWS KMS, you can create encryption keys and define the policies that control how these keys can be used. AWS KMS supports CloudTrail, so you can audit key usage to verify that keys are being used appropriately. You can use your AWS KMS keys with Amazon RDS and supported AWS services such as Amazon S3, Amazon EBS, and Amazon Redshift. For a list of services that support AWS KMS, see Supported Services in the *AWS Key Management Service Developer Guide*.

For an Amazon RDS encrypted DB instance, all logs, backups, and snapshots are encrypted. A read replica of an Amazon RDS encrypted instance is also encrypted using the same key as the master instance when both are in the same AWS Region. If the master and read replica are in different AWS Regions, you encrypt using the encryption key for that AWS Region.

Enabling Amazon RDS Encryption for a DB Instance

To enable encryption for a new DB instance, choose **Enable encryption** on the Amazon RDS console. For information on creating a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

If you use the create-db-instance AWS CLI command to create an encrypted DB instance, set the `--storage-encrypted` parameter to true. If you use the CreateDBInstance API operation, set the `StorageEncrypted` parameter to true.

When you create an encrypted DB instance, you can also supply the AWS KMS key identifier for your encryption key. If you don't specify an AWS KMS key identifier, then Amazon RDS uses your default encryption key for your new DB instance. AWS KMS creates your default encryption key for Amazon RDS for your AWS account. Your AWS account has a different default encryption key for each AWS Region.

Once you have created an encrypted DB instance, you can't change the type of encryption key used by that DB instance. Therefore, be sure to determine your encryption key requirements before you create your encrypted DB instance.

If you use the AWS CLI `create-db-instance` command to create an encrypted DB instance, set the `--kms-key-id` parameter to the Amazon Resource Name (ARN) for the AWS KMS encryption key for the DB instance. If you use the Amazon RDS API `CreateDBInstance` action, set the `KmsKeyId` parameter to the ARN for your AWS KMS key for the DB instance.

You can use the ARN of a key from another account to encrypt a DB instance. Or you might create a DB instance with the same AWS account that owns the AWS KMS encryption key used to encrypt that new DB instance. In this case, the AWS KMS key ID that you pass can be the AWS KMS key alias instead of the key's ARN.

Availability of Amazon RDS Encryption

Amazon RDS encryption is currently available for all database engines and storage types.

Amazon RDS encryption is available for most DB instance classes. The following table lists DB instance classes that *do not support* Amazon RDS encryption:

Instance Type	Instance Class
General Purpose (M1)	db.m1.small db.m1.medium db.m1.large db.m1.xlarge

Instance Type	Instance Class
Memory Optimized (M2)	db.m2.xlarge db.m2.2xlarge db.m2.4xlarge
Burst Capable (T2)	db.t2.micro

Note
Encryption at rest is not available for DB instances running SQL Server Express Edition.

Limitations of Amazon RDS Encrypted DB Instances

The following limitations exist for Amazon RDS encrypted DB instances:

- You can only enable encryption for an Amazon RDS DB instance when you create it, not after the DB instance is created.

  However, because you can encrypt a copy of an unencrypted DB snapshot, you can effectively add encryption to an unencrypted DB instance. That is, you can create a snapshot of your DB instance, and then create an encrypted copy of that snapshot. You can then restore a DB instance from the encrypted snapshot, and thus you have an encrypted copy of your original DB instance. For more information, see Copying a Snapshot (p. 306).
- DB instances that are encrypted can't be modified to disable encryption.
- You can't have an encrypted read replica of an unencrypted DB instance or an unencrypted read replica of an encrypted DB instance.
- Encrypted read replicas must be encrypted with the same key as the source DB instance when both are in the same AWS Region.
- You can't restore an unencrypted backup or snapshot to an encrypted DB instance.
- To copy an encrypted snapshot from one AWS Region to another, you must specify the KMS key identifier of the destination AWS Region. This is because KMS encryption keys are specific to the AWS Region that they are created in.

  The source snapshot remains encrypted throughout the copy process. AWS Key Management Service uses envelope encryption to protect data during the copy process. For more information about envelope encryption, see Envelope Encryption.

Key Management

You can manage keys used for Amazon RDS encrypted DB instances using the AWS Key Management Service (AWS KMS) in the AWS KMS console. If you want full control over a key, then you must create a customer-managed key.

You can't delete, revoke, or rotate default keys provisioned by AWS KMS. You can't share a snapshot that has been encrypted using the default AWS KMS encryption key of the AWS account that shared the snapshot.

You can view audit logs of every action taken with a customer-managed key by using AWS CloudTrail.

Important
When RDS encounters a DB instance encrypted by a key that RDS doesn't have access to, RDS puts the DB instance into a terminal state. In this state, the DB instance is no longer available

and the current state of the database can't be recovered. To restore the DB instance, you must re-enable access to the encryption key for RDS, and then restore the DB instance from a backup.

Using SSL/TLS to Encrypt a Connection to a DB Instance

You can use Secure Socket Layer (SSL) or Transport Layer Security (TLS) from your application to encrypt a connection to a DB instance running MySQL, MariaDB, SQL Server, Oracle, or PostgreSQL. Each DB engine has its own process for implementing SSL/TLS. To learn how to implement SSL/TLS for your DB instance, use the link following that corresponds to your DB engine:

- Using SSL with a MariaDB DB Instance (p. 505)
- Using SSL with a Microsoft SQL Server DB Instance (p. 609)
- Using SSL with a MySQL DB Instance (p. 717)
- Using SSL with an Oracle DB Instance (p. 853)
- Using SSL with a PostgreSQL DB Instance (p. 1353)

Important
For information about rotating your certificate, see Rotating Your SSL/TLS Certificate (p. 1363).

Note
All certificates are only available for download using SSL/TLS connections.

To get a root certificate that works for all AWS Regions, excluding opt-in AWS Regions, download it from https://s3.amazonaws.com/rds-downloads/rds-ca-2019-root.pem.

This root certificate is a trusted root entity and should work in most cases but might fail if your application doesn't accept certificate chains. If your application doesn't accept certificate chains, download the AWS Region–specific certificate from the list of intermediate certificates found later in this section.

To get a certificate bundle that contains both the intermediate and root certificates, download from https://s3.amazonaws.com/rds-downloads/rds-combined-ca-bundle.pem.

If your application is on Microsoft Windows and requires a PKCS7 file, you can download the PKCS7 certificate bundle. This bundle contains both the intermediate and root certificates at https://s3.amazonaws.com/rds-downloads/rds-combined-ca-bundle.p7b.

Note
Amazon RDS Proxy uses certificates from the AWS Certificate Manager (ACM). If you are using RDS Proxy, you don't need to download Amazon RDS certificates or update applications that use RDS Proxy connections. For more information about using TLS/SSL with RDS Proxy, see Using TLS/SSL with RDS Proxy (p. 158).

Root Certificates for Opt-In AWS Regions

If you are using an opt-in AWS Region, you can download the root certificate from the following table.

Opt-In AWS Region	Root Certificate
Africa (Cape Town)	rds-ca-af-south-1-2019-root.pem
Asia Pacific (Hong Kong)	rds-ca-ap-east-1-2019-root.pem
Europe (Milan)	rds-ca-eu-south-1-2019-root.pem

Opt-In AWS Region	Root Certificate
Middle East (Bahrain)	rds-ca-me-south-1-2019-root.pem

Intermediate Certificates

You might need to use an intermediate certificate to connect to your AWS Region. For example, you must use an intermediate certificate to connect to the AWS GovCloud (US-West) Region using SSL/TLS. If you need an intermediate certificate for a particular AWS Region, download the certificate from the following table.

AWS Region	Intermediate Certificate
Asia Pacific (Mumbai)	rds-ca-2019-ap-south-1.pem
Asia Pacific (Tokyo)	rds-ca-2019-ap-northeast-1.pem
Asia Pacific (Seoul)	rds-ca-2019-ap-northeast-2.pem
Asia Pacific (Osaka-Local)	rds-ca-2019-ap-northeast-3.pem
Asia Pacific (Singapore)	rds-ca-2019-ap-southeast-1.pem
Asia Pacific (Sydney)	rds-ca-2019-ap-southeast-2.pem
Canada (Central)	rds-ca-2019-ca-central-1.pem
Europe (Frankfurt)	rds-ca-2019-eu-central-1.pem
Europe (Ireland)	rds-ca-2019-eu-west-1.pem
Europe (London)	rds-ca-2019-eu-west-2.pem
Europe (Paris)	rds-ca-2019-eu-west-3.pem
Europe (Stockholm)	rds-ca-2019-eu-north-1.pem
South America (São Paulo)	rds-ca-2019-sa-east-1.pem
US East (N. Virginia)	rds-ca-2019-us-east-1.pem
US East (Ohio)	rds-ca-2019-us-east-2.pem
US West (N. California)	rds-ca-2019-us-west-1.pem
US West (Oregon)	rds-ca-2019-us-west-2.pem

AWS GovCloud (US) Certificates

You can download the root certificate for an AWS GovCloud (US) Region from the following list:

AWS GovCloud (US-East) (Root CA-2017)

AWS GovCloud (US-West) (Root CA-2017)

You can download the intermediate certificate for an AWS GovCloud (US) Region from the following list:

AWS GovCloud (US-East) (CA-2017)

AWS GovCloud (US-West) (CA-2017)

AWS GovCloud (US-West) (CA-2012)

To get a certificate bundle that contains both the intermediate and root certificates for the AWS GovCloud (US) Regions, download from https://s3.us-gov-west-1.amazonaws.com/rds-downloads/rds-combined-ca-us-gov-bundle.pem.

Rotating Your SSL/TLS Certificate

As of March 5, 2020, Amazon RDS CA-2015 certificates have expired. If you use or plan to use Secure Sockets Layer (SSL) or Transport Layer Security (TLS) with certificate verification to connect to your RDS DB instances, you require Amazon RDS CA-2019 certificates, which are enabled by default for new DB instances. If you currently do not use SSL/TLS with certificate verification, you might still have expired CA-2015 certificates and must update them to CA-2019 certificates if you plan to use SSL/TLS with certificate verification to connect to your RDS databases.

Follow these instructions to complete your updates. Before you update your DB instances to use the new CA certificate, make sure that you update your clients or applications connecting to your RDS databases.

Amazon RDS provides new CA certificates as an AWS security best practice. For information about the new certificates and the supported AWS Regions, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).

> **Note**
> Amazon RDS Proxy uses certificates from the AWS Certificate Manager (ACM). If you are using RDS Proxy, when you rotate your SSL/TLS certificate, you don't need to update applications that use RDS Proxy connections. For more information about using TLS/SSL with RDS Proxy, see Using TLS/SSL with RDS Proxy (p. 158).

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Updating Your CA Certificate by Modifying Your DB Instance

Complete the following steps to update your CA certificate.

To update your CA certificate by modifying your DB instance

1. Download the new SSL/TLS certificate as described in Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Update your applications to use the new SSL/TLS certificate.

   The methods for updating applications for new SSL/TLS certificates depend on your specific applications. Work with your application developers to update the SSL/TLS certificates for your applications.

   For information about checking for SSL/TLS connections and updating applications for each DB engine, see the following topics:

   - Updating Applications to Connect to MariaDB DB Instances Using New SSL/TLS Certificates (p. 513)
   - Updating Applications to Connect to Microsoft SQL Server DB Instances Using New SSL/TLS Certificates (p. 568)

- Updating Applications to Connect to MySQL DB Instances Using New SSL/TLS Certificates (p. 728)
- Updating Applications to Connect to Oracle DB Instances Using New SSL/TLS Certificates (p. 881)
- Updating Applications to Connect to PostgreSQL DB Instances Using New SSL/TLS Certificates (p. 1231)

For a sample script that updates a trust store for a Linux operating system, see Sample Script for Importing Certificates Into Your Trust Store (p. 1369).

Note
The certificate bundle contains certificates for both the old and new CA, so you can upgrade your application safely and maintain connectivity during the transition period. If you are using the AWS Database Migration Service to migrate a database to a DB instance, we recommend using the certificate bundle to ensure connectivity during the migration.

3. Modify the DB instance to change the CA from **rds-ca-2015** to **rds-ca-2019**.

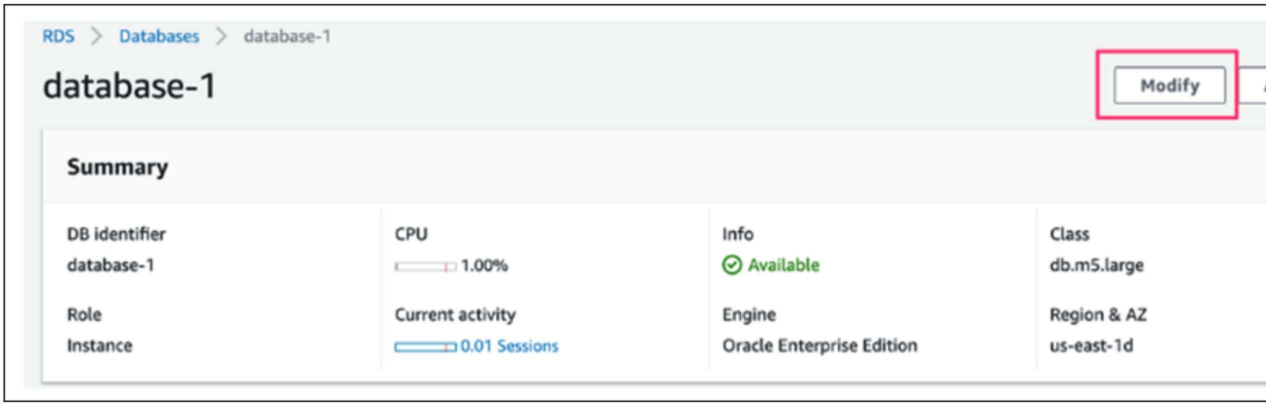
Important
By default, this operation restarts your DB instance. If you don't want to restart your DB instance during this operation, you can use the `modify-db-instance` CLI command and specify the `--no-certificate-rotation-restart` option.
This option will not rotate the certificate until the next time the database restarts, either for planned or unplanned maintenance. This option is only recommended if you don't use SSL/TLS.
If you are experiencing connectivity issues after certificate expiry, use the apply immediately option by specifying **Apply immediately** in the console or by specifying the `--apply-immediately` option using the AWS CLI. By default, this operation is scheduled to run during your next maintenance window.

You can use the AWS Management Console or the AWS CLI to change the CA certificate from **rds-ca-2015** to **rds-ca-2019** for a DB instance.

Console

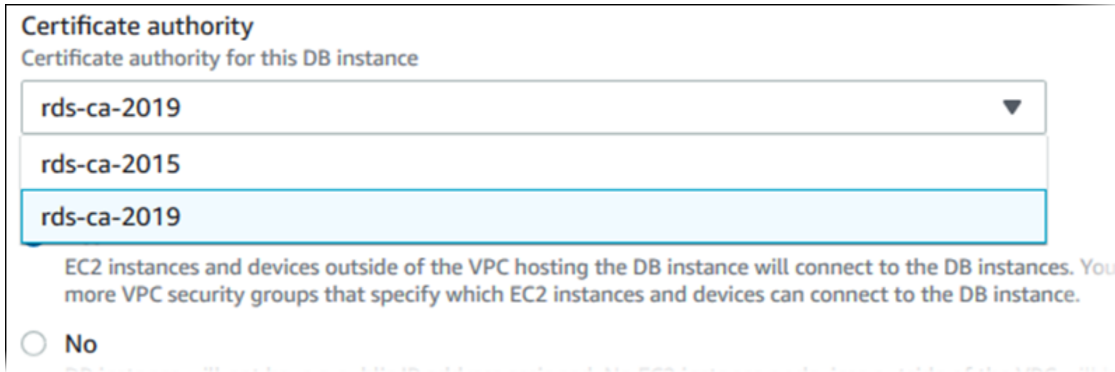
To change the CA from rds-ca-2015 to rds-ca-2019 for a DB instance

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**, and then choose the DB instance that you want to modify.
3. Choose **Modify**.



The **Modify DB Instance** page appears.

4. In the **Network & Security** section, choose **rds-ca-2019**.



5. Choose **Continue** and check the summary of modifications.
6. To apply the changes immediately, choose **Apply immediately**.

   Important
   Choosing this option restarts your database immediately.
7. On the confirmation page, review your changes. If they are correct, choose **Modify DB Instance** to save your changes.

   Important
   When you schedule this operation, make sure that you have updated your client-side trust store beforehand.

   Or choose **Back** to edit your changes or **Cancel** to cancel your changes.

AWS CLI

To use the AWS CLI to change the CA from **rds-ca-2015** to **rds-ca-2019** for a DB instance, call the modify-db-instance command. Specify the DB instance identifier and the `--ca-certificate-identifier` option.

> **Important**
> When you schedule this operation, make sure that you have updated your client-side trust store beforehand.

Example

The following code modifies `mydbinstance` by setting the CA certificate to `rds-ca-2019`. The changes are applied during the next maintenance window by using `--no-apply-immediately`. Use `--apply-immediately` to apply the changes immediately.

> **Important**
> By default, this operation reboots your DB instance. If you don't want to reboot your DB instance during this operation, you can use the `modify-db-instance` CLI command and specify the `--no-certificate-rotation-restart` option.
> This option will not rotate the certificate until the next time the database restarts, either for planned or unplanned maintenance. This option is only recommended if you do not use SSL/TLS.
> Use `--apply-immediately` to apply the update immediately. By default, this operation is scheduled to run during your next maintenance window.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
```

```
    --ca-certificate-identifier rds-ca-2019 \
    --no-apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --ca-certificate-identifier rds-ca-2019 ^
    --no-apply-immediately
```

Updating Your CA Certificate by Applying DB Instance Maintenance

Complete the following steps to update your CA certificate by applying DB instance maintenance.

To update your CA certificate by applying DB instance maintenance

1. Download the new SSL/TLS certificate as described in Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
2. Update your database applications to use the new SSL/TLS certificate.

   The methods for updating applications for new SSL/TLS certificates depend on your specific applications. Work with your application developers to update the SSL/TLS certificates for your applications.

   For information about checking for SSL/TLS connections and updating applications for each DB engine, see the following topics:

   - Updating Applications to Connect to MariaDB DB Instances Using New SSL/TLS Certificates (p. 513)
   - Updating Applications to Connect to Microsoft SQL Server DB Instances Using New SSL/TLS Certificates (p. 568)
   - Updating Applications to Connect to MySQL DB Instances Using New SSL/TLS Certificates (p. 728)
   - Updating Applications to Connect to Oracle DB Instances Using New SSL/TLS Certificates (p. 881)
   - Updating Applications to Connect to PostgreSQL DB Instances Using New SSL/TLS Certificates (p. 1231)

   For a sample script that updates a trust store for a Linux operating system, see Sample Script for Importing Certificates Into Your Trust Store (p. 1369).

   > **Note**
   > The certificate bundle contains certificates for both the old and new CA, so you can upgrade your application safely and maintain connectivity during the transition period.
3. Apply DB instance maintenance to change the CA from **rds-ca-2015** to **rds-ca-2019**.

   > **Important**
   > You can choose to apply the change immediately. By default, this operation is scheduled to run during your next maintenance window.

You can use the AWS Management Console to apply DB instance maintenance to change the CA certificate from **rds-ca-2015** to **rds-ca-2019** for multiple DB instances.

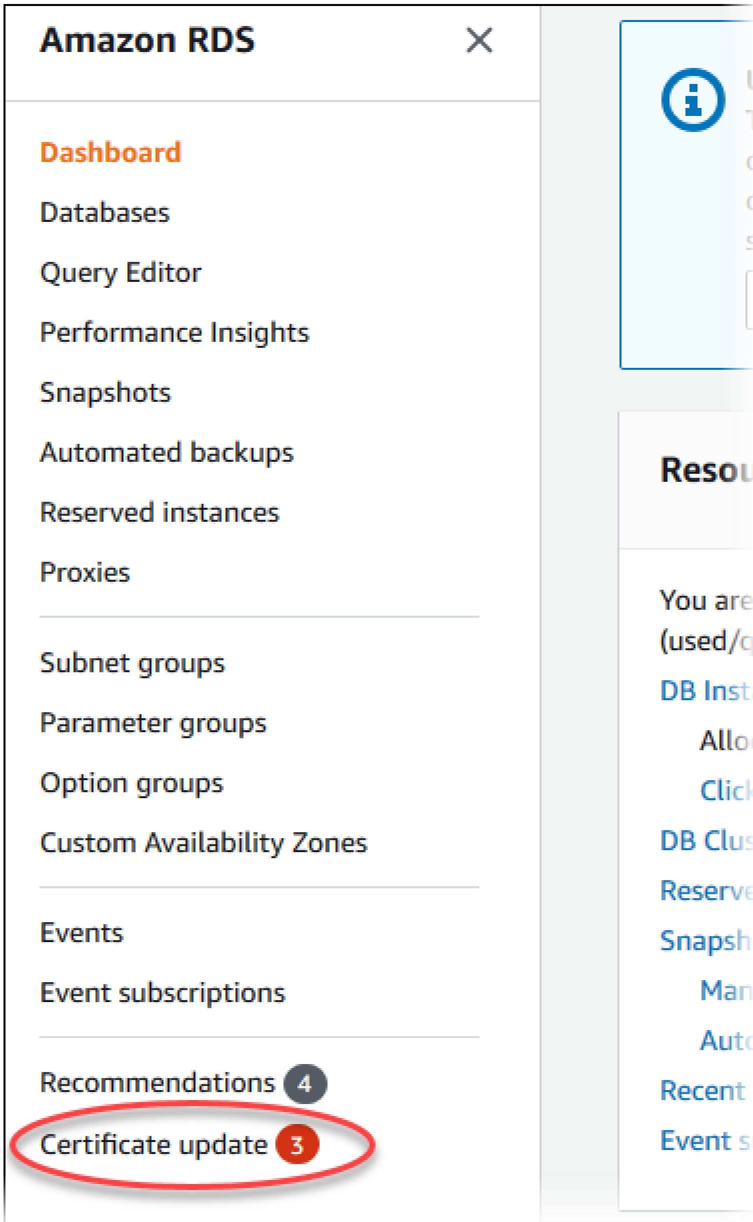
Updating Your CA Certificate by Applying Maintenance to Multiple DB Instances

Use the AWS Management Console to change the CA certificate for multiple DB instances.

To change the CA from rds-ca-2015 to rds-ca-2019 for multiple DB instances

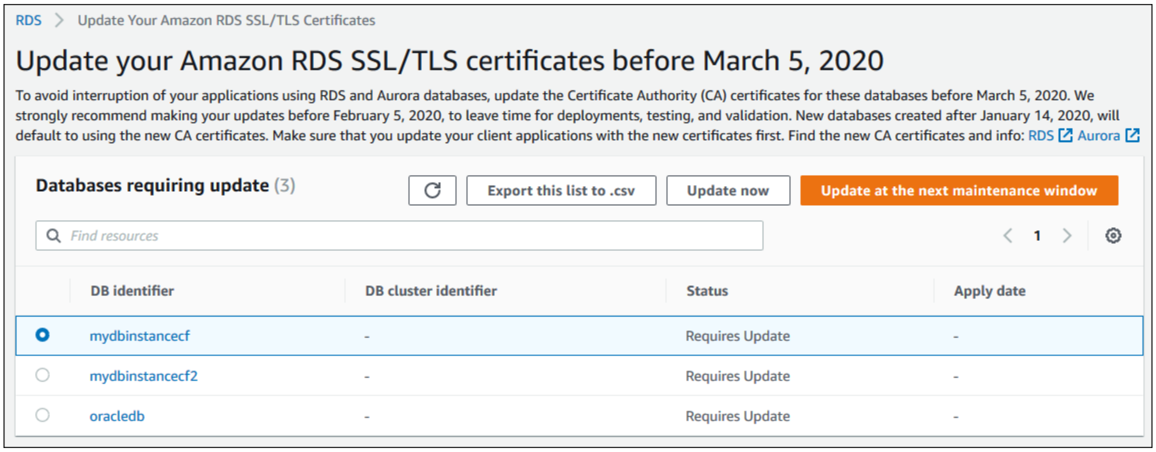
1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.

   In the navigation pane, there is a **Certificate update** option that shows the total number of affected DB instances.

   Choose **Certificate update** in the navigation pane.

   The **Update your Amazon RDS SSL/TLS certificates** page appears.



Note
This page only shows the DB instances for the current AWS Region. If you have DB instances in more than one AWS Region, check this page in each AWS Region to see all DB instances with old SSL/TLS certificates.

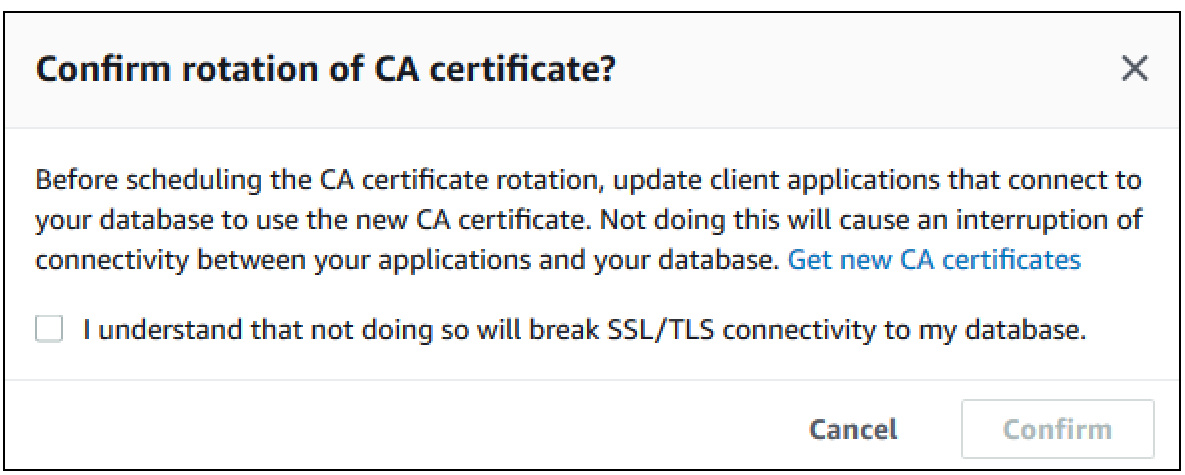
3. Choose the DB instance you want to update.

   You can schedule the certificate rotation for your next maintenance window by choosing **Update at the next maintenance window**. Apply the rotation immediately by choosing **Update now**.

   Important
   When your CA certificate is rotated, the operation restarts your DB instance.
   If you experience connectivity issues after certificate expiry, use the **Update now** option.

4. If you choose **Update at the next maintenance window** or **Update now**, you are prompted to confirm the CA certificate rotation.

   Important
   Before scheduling the CA certificate rotation on your database, update any client applications that use SSL/TLS and the server certificate to connect. These updates are specific to your DB engine. To determine whether your applications use SSL/TLS and the server certificate to connect, see Step 2: Update Your Database Applications to Use the New SSL/TLS Certificate (p. 1366). After you have updated these client applications, you can confirm the CA certificate rotation.



   To continue, choose the check box, and then choose **Confirm**.

5. Repeat steps 3 and 4 for each DB instance that you want to update.

Sample Script for Importing Certificates Into Your Trust Store

The following are sample shell scripts that import the certificate bundle into a trust store.

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Sample Script for Importing Certificates on Linux

The following is a sample shell script that imports the certificate bundle into a trust store on a Linux operating system.

```
mydir=tmp/certs
if [ ! -e "${mydir}" ]
then
mkdir -p "${mydir}"
fi

truststore=${mydir}/rds-truststore.jks
storepassword=changeit

curl -sS "https://s3.amazonaws.com/rds-downloads/rds-combined-ca-bundle.pem" > ${mydir}/
rds-combined-ca-bundle.pem
awk 'split_after == 1 {n++;split_after=0} /-----END CERTIFICATE-----/ {split_after=1}{print
 > "rds-ca-" n ".pem"}' < ${mydir}/rds-combined-ca-bundle.pem

for CERT in rds-ca-*; do
  alias=$(openssl x509 -noout -text -in $CERT | perl -ne 'next unless /Subject:/; s/.*(CN=|
CN = )//; print')
  echo "Importing $alias"
  keytool -import -file ${CERT} -alias "${alias}" -storepass ${storepassword} -keystore
 ${truststore} -noprompt
  rm $CERT
done

rm ${mydir}/rds-combined-ca-bundle.pem

echo "Trust store content is: "

keytool -list -v -keystore "$truststore" -storepass ${storepassword} | grep Alias | cut -d
 " " -f3- | while read alias
do
   expiry=`keytool -list -v -keystore "$truststore" -storepass ${storepassword} -alias
 "${alias}" | grep Valid | perl -ne 'if(/until: (.*?)\n/) { print "$1\n"; }'`
   echo " Certificate ${alias} expires in '$expiry'"
done
```

Sample Script for Importing Certificates on macOS

The following is a sample shell script that imports the certificate bundle into a trust store on macOS.

```
mydir=tmp/certs
if [ ! -e "${mydir}" ]
then
mkdir -p "${mydir}"
fi
```

```
truststore=${mydir}/rds-truststore.jks
storepassword=changeit

curl -sS "https://s3.amazonaws.com/rds-downloads/rds-combined-ca-bundle.pem" > ${mydir}/
rds-combined-ca-bundle.pem
split -p "-----BEGIN CERTIFICATE-----" ${mydir}/rds-combined-ca-bundle.pem rds-ca-

for CERT in rds-ca-*; do
  alias=$(openssl x509 -noout -text -in $CERT | perl -ne 'next unless /Subject:/; s/.*(CN=|
CN = )//; print')
  echo "Importing $alias"
  keytool -import -file ${CERT} -alias "${alias}" -storepass ${storepassword} -keystore
 ${truststore} -noprompt
  rm $CERT
done

rm ${mydir}/rds-combined-ca-bundle.pem

echo "Trust store content is: "

keytool -list -v -keystore "$truststore" -storepass ${storepassword} | grep Alias | cut -d
 " " -f3- | while read alias
do
   expiry=`keytool -list -v -keystore "$truststore" -storepass ${storepassword} -alias
 "${alias}" | grep Valid | perl -ne 'if(/until: (.*?)\n/) { print "$1\n"; }'`
   echo " Certificate ${alias} expires in '$expiry'"
done
```

Internetwork Traffic Privacy

Connections are protected both between Amazon RDS and on-premises applications and between Amazon RDS and other AWS resources within the same AWS Region.

Traffic Between Service and On-Premises Clients and Applications

You have two connectivity options between your private network and AWS:

- An AWS Site-to-Site VPN connection. For more information, see What is AWS Site-to-Site VPN?
- An AWS Direct Connect connection. For more information, see What is AWS Direct Connect?

You get access to Amazon RDS through the network by using AWS-published API operations. Clients must support Transport Layer Security (TLS) 1.0. We recommend TLS 1.2. Clients must also support cipher suites with Perfect Forward Secrecy (PFS), such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Diffie-Hellman Ephemeral (ECDHE). Most modern systems such as Java 7 and later support these modes. Additionally, you must sign requests using an access key ID and a secret access key that are associated with an IAM principal. Or you can use the AWS Security Token Service (STS) to generate temporary security credentials to sign requests.

Identity and Access Management in Amazon RDS

AWS Identity and Access Management (IAM) is an AWS service that helps an administrator securely control access to AWS resources. IAM administrators control who can be *authenticated* (signed in) and *authorized* (have permissions) to use Amazon RDS resources. IAM is an AWS service that you can use with no additional charge.

Topics

Audience

How you use AWS Identity and Access Management (IAM) differs, depending on the work you do in Amazon RDS.

Service user – If you use the Amazon RDS service to do your job, then your administrator provides you with the credentials and permissions that you need. As you use more Amazon RDS features to do your work, you might need additional permissions. Understanding how access is managed can help you request the right permissions from your administrator. If you cannot access a feature in Amazon RDS, see Troubleshooting Amazon RDS Identity and Access (p. 1407).

Service administrator – If you're in charge of Amazon RDS resources at your company, you probably have full access to Amazon RDS. It's your job to determine which Amazon RDS features and resources your employees should access. You must then submit requests to your IAM administrator to change the permissions of your service users. Review the information on this page to understand the basic concepts of IAM. To learn more about how your company can use IAM with Amazon RDS, see How Amazon RDS Works with IAM (p. 1375).

IAM administrator – If you're an IAM administrator, you might want to learn details about how you can write policies to manage access to Amazon RDS. To view example Amazon RDS identity-based policies that you can use in IAM, see Amazon RDS Identity-Based Policy Examples (p. 1377).

Authenticating With Identities

Authentication is how you sign in to AWS using your identity credentials. For more information about signing in using the AWS Management Console, see The IAM Console and Sign-in Page in the *IAM User Guide*.

You must be *authenticated* (signed in to AWS) as the AWS account root user, an IAM user, or by assuming an IAM role. You can also use your company's single sign-on authentication, or even sign in using Google or Facebook. In these cases, your administrator previously set up identity federation using IAM roles. When you access AWS using credentials from another company, you are assuming a role indirectly.

To sign in directly to the AWS Management Console, use your password with your root user email or your IAM user name. You can access AWS programmatically using your root user or IAM user access keys. AWS provides SDK and command line tools to cryptographically sign your request using your credentials. If you don't use AWS tools, you must sign the request yourself. Do this using *Signature Version 4*, a protocol for authenticating inbound API requests. For more information about authenticating requests, see Signature Version 4 Signing Process in the *AWS General Reference*.

Regardless of the authentication method that you use, you might also be required to provide additional security information. For example, AWS recommends that you use multi-factor authentication (MFA) to increase the security of your account. To learn more, see Using Multi-Factor Authentication (MFA) in AWS in the *IAM User Guide*.

AWS Account Root User

When you first create an AWS account, you begin with a single sign-in identity that has complete access to all AWS services and resources in the account. This identity is called the AWS account *root user* and is accessed by signing in with the email address and password that you used to create the account. We strongly recommend that you do not use the root user for your everyday tasks, even the administrative ones. Instead, adhere to the best practice of using the root user only to create your first IAM user. Then securely lock away the root user credentials and use them to perform only a few account and service management tasks.

IAM Users and Groups

An *IAM user* is an identity within your AWS account that has specific permissions for a single person or application. An IAM user can have long-term credentials such as a user name and password or a set of access keys. To learn how to generate access keys, see Managing Access Keys for IAM Users in the *IAM User Guide*. When you generate access keys for an IAM user, make sure you view and securely save the key pair. You cannot recover the secret access key in the future. Instead, you must generate a new access key pair.

An *IAM group* is an identity that specifies a collection of IAM users. You can't sign in as a group. You can use groups to specify permissions for multiple users at a time. Groups make permissions easier to manage for large sets of users. For example, you could have a group named *IAMAdmins* and give that group permissions to administer IAM resources.

Users are different from roles. A user is uniquely associated with one person or application, but a role is intended to be assumable by anyone who needs it. Users have permanent long-term credentials, but roles provide temporary credentials. To learn more, see When to Create an IAM User (Instead of a Role) in the *IAM User Guide*.

You can authenticate to your DB instance using IAM database authentication.

IAM database authentication works with the following DB engines:

- Amazon RDS for MySQL
- Amazon RDS for PostgreSQL

For more information about authenticating to your DB instance using IAM, see IAM Database Authentication for MySQL and PostgreSQL (p. 1387).

IAM Roles

An *IAM role* is an identity within your AWS account that has specific permissions. It is similar to an IAM user, but is not associated with a specific person. You can temporarily assume an IAM role in the AWS Management Console by switching roles. You can assume a role by calling an AWS CLI or AWS API operation or by using a custom URL. For more information about methods for using roles, see Using IAM Roles in the *IAM User Guide*.

IAM roles with temporary credentials are useful in the following situations:

- **Temporary IAM user permissions** – An IAM user can assume an IAM role to temporarily take on different permissions for a specific task.
- **Federated user access** – Instead of creating an IAM user, you can use existing identities from AWS Directory Service, your enterprise user directory, or a web identity provider. These are known as *federated users*. AWS assigns a role to a federated user when access is requested through an identity provider. For more information about federated users, see Federated Users and Roles in the *IAM User Guide*.
- **Cross-account access** – You can use an IAM role to allow someone (a trusted principal) in a different account to access resources in your account. Roles are the primary way to grant cross-account access. However, with some AWS services, you can attach a policy directly to a resource (instead of using a role as a proxy). To learn the difference between roles and resource-based policies for cross-account access, see How IAM Roles Differ from Resource-based Policies in the *IAM User Guide*.
- **AWS service access** – A service role is an IAM role that a service assumes to perform actions in your account on your behalf. When you set up some AWS service environments, you must define a role for the service to assume. This service role must include all the permissions that are required for the service to access the AWS resources that it needs. Service roles vary from service to service, but many allow you to choose your permissions as long as you meet the documented requirements for that service. Service roles provide access only within your account and cannot be used to grant access to services in other accounts. You can create, modify, and delete a service role from within IAM. For example, you can create a role that allows Amazon Redshift to access an Amazon S3 bucket on your behalf and then load data from that bucket into an Amazon Redshift cluster. For more information, see Creating a Role to Delegate Permissions to an AWS Service in the *IAM User Guide*.
- **Applications running on Amazon EC2** – You can use an IAM role to manage temporary credentials for applications that are running on an EC2 instance and making AWS CLI or AWS API requests. This is preferable to storing access keys within the EC2 instance. To assign an AWS role to an EC2 instance and make it available to all of its applications, you create an instance profile that is attached to the instance. An instance profile contains the role and enables programs that are running on the EC2 instance to get temporary credentials. For more information, see Using an IAM Role to Grant Permissions to Applications Running on Amazon EC2 Instances in the *IAM User Guide*.

To learn whether to use IAM roles, see When to Create an IAM Role (Instead of a User) in the *IAM User Guide*.

Managing Access Using Policies

You control access in AWS by creating policies and attaching them to IAM identities or AWS resources. A policy is an object in AWS that, when associated with an identity or resource, defines their permissions. AWS evaluates these policies when an entity (root user, IAM user, or IAM role) makes a request. Permissions in the policies determine whether the request is allowed or denied. Most policies are stored in AWS as JSON documents. For more information about the structure and contents of JSON policy documents, see Overview of JSON Policies in the *IAM User Guide*.

An IAM administrator can use policies to specify who has access to AWS resources, and what actions they can perform on those resources. Every IAM entity (user or role) starts with no permissions. In other words, by default, users can do nothing, not even change their own password. To give a user permission to do something, an administrator must attach a permissions policy to a user. Or the administrator can add the user to a group that has the intended permissions. When an administrator gives permissions to a group, all users in that group are granted those permissions.

IAM policies define permissions for an action regardless of the method that you use to perform the operation. For example, suppose that you have a policy that allows the `iam:GetRole` action. A user with that policy can get role information from the AWS Management Console, the AWS CLI, or the AWS API.

Identity-Based Policies

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, role, or group. These policies control what actions that identity can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM Policies in the *IAM User Guide*.

Identity-based policies can be further categorized as *inline policies* or *managed policies*. Inline policies are embedded directly into a single user, group, or role. Managed policies are standalone policies that you can attach to multiple users, groups, and roles in your AWS account. Managed policies include AWS managed policies and customer managed policies. To learn how to choose between a managed policy or an inline policy, see Choosing Between Managed Policies and Inline Policies in the *IAM User Guide*.

The following AWS managed policies, which you can attach to users in your account, are specific to Amazon RDS:

- **AmazonRDSReadOnlyAccess** – Grants read-only access to all Amazon RDS resources for the AWS account specified.
- **AmazonRDSFullAccess** – Grants full access to all Amazon RDS resources for the AWS account specified.

Other Policy Types

AWS supports additional, less-common policy types. These policy types can set the maximum permissions granted to you by the more common policy types.

- **Permissions boundaries** – A permissions boundary is an advanced feature in which you set the maximum permissions that an identity-based policy can grant to an IAM entity (IAM user or role). You can set a permissions boundary for an entity. The resulting permissions are the intersection of entity's identity-based policies and its permissions boundaries. Resource-based policies that specify the user or role in the `Principal` field are not limited by the permissions boundary. An explicit deny in any of these policies overrides the allow. For more information about permissions boundaries, see Permissions Boundaries for IAM Entities in the *IAM User Guide*.
- **Service control policies (SCPs)** – SCPs are JSON policies that specify the maximum permissions for an organization or organizational unit (OU) in AWS Organizations. AWS Organizations is a service for grouping and centrally managing multiple AWS accounts that your business owns. If you enable all features in an organization, then you can apply service control policies (SCPs) to any or all of your accounts. The SCP limits permissions for entities in member accounts, including each AWS account root user. For more information about Organizations and SCPs, see How SCPs Work in the *AWS Organizations User Guide*.
- **Session policies** – Session policies are advanced policies that you pass as a parameter when you programmatically create a temporary session for a role or federated user. The resulting session's permissions are the intersection of the user or role's identity-based policies and the session policies. Permissions can also come from a resource-based policy. An explicit deny in any of these policies overrides the allow. For more information, see Session Policies in the *IAM User Guide*.

Multiple Policy Types

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy Evaluation Logic in the *IAM User Guide*.

For more information about identity and access management for Amazon RDS, continue to the following pages:

How Amazon RDS Works with IAM

Before you use IAM to manage access to Amazon RDS, you should understand what IAM features are available to use with Amazon RDS. To get a high-level view of how Amazon RDS and other AWS services work with IAM, see AWS Services That Work with IAM in the *IAM User Guide*.

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Amazon RDS Identity-Based Policies

With IAM identity-based policies, you can specify allowed or denied actions and resources as well as the conditions under which actions are allowed or denied. Amazon RDS supports specific actions, resources, and condition keys. To learn about all of the elements that you use in a JSON policy, see IAM JSON Policy Elements Reference in the *IAM User Guide*.

Actions

The `Action` element of an IAM identity-based policy describes the specific action or actions that will be allowed or denied by the policy. Policy actions usually have the same name as the associated AWS API operation. The action is used in a policy to grant permissions to perform the associated operation.

Policy actions in Amazon RDS use the following prefix before the action: `rds:`. For example, to grant someone permission to describe DB instances with the Amazon RDS `DescribeDBInstances` API operation, you include the `rds:DescribeDBInstances` action in their policy. Policy statements must include either an `Action` or `NotAction` element. Amazon RDS defines its own set of actions that describe tasks that you can perform with this service.

To specify multiple actions in a single statement, separate them with commas as follows:

```
"Action": [
      "rds:action1",
      "rds:action2"
```

You can specify multiple actions using wildcards (*). For example, to specify all actions that begin with the word `Describe`, include the following action:

```
"Action": "rds:Describe*"
```

To see a list of Amazon RDS actions, see Actions Defined by Amazon RDS in the *IAM User Guide*.

Resources

The `Resource` element specifies the object or objects to which the action applies. Statements must include either a `Resource` or a `NotResource` element. You specify a resource using an ARN or using the wildcard (*) to indicate that the statement applies to all resources.

The DB instance resource has the following ARN:

```
arn:${Partition}:rds:${Region}:${Account}:{ResourceType}/${Resource}
```

For more information about the format of ARNs, see Amazon Resource Names (ARNs) and AWS Service Namespaces.

For example, to specify the `dbtest` DB instance in your statement, use the following ARN:

```
"Resource": "arn:aws:rds:us-west-2:123456789012:db:dbtest"
```

To specify all DB instances that belong to a specific account, use the wildcard (*):

```
"Resource": "arn:aws:rds:us-east-1:123456789012:db:*"
```

Some RDS API operations, such as those for creating resources, cannot be performed on a specific resource. In those cases, you must use the wildcard (*).

```
"Resource": "*"
```

Many Amazon RDS API operations involve multiple resources. For example, `CreateDBInstance` creates a DB instance. You can specify that an IAM user must use a specific security group and parameter group when creating a DB instance. To specify multiple resources in a single statement, separate the ARNs with commas.

```
"Resource": [
      "resource1",
      "resource2"
```

To see a list of Amazon RDS resource types and their ARNs, see Resources Defined by Amazon RDS in the *IAM User Guide*. To learn with which actions you can specify the ARN of each resource, see Actions Defined by Amazon RDS.

Condition Keys

The `Condition` element (or `Condition` *block*) lets you specify conditions in which a statement is in effect. The `Condition` element is optional. You can build conditional expressions that use condition operators, such as equals or less than, to match the condition in the policy with values in the request.

If you specify multiple `Condition` elements in a statement, or multiple keys in a single `Condition` element, AWS evaluates them using a logical `AND` operation. If you specify multiple values for a single condition key, AWS evaluates the condition using a logical `OR` operation. All of the conditions must be met before the statement's permissions are granted.

You can also use placeholder variables when you specify conditions. For example, you can grant an IAM user permission to access a resource only if it is tagged with their IAM user name. For more information, see IAM Policy Elements: Variables and Tags in the *IAM User Guide*.

Amazon RDS defines its own set of condition keys and also supports using some global condition keys. To see all AWS global condition keys, see AWS Global Condition Context Keys in the *IAM User Guide*.

All RDS API operations support the `aws:RequestedRegion` condition key.

To see a list of Amazon RDS condition keys, see Condition Keys for Amazon RDS in the *IAM User Guide*. To learn with which actions and resources you can use a condition key, see Actions Defined by Amazon RDS.

Examples

To view examples of Amazon RDS identity-based policies, see Amazon RDS Identity-Based Policy Examples (p. 1377).

Amazon RDS Resource-Based Policies

Amazon RDS does not support resource-based policies.

Authorization Based on Amazon RDS Tags

You can attach tags to Amazon RDS resources or pass tags in a request to Amazon RDS. To control access based on tags, you provide tag information in the condition element of a policy using the `rds:ResourceTag/key-name`, `aws:RequestTag/key-name`, or `aws:TagKeys` condition keys. For more information about tagging Amazon RDS resources, see Specifying Conditions: Using Custom Tags (p. 1384).

To view an example identity-based policy for limiting access to a resource based on the tags on that resource, see Grant Permission for Actions on a Resource with a Specific Tag with Two Different Values (p. 1382).

Amazon RDS IAM Roles

An IAM role is an entity within your AWS account that has specific permissions.

Using Temporary Credentials with Amazon RDS

You can use temporary credentials to sign in with federation, assume an IAM role, or to assume a cross-account role. You obtain temporary security credentials by calling AWS STS API operations such as AssumeRole or GetFederationToken.

Amazon RDS supports using temporary credentials.

Service-Linked Roles

Service-linked roles allow AWS services to access resources in other services to complete an action on your behalf. Service-linked roles appear in the Roles list in the IAM Management Console and are owned by the service. An IAM administrator can view but not edit the permissions for service-linked roles.

Amazon RDS supports service-linked roles. For details about creating or managing Amazon RDS service-linked roles, see Using Service-Linked Roles for Amazon RDS (p. 1429).

Service Roles

This feature allows a service to assume a service role on your behalf. This role allows the service to access resources in other services to complete an action on your behalf. Service roles appear in the Roles list in the IAM Management Console and are owned by your account. This means that an IAM administrator can change the permissions for this role. However, doing so might break the functionality of the service.

Amazon RDS supports service roles.

Amazon RDS Identity-Based Policy Examples

By default, IAM users and roles don't have permission to create or modify Amazon RDS resources. They also can't perform tasks using the AWS Management Console, AWS CLI, or AWS API. An IAM administrator must create IAM policies that grant users and roles permission to perform specific API operations on the specified resources they need. The administrator must then attach those policies to the IAM users or groups that require those permissions.

To learn how to create an IAM identity-based policy using these example JSON policy documents, see Creating Policies on the JSON Tab in the *IAM User Guide*.

Topics

Policy Best Practices

Identity-based policies are very powerful. They determine whether someone can create, access, or delete Amazon RDS resources in your account. These actions can incur costs for your AWS account. When you create or edit identity-based policies, follow these guidelines and recommendations:

- **Get Started Using AWS Managed Policies** – To start using Amazon RDS quickly, use AWS managed policies to give your employees the permissions they need. These policies are already available in your account and are maintained and updated by AWS. For more information, see Get Started Using Permissions With AWS Managed Policies in the *IAM User Guide*.
- **Grant Least Privilege** – When you create custom policies, grant only the permissions required to perform a task. Start with a minimum set of permissions and grant additional permissions as necessary. Doing so is more secure than starting with permissions that are too lenient and then trying to tighten them later. For more information, see Grant Least Privilege in the *IAM User Guide*.
- **Enable MFA for Sensitive Operations** – For extra security, require IAM users to use multi-factor authentication (MFA) to access sensitive resources or API operations. For more information, see Using Multi-Factor Authentication (MFA) in AWS in the *IAM User Guide*.
- **Use Policy Conditions for Extra Security** – To the extent that it's practical, define the conditions under which your identity-based policies allow access to a resource. For example, you can write conditions to specify a range of allowable IP addresses that a request must come from. You can also write conditions to allow requests only within a specified date or time range, or to require the use of SSL or MFA. For more information, see IAM JSON Policy Elements: Condition in the *IAM User Guide*.

Using the Amazon RDS Console

To access the Amazon RDS console, you must have a minimum set of permissions. These permissions must enable you to list and view details about the Amazon RDS resources in your AWS account. You can create an identity-based policy that is more restrictive than the minimum required permissions. However, if you do, the console doesn't function as intended for entities (IAM users or roles) with that policy.

To ensure that those entities can still use the Amazon RDS console, also attach the following AWS managed policy to the entities. For more information, see Adding Permissions to a User in the *IAM User Guide*.

```
AmazonRDSReadOnlyAccess
```

You don't need to allow minimum console permissions for users that are making calls only to the AWS CLI or the AWS API. Instead, allow access to only the actions that match the API operation that you're trying to perform.

Allow Users to View Their Own Permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.

```
{
       "Version": "2012-10-17",
       "Statement": [
           {
               "Sid": "ViewOwnUserInfo",
               "Effect": "Allow",
               "Action": [
                   "iam:GetUserPolicy",
                   "iam:ListGroupsForUser",
                   "iam:ListAttachedUserPolicies",
                   "iam:ListUserPolicies",
                   "iam:GetUser"
               ],
               "Resource": [
                   "arn:aws:iam::*:user/${aws:username}"
               ]
           },
           {
               "Sid": "NavigateInConsole",
               "Effect": "Allow",
               "Action": [
                   "iam:GetGroupPolicy",
                   "iam:GetPolicyVersion",
                   "iam:GetPolicy",
                   "iam:ListAttachedGroupPolicies",
                   "iam:ListGroupPolicies",
                   "iam:ListPolicyVersions",
                   "iam:ListPolicies",
                   "iam:ListUsers"
               ],
               "Resource": "*"
           }
       ]
   }
```

Allow a User to Create to DB Instances in an AWS account

The following is an example policy that allows the user with the ID `123456789012` to create DB instances for your AWS account. The policy requires that the name of the new DB instance begin with `test`. The new DB instance must also use the MySQL database engine and the `db.t2.micro` DB instance class. In addition, the new DB instance must use an option group and a DB parameter group that starts with `default`, and it must use the `default` subnet group.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AllowCreateDBInstanceOnly",
            "Effect": "Allow",
            "Action": [
                "rds:CreateDBInstance"
            ],
            "Resource": [
                "arn:aws:rds:*:123456789012:db:test*",
                "arn:aws:rds:*:123456789012:og:default*",
                "arn:aws:rds:*:123456789012:pg:default*",
                "arn:aws:rds:*:123456789012:subgrp:default"
            ],
            "Condition": {
                "StringEquals": {
                    "rds:DatabaseEngine": "mysql",
                    "rds:DatabaseClass": "db.t2.micro"
                }
            }
        }
    ]
}
```

The policy includes a single statement that specifies the following permissions for the IAM user:

- The policy allows the IAM user to create a DB instance using the CreateDBInstance API operation (this also applies to the create-db-instance AWS CLI command and the AWS Management Console).
- The `Resource` element specifies that the user can perform actions on or with resources. You specify resources using an Amazon Resources Name (ARN). This ARN includes the name of the service that the resource belongs to (`rds`), the AWS Region (`*` indicates any region in this example), the user account number (`123456789012` is the user ID in this example), and the type of resource. For more information about creating ARNs, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).

  The `Resource` element in the example specifies the following policy constraints on resources for the user:

  - The DB instance identifier for the new DB instance must begin with `test` (for example, `testCustomerData1`, `test-region2-data`).
  - The option group for the new DB instance must begin with `default`.
  - The DB parameter group for the new DB instance must begin with `default`.
  - The subnet group for the new DB instance must be the `default` subnet group.
- The `Condition` element specifies that the DB engine must be MySQL and the DB instance class must be `db.t2.micro`. The `Condition` element specifies the conditions when a policy should take effect. You can add additional permissions or restrictions by using the `Condition` element. For more information about specifying conditions, see Condition Keys (p. 1376). This example specifies the `rds:DatabaseEngine` and `rds:DatabaseClass` conditions. For information about the valid condition values for `rds:DatabaseEngine`, see the list under the `Engine` parameter in CreateDBInstance. For information about the valid condition values for `rds:DatabaseClass`, see Supported DB Engines for All Available DB Instance Classes (p. 12) .

The policy doesn't specify the `Principal` element because in an identity-based policy you don't specify the principal who gets the permission. When you attach policy to a user, the user is the implicit principal. When you attach a permission policy to an IAM role, the principal identified in the role's trust policy gets the permissions.

To see a list of Amazon RDS actions, see Actions Defined by Amazon RDS in the *IAM User Guide*.

Permissions Required to Use the Console

For a user to work with the console, that user must have a minimum set of permissions. These permissions allow the user to describe the Amazon RDS resources for their AWS account and to provide other related information, including Amazon EC2 security and network information.

If you create an IAM policy that is more restrictive than the minimum required permissions, the console doesn't function as intended for users with that IAM policy. To ensure that those users can still use the console, also attach the `AmazonRDSReadOnlyAccess` managed policy to the user, as described in Managing Access Using Policies (p. 1373).

You don't need to allow minimum console permissions for users that are making calls only to the AWS CLI or the Amazon RDS API.

The following policy grants full access to all Amazon RDS resources for the root AWS account:

```
AmazonRDSFullAccess
```

Allow a User to Perform Any Describe Action on Any RDS Resource

The following permissions policy grants permissions to a user to run all of the actions that begin with `Describe`. These actions show information about an RDS resource, such as a DB instance. The wildcard character (*) in the `Resource` element indicates that the actions are allowed for all Amazon RDS resources owned by the account.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"AllowRDSDescribe",
         "Effect":"Allow",
         "Action":"rds:Describe*",
         "Resource":"*"
      }
   ]
}
```

Allow a User to Create a DB Instance That Uses the Specified DB Parameter and Security Groups

The following permissions policy grants permissions to allow a user to only create a DB instance that must use the `mysql-production` DB parameter group and the `db-production` DB security group.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"AllowMySQLProductionCreate",
         "Effect":"Allow",
         "Action":"rds:CreateDBInstance",
         "Resource":[
            "arn:aws:rds:us-west-2:123456789012:pg:mysql-production",
```

```
            "arn:aws:rds:us-west-2:123456789012:secgrp:db-production"
         ]
      }
   ]
}
```

Grant Permission for Actions on a Resource with a Specific Tag with Two Different Values

You can use conditions in your identity-based policy to control access to Amazon RDS resources based on tags. The following policy allows permission to perform the `ModifyDBInstance` and `CreateDBSnapshot` APIs on DB instances with either the `stage` tag set to `development` or `test`.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"AllowDevTestCreate",
         "Effect":"Allow",
         "Action":[
            "rds:ModifyDBInstance",
            "rds:CreateDBSnapshot"
         ],
         "Resource":"*",
         "Condition":{
            "StringEquals":{
               "rds:db-tag/stage":[
                  "development",
                  "test"
               ]
            }
         }
      }
   ]
}
```

Prevent a User from Deleting a DB Instance

The following permissions policy grants permissions to prevent a user from deleting a specific DB instance. For example, you might want to deny the ability to delete your production DB instances to any user that is not an administrator.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"DenyDelete1",
         "Effect":"Deny",
         "Action":"rds:DeleteDBInstance",
         "Resource":"arn:aws:rds:us-west-2:123456789012:db:my-mysql-instance"
      }
   ]
}
```

Example Policies: Using Condition Keys

Following are examples of how you can use condition keys in Amazon RDS IAM permissions policies.

Example 1: Grant Permission to Create a DB Instance that Uses a Specific DB Engine and Isn't MultiAZ

The following policy uses an RDS condition key and allows a user to create only DB instances that use the MySQL database engine and don't use MultiAZ. The `Condition` element indicates the requirement that the database engine is MySQL.

```
{

   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"AllowMySQLCreate",
         "Effect":"Allow",
         "Action":"rds:CreateDBInstance",
         "Resource":"*",
         "Condition":{
            "StringEquals":{
               "rds:DatabaseEngine":"mysql"
            },
            "Bool":{
                    "rds:MultiAz": false
            }
         }
      }
   ]
}
```

Example 2: Explicitly Deny Permission to Create DB Instances for Certain DB Instance Classes and Create DB Instances that Use Provisioned IOPS

The following policy explicitly denies permission to create DB instances that use the DB instance classes `r3.8xlarge` and `m4.10xlarge`, which are the largest and most expensive DB instance classes. This policy also prevents users from creating DB instances that use Provisioned IOPS, which incurs an additional cost.

Explicitly denying permission supersedes any other permissions granted. This ensures that identities to not accidentally get permission that you never want to grant.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"DenyLargeCreate",
         "Effect":"Deny",
         "Action":"rds:CreateDBInstance",
         "Resource":"*",
         "Condition":{
            "StringEquals":{
               "rds:DatabaseClass":[
                  "db.r3.8xlarge",
                  "db.m4.10xlarge"
               ]
            }
         }
      },
      {
         "Sid":"DenyPIOPSCreate",
         "Effect":"Deny",
         "Action":"rds:CreateDBInstance",
         "Resource":"*",
```

```
            "Condition":{
               "NumericNotEquals":{
                  "rds:Piops":"0"
               }
            }
         }
      ]
}
```

Example 3: Limit the Set of Tag Keys and Values That Can Be Used to Tag a Resource

The following policy uses an RDS condition key and allows the addition of a tag with the key `stage` to be added to a resource with the values `test`, `qa`, and `production`.

```
{

 {
    "Version" : "2012-10-17",
    "Statement" : [{
       "Effect" : "Allow",
       "Action" : [ "rds:AddTagsToResource", "rds:RemoveTagsFromResource"
       ],
       "Resource" : "*",
       "Condition" : { "streq" : { "rds:req-tag/stage" : [ "test", "qa",
       "production" ] } }
  }
 ]
}
}
```

Specifying Conditions: Using Custom Tags

Amazon RDS supports specifying conditions in an IAM policy using custom tags.

For example, suppose that you add a tag named `environment` to your DB instances with values such as `beta`, `staging`, `production`, and so on. If you do, you can create a policy that restricts certain users to DB instances based on the `environment` tag value.

> **Note**
> Custom tag identifiers are case-sensitive.

The following table lists the RDS tag identifiers that you can use in a `Condition` element.

RDS Tag Identifier	Applies To
`db-tag`	DB instances, including read replicas
`snapshot-tag`	DB snapshots
`ri-tag`	Reserved DB instances
`secgrp-tag`	DB security groups
`og-tag`	DB option groups
`pg-tag`	DB parameter groups
`subgrp-tag`	DB subnet groups
`es-tag`	Event subscriptions

RDS Tag Identifier	Applies To
`cluster-tag`	DB clusters
`cluster-pg-tag`	DB cluster parameter groups
`cluster-snapshot-tag`	DB cluster snapshots

The syntax for a custom tag condition is as follows:

```
"Condition":{"StringEquals":{"rds:rds-tag-identifier/tag-name": ["value"]} }
```

For example, the following `Condition` element applies to DB instances with a tag named `environment` and a tag value of `production`.

```
"Condition":{"StringEquals":{"rds:db-tag/environment": ["production"]} }
```

For information about creating tags, see Tagging Amazon RDS Resources (p. 266).

Important
If you manage access to your RDS resources using tagging, we recommend that you secure access to the tags for your RDS resources. You can manage access to tags by creating policies for the `AddTagsToResource` and `RemoveTagsFromResource` actions. For example, the following policy denies users the ability to add or remove tags for all resources. You can then create policies to allow specific users to add or remove tags.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"DenyTagUpdates",
         "Effect":"Deny",
         "Action":[
            "rds:AddTagsToResource",
            "rds:RemoveTagsFromResource"
         ],
         "Resource":"*"
      }
   ]
}
```

To see a list of Amazon RDS actions, see Actions Defined by Amazon RDS in the *IAM User Guide*.

Example Policies: Using Custom Tags

Following are examples of how you can use custom tags in Amazon RDS IAM permissions policies. For more information about adding tags to an Amazon RDS resource, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).

Note
All examples use the us-west-2 region and contain fictitious account IDs.

Example 1: Grant Permission for Actions on a Resource with a Specific Tag with Two Different Values

The following policy allows permission to perform the `ModifyDBInstance` and `CreateDBSnapshot` APIs on DB instances with either the `stage` tag set to `development` or `test`.

```
{
   "Version":"2012-10-17",
```

```
   "Statement":[
      {
         "Sid":"AllowDevTestCreate",
         "Effect":"Allow",
         "Action":[
            "rds:ModifyDBInstance",
            "rds:CreateDBSnapshot"
         ],
         "Resource":"*",
         "Condition":{
            "StringEquals":{
               "rds:db-tag/stage":[
                  "development",
                  "test"
               ]
            }
         }
      }
   ]
}
```

Example 2: Explicitly Deny Permission to Create a DB Instance that Uses Specified DB Parameter Groups

The following policy explicitly denies permission to create a DB instance that uses DB parameter groups with specific tag values. You might apply this policy if you require that a specific customer-created DB parameter group always be used when creating DB instances. Policies that use `Deny` are most often used to restrict access that was granted by a broader policy.

Explicitly denying permission supersedes any other permissions granted. This ensures that identities to not accidentally get permission that you never want to grant.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"DenyProductionCreate",
         "Effect":"Deny",
         "Action":"rds:CreateDBInstance",
         "Resource":"*",
         "Condition":{
            "StringEquals":{
               "rds:pg-tag/usage":"prod"
            }
         }
      }
   ]
}
```

Example 3: Grant Permission for Actions on a DB Instance with an Instance Name that is Prefixed with a User Name

The following policy allows permission to call any API (except to `AddTagsToResource` or `RemoveTagsFromResource`) on a DB instance that has a DB instance name that is prefixed with the user's name and that has a tag called `stage` equal to `devo` or that has no tag called `stage`.

The `Resource` line in the policy identifies a resource by its Amazon Resource Name (ARN). For more information about using ARNs with Amazon RDS resources, see Working with Amazon Resource Names (ARNs) in Amazon RDS (p. 271).

```
{
   "Version":"2012-10-17",
```

```
   "Statement":[
      {
         "Sid":"AllowFullDevAccessNoTags",
         "Effect":"Allow",
         "NotAction":[
            "rds:AddTagsToResource",
            "rds:RemoveTagsFromResource"
         ],
         "Resource":"arn:aws:rds:*:123456789012:db:${aws:username}*",
         "Condition":{
            "StringEqualsIfExists":{
               "rds:db-tag/stage":"devo"
            }
         }
      }
   ]
}
```

IAM Database Authentication for MySQL and PostgreSQL

You can authenticate to your DB instance using AWS Identity and Access Management (IAM) database authentication. IAM database authentication works with MySQL and PostgreSQL. With this authentication method, you don't need to use a password when you connect to a DB instance. Instead, you use an authentication token.

An *authentication token* is a unique string of characters that Amazon RDS generates on request. Authentication tokens are generated using AWS Signature Version 4. Each token has a lifetime of 15 minutes. You don't need to store user credentials in the database, because authentication is managed externally using IAM. You can also still use standard database authentication.

IAM database authentication provides the following benefits:

- Network traffic to and from the database is encrypted using Secure Sockets Layer (SSL).
- You can use IAM to centrally manage access to your database resources, instead of managing access individually on each DB instance.
- For applications running on Amazon EC2, you can use profile credentials specific to your EC2 instance to access your database instead of a password, for greater security.

Topics

Availability for IAM Database Authentication

IAM database authentication is available for the following database engines and DB instance classes:

- MySQL 5.6, minor version 5.6.34 or higher.
- MySQL 5.7, minor version 5.7.16 or higher.

- MySQL 8.0, minor version 8.0.16 or higher.
- PostgreSQL versions 10.6 or higher, 9.6.11 or higher, and 9.5.15 or higher.

> **Note**
> IAM database authentication is not supported for MySQL 5.5.

MySQL Limitations for IAM Database Authentication

When using IAM database authentication with MySQL, you are limited to a maximum of 200 new connections per second. If you are using a db.t2.micro DB instance class, the limit is 10 connections per second.

The database engines that work with Amazon RDS don't impose any limits on authentication attempts per second. However, when you use IAM database authentication, your application must generate an authentication token. Your application then uses that token to connect to the DB instance. If you exceed the limit of maximum new connections per second, then the extra overhead of IAM database authentication can cause connection throttling. The extra overhead can cause even existing connections to drop. For information about the maximum total connections for MySQL, see Maximum MySQL and MariaDB Connections (p. 1464).

We recommend the following when using the MySQL engine:

- Use IAM database authentication as a mechanism for temporary, personal access to databases.
- Use IAM database authentication only for workloads that can be easily retried.
- Don't use IAM database authentication if your application requires more than 200 new connections per second.

PostgreSQL Limitations for IAM Database Authentication

When using IAM database authentication with PostgreSQL, note the following limitation:

- The maximum number of connections per second for your database instance may be limited depending on the instance type and your workload.

Enabling and Disabling IAM Database Authentication

By default, IAM database authentication is disabled on DB instances. You can enable IAM database authentication (or disable it again) using the AWS Management Console, AWS CLI, or the API.

IAM authentication for PostgreSQL DB instances requires that the SSL value be 1. You can't enable IAM authentication for a PostgreSQL DB instance if the SSL value is 0. You can't change the SSL value to 0 if IAM authentication is enabled for a PostgreSQL DB instance.

Console

To create a new DB instance with IAM authentication by using the console, see Creating an Amazon RDS DB Instance (p. 136).

Each creation workflow has a **Configure Advanced Settings** page, where you can enable IAM DB authentication. In that page's **Database Options** section, choose **Yes** for **Enable IAM DB Authentication**.

To enable or disable IAM authentication for an existing DB instance

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.

3. Choose the DB instance that you want to modify.

   Note
   Make sure that all affected DB instances are compatible with IAM authentication. Check the compatibility requirements in Availability for IAM Database Authentication (p. 1387). For an Aurora DB cluster, you can only enable IAM authentication if all DB instances in the cluster are compatible with IAM.
4. Choose **Modify**.
5. In the **Database options** section, for **IAM DB authentication** choose **Enable IAM DB authentication** or **Disable**, and then choose **Continue**.
6. To apply the changes immediately, choose **Apply immediately**.
7. Choose **Modify DB instance** .

To restore a DB instance

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Snapshots**.
3. Choose the snapshot that you want to restore, and then choose **Restore Snapshot** for **Actions**.
4. In the **Settings** section, enter an identifier for the DB instance for **DB Instance Identifier**.
5. In the **Database options** section, for **IAM DB authentication**, choose **Enable IAM DB authentication** or **Disable**.
6. Choose **Restore DB Instance**.

AWS CLI

To create a new DB instance with IAM authentication by using the AWS CLI, use the `create-db-instance` command. Specify the `--enable-iam-database-authentication` option, as shown in the following example.

```
aws rds create-db-instance \
    --db-instance-identifier mydbinstance \
    --db-instance-class db.m3.medium \
    --engine MySQL \
    --allocated-storage 20 \
    --master-username masterawsuser \
    --master-user-password masteruserpassword \
    --enable-iam-database-authentication
```

To update an existing DB instance to have or not have IAM authentication, use the AWS CLI command `modify-db-instance`. Specify either the `--enable-iam-database-authentication` or `--no-enable-iam-database-authentication` option, as appropriate.

Note
Make sure that all affected DB instances are compatible with IAM authentication. Check the compatibility requirements in Availability for IAM Database Authentication (p. 1387). For an Aurora DB cluster, you can only enable IAM authentication if all DB instances in the cluster are compatible with IAM.

By default, Amazon RDS performs the modification during the next maintenance window. If you want to override this and enable IAM DB authentication as soon as possible, use the `--apply-immediately` parameter.

The following example shows how to immediately enable IAM authentication for an existing DB instance.

```
aws rds modify-db-instance \
```

```
    --db-instance-identifier mydbinstance \
    --apply-immediately \
    --enable-iam-database-authentication
```

If you are restoring a DB instance, use one of the following AWS CLI commands:

- `restore-db-instance-to-point-in-time`
- `restore-db-instance-from-db-snapshot`

The IAM database authentication setting defaults to that of the source snapshot. To change this setting, set the `--enable-iam-database-authentication` or `--no-enable-iam-database-authentication` option, as appropriate.

RDS API

To create a new DB instance with IAM authentication by using the API, use the API operation `CreateDBInstance`. Set the `EnableIAMDatabaseAuthentication` parameter to `true`.

To update an existing DB instance to have IAM authentication, use the API operation `ModifyDBInstance`. Set the `EnableIAMDatabaseAuthentication` parameter to `true` to enable IAM authentication, or `false` to disable it.

> **Note**
> Make sure that all affected DB instances are compatible with IAM authentication. Check the compatibility requirements in Availability for IAM Database Authentication (p. 1387). For an Aurora DB cluster, you can only enable IAM authentication if all DB instances in the cluster are compatible with IAM.

If you are restoring a DB instance, use one of the following API operations:

- `RestoreDBInstanceToPointInTime`
- `RestoreDBInstanceFromDBSnapshot`

The IAM database authentication setting defaults to that of the source snapshot. To change this setting, set the `EnableIAMDatabaseAuthentication` parameter to `true` to enable IAM authentication, or `false` to disable it.

Creating and Using an IAM Policy for IAM Database Access

To allow an IAM user or role to connect to your DB instance, you must create an IAM policy. After that, you attach the policy to an IAM user or role.

> **Note**
> To learn more about IAM policies, see Identity and Access Management in Amazon RDS (p. 1371).

The following example policy allows an IAM user to connect to a DB instance using IAM database authentication.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
             "rds-db:connect"
         ],
         "Resource": [
```

```
                "arn:aws:rds-db:us-east-2:1234567890:dbuser:db-ABCDEFGHIJKL01234/db_user"
            ]
        }
    ]
}
```

Important

An IAM administrator user can access DB instances without explicit permissions in an IAM policy. The example in Create an IAM User (p. 58) creates an IAM administrator user. If you want to restrict administrator access to DB instances, you can create an IAM role with the appropriate, lesser privileged permissions and assign it to the administrator.

Note

Don't confuse the `rds-db:` prefix with other RDS API operation prefixes that begin with `rds:`. You use the `rds-db:` prefix and the `rds-db:connect` action only for IAM database authentication. They aren't valid in any other context.
Currently, the IAM console displays an error for policies with the `rds-db:connect` action. You can ignore this error.

The example policy includes a single statement with the following elements:

- `Effect` – Specify `Allow` to grant access to the DB instance. If you don't explicitly allow access, then access is denied by default.
- `Action` – Specify `rds-db:connect` to allow connections to the DB instance.
- `Resource` – Specify an Amazon Resource Name (ARN) that describes one database account in one DB instance. The ARN format is as follows.

```
arn:aws:rds-db:region:account-id:dbuser:DbiResourceId/db-user-name
```

In this format, replace the following:

- *`region`* is the AWS Region for the DB instance. In the example policy, the AWS Region is `us-east-2`.
- *`account-id`* is the AWS account number for the DB instance. In the example policy, the account number is `1234567890`.
- *`DbiResourceId`* is the identifier for the DB instance. This identifier is unique to an AWS Region and never changes. In the example policy, the identifier is `db-ABCDEFGHIJKL01234`.

  To find a DB instance resource ID in the AWS Management Console for Amazon RDS, choose the DB instance to see its details. Then choose the **Configuration** tab. The **Resource ID** is shown in the **Configuration** section.

  Alternatively, you can use the AWS CLI command to list the identifiers and resource IDs for all of your DB instance in the current AWS Region, as shown following.

```
aws rds describe-db-instances --query "DBInstances[*].
[DBInstanceIdentifier,DbiResourceId]"
```

- *`db-user-name`* is the name of the database account to associate with IAM authentication. In the example policy, the database account is `db_user`.

You can construct other ARNs to support various access patterns. The following policy allows access to two different database accounts in a DB instance.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
             "rds-db:connect"
         ],
         "Resource": [
             "arn:aws:rds-db:us-east-2:123456789012:dbuser:db-ABCDEFGHIJKL01234/jane_doe",
             "arn:aws:rds-db:us-east-2:123456789012:dbuser:db-ABCDEFGHIJKL01234/mary_roe"
         ]
      }
   ]
}
```

The following policy uses the "*" character to match all DB instances and database accounts for a particular AWS account and AWS Region.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "rds-db:connect"
            ],
            "Resource": [
                "arn:aws:rds-db:us-east-2:1234567890:dbuser:*/*"
            ]
        }
    ]
}
```

The following policy matches all of the DB instances for a particular AWS account and AWS Region. However, the policy only grants access to DB instances that have a `jane_doe` database account.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
             "rds-db:connect"
         ],
         "Resource": [
             "arn:aws:rds-db:us-east-2:123456789012:dbuser:*/jane_doe"
         ]
      }
   ]
}
```

The IAM user or role has access to only those databases that the database user does. For example, suppose that your DB instance has a database named *dev*, and another database named *test*. If the database user `jane_doe` has access only to *dev*, any IAM users or roles that access that DB instance with the `jane_doe` user also have access only to *dev*. This access restriction is also true for other database objects, such as tables, views, and so on.

Attaching an IAM Policy to an IAM User or Role

After you create an IAM policy to allow database authentication, you need to attach the policy to an IAM user or role. For a tutorial on this topic, see Create and Attach Your First Customer Managed Policy in the *IAM User Guide*.

As you work through the tutorial, you can use one of the policy examples shown in this section as a starting point and tailor it to your needs. At the end of the tutorial, you have an IAM user with an attached policy that can make use of the `rds-db:connect` action.

> **Note**
> You can map multiple IAM users or roles to the same database user account. For example, suppose that your IAM policy specified the following resource ARN.
>
> ```
> arn:aws:rds-db:us-east-2:123456789012:dbuser:db-12ABC34DEFG5HIJ6KLMNOP78QR/jane_doe
> ```
>
> If you attach the policy to IAM users *Jane*, *Bob*, and *Diego*, then each of those users can connect to the specified DB instance using the `jane_doe` database account.

Creating a Database Account Using IAM Authentication

With IAM database authentication, you don't need to assign database passwords to the user accounts you create. If you remove an IAM user that is mapped to a database account, you should also remove the database account with the `DROP USER` statement.

Using IAM Authentication with PostgreSQL

To use IAM authentication with PostgreSQL, connect to the DB instance, create database users, and then grant them the `rds_iam` role as shown in the following example.

```
CREATE USER db_userx;
GRANT rds_iam TO db_userx;
```

Using IAM Authentication with MySQL

With MySQL, authentication is handled by `AWSAuthenticationPlugin`—an AWS-provided plugin that works seamlessly with IAM to authenticate your IAM users. Connect to the DB instance and issue the `CREATE USER` statement, as shown in the following example.

```
CREATE USER jane_doe IDENTIFIED WITH AWSAuthenticationPlugin AS 'RDS';
```

The `IDENTIFIED WITH` clause allows MySQL to use the `AWSAuthenticationPlugin` to authenticate the database account (`jane_doe`). The `AS 'RDS'` clause refers to the authentication method, and the specified database account should have the same name as the IAM user or role. In this example, both the database account and the IAM user or role are named `jane_doe`.

> **Note**
> If you see the following message, it means that the AWS-provided plugin is not available for the current DB instance.
> `ERROR 1524 (HY000): Plugin 'AWSAuthenticationPlugin' is not loaded`

To troubleshoot this error, verify that you are using a supported configuration and that you have enabled IAM database authentication on your DB instance. For more information, see Availability for IAM Database Authentication (p. 1387) and Enabling and Disabling IAM Database Authentication (p. 1388).

After you create an account using `AWSAuthenticationPlugin`, you manage it in the same way as other database accounts. For example, you can modify account privileges with `GRANT` and `REVOKE` statements, or modify various account attributes with the `ALTER USER` statement.

Connecting to Your DB Instance Using IAM Authentication

With IAM database authentication, you use an authentication token when you connect to your DB instance. An *authentication token* is a string of characters that you use instead of a password. After you generate an authentication token, it's valid for 15 minutes before it expires. If you try to connect using an expired token, the connection request is denied.

Every authentication token must be accompanied by a valid signature, using AWS signature version 4. (For more information, see Signature Version 4 Signing Process in the *AWS General Reference*.) The AWS CLI and an AWS SDK, such as the AWS SDK for Java or AWS SDK for Python (Boto 3), can automatically sign each token you create.

You can use an authentication token when you connect to Amazon RDS from another AWS service, such as AWS Lambda. By using a token, you can avoid placing a password in your code. Alternatively, you can use an AWS SDK to programmatically create and programmatically sign an authentication token.

After you have a signed IAM authentication token, you can connect to an Amazon RDS DB instance. Following, you can find out how to do this using either a command line tool or an AWS SDK, such as the AWS SDK for Java or AWS SDK for Python (Boto 3).

For more information, see the following blog posts:

- Use IAM authentication to connect with SQL Workbench/J to Amazon Aurora MySQL or Amazon RDS for MySQL
- Using IAM authentication to connect with pgAdmin Amazon Aurora PostgreSQL or Amazon RDS for PostgreSQL

Topics

Connecting to Your DB Instance Using IAM Authentication from the Command Line: AWS CLI and mysql Client

You can connect from the command line to an Amazon RDS DB instance with the AWS CLI and `mysql` command line tool as described following.

Topics

Generating an IAM Authentication Token

The following example shows how to get a signed authentication token using the AWS CLI.

```
aws rds generate-db-auth-token \
   --hostname rdsmysql.cdgmuqiadpid.us-west-2.rds.amazonaws.com \
   --port 3306 \
   --region us-west-2 \
   --username jane_doe
```

In the example, the parameters are as follows:

- `--hostname` – The host name of the DB instance that you want to access.
- `--port` – The port number used for connecting to your DB instance.
- `--region` – The AWS Region where the DB instance is running.
- `--username` – The database account that you want to access.

The first several characters of the token look like the following.

```
rdsmysql.cdgmuqiadpid.us-west-2.rds.amazonaws.com:3306/?Action=connect&DBUser=jane_doe&X-
Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Expires=900...
```

Connecting to a DB Instance

The general format for connecting is shown following.

```
mysql --host=hostName --port=portNumber --ssl-ca=[full path]rds-combined-ca-bundle.pem --
enable-cleartext-plugin --user=userName --password=authToken
```

The parameters are as follows:

- `--host` – The host name of the DB instance that you want to access.
- `--port` – The port number used for connecting to your DB instance.
- `--ssl-ca` – The SSL certificate file that contains the public key. For more information, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).
- `--enable-cleartext-plugin` – A value that specifies that `AWSAuthenticationPlugin` must be used for this connection.
- `--user` – The database account that you want to access.
- `--password` – A signed IAM authentication token.

The authentication token consists of several hundred characters. It can be unwieldy on the command line. One way to work around this is to save the token to an environment variable, and then use that variable when you connect. The following example shows one way to perform this workaround.

```
RDSHOST="rdsmysql.cdgmuqiadpid.us-west-2.rds.amazonaws.com"
TOKEN="$(aws rds generate-db-auth-token --hostname $RDSHOST --port 3306 --region us-west-2
 --username jane_doe )"

mysql --host=$RDSHOST --port=3306 --ssl-ca=/sample_dir/rds-combined-ca-bundle.pem --enable-
cleartext-plugin --user=jane_doe --password=$TOKEN
```

When you connect using `AWSAuthenticationPlugin`, the connection is secured using SSL. To verify this, type the following at the `mysql>` command prompt.

```
show status like 'Ssl%';
```

The following lines in the output show more details.

```
+---------------+-------------+
| Variable_name | Value                                                                                                                                                                                                                                |
+---------------+-------------+
| ...           | ...
| Ssl_cipher    | AES256-SHA                                                                                                                                                                                                                                |
| ...           | ...
| Ssl_version   | TLSv1.1                                                                                                                                                                                                                                |
| ...           | ...
+-----------------------------+
```

Connecting to Your DB Instance Using IAM Authentication from the Command Line: AWS CLI and psql Client

You can connect from the command line to an Amazon RDS for PostgreSQL DB instance with the AWS CLI and psql command line tool as described following.

Topics

Generating an IAM Authentication Token

The authentication token consists of several hundred characters so it can be unwieldy on the command line. One way to work around this is to save the token to an environment variable, and then use that variable when you connect. The following example shows how to use the AWS CLI to get a signed authentication token using the `generated-db-auth-token` command, and store it in a `PGPASSWORD` environment variable.

```
export RDSHOST="rdspostgres.cdgmuqiadpid.us-west-2.rds.amazonaws.com"
export PGPASSWORD="$(aws rds generate-db-auth-token --hostname $RDSHOST --port 5432 --
region us-west-2 --username jane_doe )"
```

In the example, the parameters to the `generate-db-auth-token` command are as follows:

- `--hostname` – The host name of the DB instance that you want to access.
- `--port` – The port number used for connecting to your DB instance.
- `--region` – The AWS Region where the DB instance is running.
- `--username` – The database account that you want to access.

The first several characters of the generated token look like the following.

```
rdspostgres.cdgmuqiadpid.us-west-2.rds.amazonaws.com:5432/?
Action=connect&DBUser=jane_doe&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Expires=900...
```

Connecting to an Amazon RDS PostgreSQL Instance

The general format for using psql to connect is shown following.

```
psql "host=hostName port=portNumber sslmode=verify-full sslrootcert=certificateFile
 dbname=DBName user=userName"
```

The parameters are as follows:

- `host` – The host name of the DB instance that you want to access.
- `port` – The port number used for connecting to your DB instance.
- `sslmode` – The SSL mode to use. When you use `sslmode=verify-full`, the SSL connection verifies the DB instance endpoint against the endpoint in the SSL certificate.
- `sslrootcert` – The SSL certificate file that contains the public key. For more information, see Using SSL with a PostgreSQL DB Instance.
- `dbname` – The database that you want to access.
- `user` – The database account that you want to access.

The following example shows using psql to connect. In the example psql uses the environment variable `PGPASSWORD` that was set when the token was generated in the previous section.

```
psql "host=$RDSHOST port=5432 sslmode=verify-full sslrootcert=/sample_dir/rds-combined-ca-bundle.pem dbname=DBName user=jane_doe"
```

Connecting to Your DB Instance Using IAM Authentication and the AWS SDK for Python (Boto 3)

You can connect from the command line to an Amazon RDS MySQL or PostgreSQL DB instance with the AWS SDK for Python (Boto 3) as described following.

Topics

Generating an IAM Authentication Token

You can call the `generate_db_auth_token` method to obtain a signed token. Provide the DB instance endpoint, port, user name, AWS Region, and DB engine to generate the token for connecting to a DB Instance with IAM credentials. The following code example illustrates how to do this with a PostgreSQL database.

This code generates an IAM authentication token for a MySQL DB instance.

```
import sys
import boto3

ENDPOINT="mysqldb.123456789012.us-east-1.rds.amazonaws.com"
PORT="3306"
USR="jane_doe"
REGION="us-east-1"
os.environ['LIBMYSQL_ENABLE_CLEARTEXT_PLUGIN'] = '1'

#gets the credentials from .aws/credentials
```

```
session = boto3.Session(profile_name='RDSCreds')
client = boto3.client('rds')

token = client.generate_db_auth_token(DBHostname=ENDPOINT, Port=PORT, DBUsername=USR,
 Region=REGION)
```

This code generates an IAM authentication token for a PostgreSQL DB instance.

```
import sys
import boto3

ENDPOINT="postgresmydb.123456789012.us-east-1.rds.amazonaws.com"
PORT="5432"
USR="jane_doe"
REGION="us-east-1"

#gets the credentials from .aws/credentials
session = boto3.Session(profile_name='RDSCreds')
client = boto3.client('rds')

token = client.generate_db_auth_token(DBHostname=ENDPOINT, Port=PORT, DBUsername=USR,
 Region=REGION)
```

Connecting to a DB Instance

The following code example shows how to generate an authentication token, and then use it to connect to a DB instance running PostgreSQL.

To run this code example, you need the AWS SDK for Python (Boto 3), found on the AWS site.

Modify the values of the following variables as needed:

- `ENDPOINT` – The endpoint of the DB instance that you want to access
- `PORT` – The port number used for connecting to your DB instance
- `USER` – The database account that you want to access.
- `REGION` – The AWS Region where the DB instance is running
- `DBNAME` – The DB engine, either `mysql` or `postgres`

This code connects to a MySQL DB instance.

```
import mysql.connector
import sys
import boto3
import os

ENDPOINT="mysqldb.123456789012.us-east-1.rds.amazonaws.com"
PORT="3306"
USR="jane_doe"
REGION="us-east-1"
DBNAME="mysql"
os.environ['LIBMYSQL_ENABLE_CLEARTEXT_PLUGIN'] = '1'

#gets the credentials from .aws/credentials
session = boto3.Session(profile_name='default')
client = boto3.client('rds')
```

```
token = client.generate_db_auth_token(DBHostname=ENDPOINT, Port=PORT, DBUsername=USR,
 Region=REGION)

try:
    conn =  mysql.connector.connect(host=ENDPOINT, user=USR, passwd=token, port=PORT,
 database=DBNAME)
    cur = conn.cursor()
    cur.execute("""SELECT now()""")
    query_results = cur.fetchall()
    print(query_results)
except Exception as e:
    print("Database connection failed due to {}".format(e))
```

This code connects to a PostgreSQL DB instance.

```
import psycopg2
import sys
import boto3

ENDPOINT="postgresmydb.123456789012.us-east-1.rds.amazonaws.com"
PORT="5432"
USR="jane_doe"
REGION="us-east-1"
DBNAME="postgres"

#gets the credentials from .aws/credentials
session = boto3.Session(profile_name='RDSCreds')
client = boto3.client('rds')

token = client.generate_db_auth_token(DBHostname=ENDPOINT, Port=PORT, DBUsername=USR,
 Region=REGION)

try:
    conn = psycopg2.connect(host=ENDPOINT, port=PORT, database=DBNAME, user=USR,
 password=token)
    cur = conn.cursor()
    cur.execute("""SELECT now()""")
    query_results = cur.fetchall()
    print(query_results)
except Exception as e:
    print("Database connection failed due to {}".format(e))
```

Connecting to Your DB Instance Using IAM Authentication and the AWS SDK for Java

You can connect from the command line to an Amazon RDS MySQL or PostgreSQL DB instance with the AWS SDK for Java as described following.

Topics

Generating an IAM Authentication Token

If you are writing programs using the AWS SDK for Java, you can get a signed authentication token using the `RdsIamAuthTokenGenerator` class. Using this class requires that you provide AWS credentials. To do this, you create an instance of the `DefaultAWSCredentialsProviderChain` class. `DefaultAWSCredentialsProviderChain` uses the first AWS access key and secret key that it finds in the default credential provider chain. For more information about AWS access keys, see Managing Access Keys for IAM Users.

After you create an instance of `RdsIamAuthTokenGenerator`, you can call the `getAuthToken` method to obtain a signed token. Provide the AWS Region, host name, port number, and user name. The following code example illustrates how to do this.

```
package com.amazonaws.codesamples;

import com.amazonaws.auth.DefaultAWSCredentialsProviderChain;
import com.amazonaws.services.rds.auth.GetIamAuthTokenRequest;
import com.amazonaws.services.rds.auth.RdsIamAuthTokenGenerator;

public class GenerateRDSAuthToken {

    public static void main(String[] args) {

     String region = "us-west-2";
     String hostname = "rdsmysql.cdgmuqiadpid.us-west-2.rds.amazonaws.com";
     String port = "3306";
     String username = "jane_doe";

     System.out.println(generateAuthToken(region, hostname, port, username));
    }

    static String generateAuthToken(String region, String hostName, String port, String
 username) {

     RdsIamAuthTokenGenerator generator = RdsIamAuthTokenGenerator.builder()
      .credentials(new DefaultAWSCredentialsProviderChain())
      .region(region)
      .build();

     String authToken = generator.getAuthToken(
      GetIamAuthTokenRequest.builder()
      .hostname(hostName)
      .port(Integer.parseInt(port))
      .userName(username)
      .build());

     return authToken;
    }

}
```

Manually Constructing an IAM Authentication Token

In Java, the easiest way to generate an authentication token is to use `RdsIamAuthTokenGenerator`. This class creates an authentication token for you, and then signs it using AWS signature version 4. For more information, see Signature Version 4 Signing Process in the *AWS General Reference.*

However, you can also construct and sign an authentication token manually, as shown in the following code example.

```
package com.amazonaws.codesamples;

import com.amazonaws.SdkClientException;
import com.amazonaws.auth.DefaultAWSCredentialsProviderChain;
import com.amazonaws.auth.SigningAlgorithm;
import com.amazonaws.util.BinaryUtils;
import org.apache.commons.lang3.StringUtils;
```

```
import javax.crypto.Mac;
import javax.crypto.spec.SecretKeySpec;
import java.nio.charset.Charset;
import java.security.MessageDigest;
import java.text.SimpleDateFormat;
import java.util.Date;
import java.util.SortedMap;
import java.util.TreeMap;

import static com.amazonaws.auth.internal.SignerConstants.AWS4_TERMINATOR;
import static com.amazonaws.util.StringUtils.UTF8;

public class CreateRDSAuthTokenManually {
    public static String httpMethod = "GET";
    public static String action = "connect";
    public static String canonicalURIParameter = "/";
    public static SortedMap<String, String> canonicalQueryParameters = new TreeMap();
    public static String payload = StringUtils.EMPTY;
    public static String signedHeader = "host";
    public static String algorithm = "AWS4-HMAC-SHA256";
    public static String serviceName = "rds-db";
    public static String requestWithoutSignature;

    public static void main(String[] args) throws Exception {

        String region = "us-west-2";
        String instanceName = "rdsmysql.cdgmuqiadpid.us-west-2.rds.amazonaws.com";
        String port = "3306";
        String username = "jane_doe";

        Date now = new Date();
        String date = new SimpleDateFormat("yyyyMMdd").format(now);
        String dateTimeStamp = new SimpleDateFormat("yyyyMMdd'T'HHmmssZ").format(now);
        DefaultAWSCredentialsProviderChain creds = new
 DefaultAWSCredentialsProviderChain();
     String awsAccessKey = creds.getCredentials().getAWSAccessKeyId();
     String awsSecretKey = creds.getCredentials().getAWSSecretKey();
        String expiryMinutes = "900";

        System.out.println("Step 1:  Create a canonical request:");
        String canonicalString = createCanonicalString(username, awsAccessKey, date,
 dateTimeStamp, region, expiryMinutes, instanceName, port);
        System.out.println(canonicalString);
        System.out.println();

        System.out.println("Step 2:  Create a string to sign:");
        String stringToSign = createStringToSign(dateTimeStamp, canonicalString,
 awsAccessKey, date, region);
        System.out.println(stringToSign);
        System.out.println();

        System.out.println("Step 3:  Calculate the signature:");
        String signature = BinaryUtils.toHex(calculateSignature(stringToSign,
 newSigningKey(awsSecretKey, date, region, serviceName)));
        System.out.println(signature);
        System.out.println();

        System.out.println("Step 4:  Add the signing info to the request");
        System.out.println(appendSignature(signature));
        System.out.println();

    }

    //Step 1: Create a canonical request date should be in format YYYYMMDD and dateTime
 should be in format YYYYMMDDTHHMMSSZ
```

```
    public static String createCanonicalString(String user, String accessKey, String date,
String dateTime, String region, String expiryPeriod, String hostName, String port) throws
Exception {
        canonicalQueryParameters.put("Action", action);
        canonicalQueryParameters.put("DBUser", user);
        canonicalQueryParameters.put("X-Amz-Algorithm", "AWS4-HMAC-SHA256");
        canonicalQueryParameters.put("X-Amz-Credential", accessKey + "%2F" + date + "%2F" +
region + "%2F" + serviceName + "%2Faws4_request");
        canonicalQueryParameters.put("X-Amz-Date", dateTime);
        canonicalQueryParameters.put("X-Amz-Expires", expiryPeriod);
        canonicalQueryParameters.put("X-Amz-SignedHeaders", signedHeader);
        String canonicalQueryString = "";
        while(!canonicalQueryParameters.isEmpty()) {
            String currentQueryParameter = canonicalQueryParameters.firstKey();
            String currentQueryParameterValue =
canonicalQueryParameters.remove(currentQueryParameter);
            canonicalQueryString = canonicalQueryString + currentQueryParameter + "=" +
currentQueryParameterValue;
            if (!currentQueryParameter.equals("X-Amz-SignedHeaders")) {
                canonicalQueryString += "&";
            }
        }
        String canonicalHeaders = "host:" + hostName + ":" + port + '\n';
        requestWithoutSignature = hostName + ":" + port + "/?" + canonicalQueryString;

        String hashedPayload = BinaryUtils.toHex(hash(payload));
        return httpMethod + '\n' + canonicalURIParameter + '\n' + canonicalQueryString +
'\n' + canonicalHeaders + '\n' + signedHeader + '\n' + hashedPayload;

    }

    //Step 2: Create a string to sign using sig v4
    public static String createStringToSign(String dateTime, String canonicalRequest,
String accessKey, String date, String region) throws Exception {
        String credentialScope = date + "/" + region + "/" + serviceName + "/aws4_request";
        return algorithm + '\n' + dateTime + '\n' + credentialScope + '\n' +
BinaryUtils.toHex(hash(canonicalRequest));

    }

    //Step 3: Calculate signature
    /**
     * Step 3 of the AWS Signature version 4 calculation. It involves deriving
     * the signing key and computing the signature. Refer to
     * http://docs.aws.amazon
     * .com/general/latest/gr/sigv4-calculate-signature.html
     */
    public static byte[] calculateSignature(String stringToSign,
                                            byte[] signingKey) {
        return sign(stringToSign.getBytes(Charset.forName("UTF-8")), signingKey,
                SigningAlgorithm.HmacSHA256);
    }

    public static byte[] sign(byte[] data, byte[] key,
                          SigningAlgorithm algorithm) throws SdkClientException {
        try {
            Mac mac = algorithm.getMac();
            mac.init(new SecretKeySpec(key, algorithm.toString()));
            return mac.doFinal(data);
        } catch (Exception e) {
            throw new SdkClientException(
                    "Unable to calculate a request signature: "
                            + e.getMessage(), e);
        }
    }
```

```
    public static byte[] newSigningKey(String secretKey,
                                String dateStamp, String regionName, String serviceName)
 {
        byte[] kSecret = ("AWS4" + secretKey).getBytes(Charset.forName("UTF-8"));
        byte[] kDate = sign(dateStamp, kSecret, SigningAlgorithm.HmacSHA256);
        byte[] kRegion = sign(regionName, kDate, SigningAlgorithm.HmacSHA256);
        byte[] kService = sign(serviceName, kRegion,
                SigningAlgorithm.HmacSHA256);
        return sign(AWS4_TERMINATOR, kService, SigningAlgorithm.HmacSHA256);
    }

    public static byte[] sign(String stringData, byte[] key,
                       SigningAlgorithm algorithm) throws SdkClientException {
        try {
            byte[] data = stringData.getBytes(UTF8);
            return sign(data, key, algorithm);
        } catch (Exception e) {
            throw new SdkClientException(
                    "Unable to calculate a request signature: "
                            + e.getMessage(), e);
        }
    }

    //Step 4: append the signature
    public static String appendSignature(String signature) {
        return requestWithoutSignature + "&X-Amz-Signature=" + signature;
    }

    public static byte[] hash(String s) throws Exception {
        try {
            MessageDigest md = MessageDigest.getInstance("SHA-256");
            md.update(s.getBytes(UTF8));
            return md.digest();
        } catch (Exception e) {
            throw new SdkClientException(
                    "Unable to compute hash while signing request: "
                            + e.getMessage(), e);
        }
    }
}
```

Connecting to a DB Instance

The following code example shows how to generate an authentication token, and then use it to connect to an instance running MySQL.

To run this code example, you need the AWS SDK for Java, found on the AWS site. In addition, you need the following:

- MySQL Connector/J. This code example was tested with `mysql-connector-java-5.1.33-bin.jar`.
- An intermediate certificate for Amazon RDS that is specific to an AWS Region. (For more information, see Using SSL/TLS to Encrypt a Connection to a DB Instance (p. 1361).) At runtime, the class loader looks for the certificate in the same directory as this Java code example, so that the class loader can find it.
- Modify the values of the following variables as needed:
  - `RDS_INSTANCE_HOSTNAME` – The host name of the DB instance that you want to access.
  - `RDS_INSTANCE_PORT` – The port number used for connecting to your PostgreSQL DB instance.
  - `REGION_NAME` – The AWS Region where the DB instance is running.
  - `DB_USER` – The database account that you want to access.
  - `SSL_CERTIFICATE` – An SSL certificate for Amazon RDS that is specific to an AWS Region.

To download a certificate for your AWS Region, see Intermediate Certificates (p. 1362). Place the SSL certificate in the same directory as this Java program file, so that the class loader can find the certificate at runtime.

This code example obtains AWS credentials from the default credential provider chain.

```
package com.amazonaws.samples;

import com.amazonaws.services.rds.auth.RdsIamAuthTokenGenerator;
import com.amazonaws.services.rds.auth.GetIamAuthTokenRequest;
import com.amazonaws.auth.BasicAWSCredentials;
import com.amazonaws.auth.DefaultAWSCredentialsProviderChain;
import com.amazonaws.auth.AWSStaticCredentialsProvider;

import java.io.File;
import java.io.FileOutputStream;
import java.io.InputStream;
import java.security.KeyStore;
import java.security.cert.CertificateFactory;
import java.security.cert.X509Certificate;

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.Statement;
import java.util.Properties;

import java.net.URL;

public class IAMDatabaseAuthenticationTester {
    //AWS Credentials of the IAM user with policy enabling IAM Database Authenticated
 access to the db by the db user.
    private static final DefaultAWSCredentialsProviderChain creds = new
 DefaultAWSCredentialsProviderChain();
    private static final String AWS_ACCESS_KEY =
 creds.getCredentials().getAWSAccessKeyId();
    private static final String AWS_SECRET_KEY = creds.getCredentials().getAWSSecretKey();

    //Configuration parameters for the generation of the IAM Database Authentication token
    private static final String RDS_INSTANCE_HOSTNAME = "rdsmysql.cdgmuqiadpid.us-
west-2.rds.amazonaws.com";
    private static final int RDS_INSTANCE_PORT = 3306;
    private static final String REGION_NAME = "us-west-2";
    private static final String DB_USER = "jane_doe";
    private static final String JDBC_URL = "jdbc:mysql://" + RDS_INSTANCE_HOSTNAME + ":" +
 RDS_INSTANCE_PORT;

    private static final String SSL_CERTIFICATE = "rds-ca-2015-us-west-2.pem";

    private static final String KEY_STORE_TYPE = "JKS";
    private static final String KEY_STORE_PROVIDER = "SUN";
    private static final String KEY_STORE_FILE_PREFIX = "sys-connect-via-ssl-test-cacerts";
    private static final String KEY_STORE_FILE_SUFFIX = ".jks";
    private static final String DEFAULT_KEY_STORE_PASSWORD = "changeit";

    public static void main(String[] args) throws Exception {
        //get the connection
        Connection connection = getDBConnectionUsingIam();

        //verify the connection is successful
        Statement stmt= connection.createStatement();
        ResultSet rs=stmt.executeQuery("SELECT 'Success!' FROM DUAL;");
        while (rs.next()) {
```

```
             String id = rs.getString(1);
            System.out.println(id); //Should print "Success!"
        }

        //close the connection
        stmt.close();
        connection.close();

        clearSslProperties();

    }

    /**
     * This method returns a connection to the db instance authenticated using IAM Database
 Authentication
     * @return
     * @throws Exception
     */
    private static Connection getDBConnectionUsingIam() throws Exception {
        setSslProperties();
        return DriverManager.getConnection(JDBC_URL, setMySqlConnectionProperties());
    }

    /**
     * This method sets the mysql connection properties which includes the IAM Database
 Authentication token
     * as the password. It also specifies that SSL verification is required.
     * @return
     */
    private static Properties setMySqlConnectionProperties() {
        Properties mysqlConnectionProperties = new Properties();
        mysqlConnectionProperties.setProperty("verifyServerCertificate","true");
        mysqlConnectionProperties.setProperty("useSSL", "true");
        mysqlConnectionProperties.setProperty("user",DB_USER);
        mysqlConnectionProperties.setProperty("password",generateAuthToken());
        return mysqlConnectionProperties;
    }

    /**
     * This method generates the IAM Auth Token.
     * An example IAM Auth Token would look like follows:
     * btusi123.cmz7kenwo2ye.rds.cn-north-1.amazonaws.com.cn:3306/?
Action=connect&DBUser=iamtestuser&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-
Date=20171003T010726Z&X-Amz-SignedHeaders=host&X-Amz-Expires=899&X-Amz-
Credential=AKIAPFXHGVDI5RNFO4AQ%2F20171003%2Fcn-north-1%2Frds-db%2Faws4_request&X-Amz-
Signature=f9f45ef96c1f770cdad11a53e33ffa4c3730bc03fdee820cfdf1322eed15483b
     * @return
     */
    private static String generateAuthToken() {
        BasicAWSCredentials awsCredentials = new BasicAWSCredentials(AWS_ACCESS_KEY,
 AWS_SECRET_KEY);

        RdsIamAuthTokenGenerator generator = RdsIamAuthTokenGenerator.builder()
                .credentials(new
 AWSStaticCredentialsProvider(awsCredentials)).region(REGION_NAME).build();
        return generator.getAuthToken(GetIamAuthTokenRequest.builder()

 .hostname(RDS_INSTANCE_HOSTNAME).port(RDS_INSTANCE_PORT).userName(DB_USER).build());
    }

    /**
     * This method sets the SSL properties which specify the key store file, its type and
 password:
     * @throws Exception
     */
    private static void setSslProperties() throws Exception {
```

```
        System.setProperty("javax.net.ssl.trustStore", createKeyStoreFile());
        System.setProperty("javax.net.ssl.trustStoreType", KEY_STORE_TYPE);
        System.setProperty("javax.net.ssl.trustStorePassword", DEFAULT_KEY_STORE_PASSWORD);
    }

    /**
     * This method returns the path of the Key Store File needed for the SSL verification
 during the IAM Database Authentication to
     * the db instance.
     * @return
     * @throws Exception
     */
    private static String createKeyStoreFile() throws Exception {
        return createKeyStoreFile(createCertificate()).getPath();
    }

    /**
     *  This method generates the SSL certificate
     * @return
     * @throws Exception
     */
    private static X509Certificate createCertificate() throws Exception {
        CertificateFactory certFactory = CertificateFactory.getInstance("X.509");
        URL url = new File(SSL_CERTIFICATE).toURI().toURL();
        if (url == null) {
            throw new Exception();
        }
        try (InputStream certInputStream = url.openStream()) {
            return (X509Certificate) certFactory.generateCertificate(certInputStream);
        }
    }

    /**
     * This method creates the Key Store File
     * @param rootX509Certificate - the SSL certificate to be stored in the KeyStore
     * @return
     * @throws Exception
     */
    private static File createKeyStoreFile(X509Certificate rootX509Certificate) throws
 Exception {
        File keyStoreFile = File.createTempFile(KEY_STORE_FILE_PREFIX,
 KEY_STORE_FILE_SUFFIX);
        try (FileOutputStream fos = new FileOutputStream(keyStoreFile.getPath())) {
            KeyStore ks = KeyStore.getInstance(KEY_STORE_TYPE, KEY_STORE_PROVIDER);
            ks.load(null);
            ks.setCertificateEntry("rootCaCertificate", rootX509Certificate);
            ks.store(fos, DEFAULT_KEY_STORE_PASSWORD.toCharArray());
        }
        return keyStoreFile;
    }

    /**
     * This method clears the SSL properties.
     * @throws Exception
     */
    private static void clearSslProperties() throws Exception {
           System.clearProperty("javax.net.ssl.trustStore");
           System.clearProperty("javax.net.ssl.trustStoreType");
           System.clearProperty("javax.net.ssl.trustStorePassword");
    }

}
```

Troubleshooting Amazon RDS Identity and Access

Use the following information to help you diagnose and fix common issues that you might encounter when working with Amazon RDS and IAM.

Topics

I Am Not Authorized to Perform an Action in Amazon RDS

If the AWS Management Console tells you that you're not authorized to perform an action, then you must contact your administrator for assistance. Your administrator is the person that provided you with your user name and password.

The following example error occurs when the `mateojackson` IAM user tries to use the console to view details about a *`widget`* but does not have `rds:`*`GetWidget`* permissions.

```
User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform:
 rds:GetWidget on resource: my-example-widget
```

In this case, Mateo asks his administrator to update his policies to allow him to access the *`my-example-widget`* resource using the `rds:`*`GetWidget`* action.

I Am Not Authorized to Perform iam:PassRole

If you receive an error that you're not authorized to perform the `iam:PassRole` action, then you must contact your administrator for assistance. Your administrator is the person that provided you with your user name and password. Ask that person to update your policies to allow you to pass a role to Amazon RDS.

Some AWS services allow you to pass an existing role to that service, instead of creating a new service role or service-linked role. To do this, you must have permissions to pass the role to the service.

The following example error occurs when an IAM user named `marymajor` tries to use the console to perform an action in Amazon RDS. However, the action requires the service to have permissions granted by a service role. Mary does not have permissions to pass the role to the service.

```
User: arn:aws:iam::123456789012:user/marymajor is not authorized to perform: iam:PassRole
```

In this case, Mary asks her administrator to update her policies to allow her to perform the `iam:PassRole` action.

I Want to View My Access Keys

After you create your IAM user access keys, you can view your access key ID at any time. However, you can't view your secret access key again. If you lose your secret key, you must create a new access key pair.

Access keys consist of two parts: an access key ID (for example, `AKIAIOSFODNN7EXAMPLE`) and a secret access key (for example, `wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY`). Like a user name and password, you must use both the access key ID and secret access key together to authenticate your requests. Manage your access keys as securely as you do your user name and password.

> **Important**
> Do not provide your access keys to a third party, even to help find your canonical user ID. By doing this, you might give someone permanent access to your account.

When you create an access key pair, you are prompted to save the access key ID and secret access key in a secure location. The secret access key is available only at the time you create it. If you lose your secret access key, you must add new access keys to your IAM user. You can have a maximum of two access keys. If you already have two, you must delete one key pair before creating a new one. To view instructions, see Managing Access Keys in the *IAM User Guide*.

I'm an Administrator and Want to Allow Others to Access Amazon RDS

To enable others to access Amazon RDS, you must create an IAM entity (user or role) for the person or application that needs access. They use the credentials for that entity to access AWS. You must then attach a policy to the entity that grants them the correct permissions in Amazon RDS.

To get started right away, see Creating Your First IAM Delegated User and Group in the *IAM User Guide*.

I Want to Allow People Outside of My AWS Account to Access My Amazon RDS Resources

You can create a role that users in other accounts or people outside of your organization can use to access your resources. You can specify who is trusted to assume the role. For services that support resource-based policies or access control lists (ACLs), you can use those policies to grant people access to your resources.

To learn more, consult the following:

- To learn whether Amazon RDS supports these features, see How Amazon RDS Works with IAM (p. 1375).
- To learn how to provide access to your resources across AWS accounts that you own, see Providing Access to an IAM User in Another AWS Account That You Own in the *IAM User Guide*.
- To learn how to provide access to your resources to third-party AWS accounts, see Providing Access to AWS Accounts Owned by Third Parties in the *IAM User Guide*.
- To learn how to provide access through identity federation, see Providing Access to Externally Authenticated Users (Identity Federation) in the *IAM User Guide*.
- To learn the difference between using roles and resource-based policies for cross-account access, see How IAM Roles Differ from Resource-based Policies in the *IAM User Guide*.

Kerberos Authentication

Amazon RDS supports external authentication of database users using Kerberos and Microsoft Active Directory. Kerberos is a network authentication protocol that uses tickets and symmetric-key cryptography to eliminate the need to transmit passwords over the network. Kerberos has been built into Active Directory and is designed to authenticate users to network resources, such as databases.

Amazon RDS support for Kerberos and Active Directory provides the benefits of single sign-on and centralized authentication of database users. You can keep your user credentials in Active Directory. Active Directory provides a centralized place for storing and managing credentials for multiple DB instances.

You can enable your database users to authenticate against DB instances in two ways. They can use credentials stored either in AWS Directory Service for Microsoft Active Directory or in your on-premises Active Directory.

Currently, RDS supports Kerberos authentication for MySQL, Microsoft SQL Server, Oracle, and PostgreSQL DB instances. Microsoft SQL Server and Oracle DB instances support one and two-way external and forest trust relationships. For more information, see When to Create a Trust Relationship in the *AWS Directory Service Administration Guide*.

For information about Kerberos authentication with a specific engine, see the following:

- Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612)
- Using Kerberos Authentication for MySQL (p. 806)
- Using Kerberos Authentication with Amazon RDS for Oracle (p. 1053)
- Using Kerberos Authentication with Amazon RDS for PostgreSQL (p. 1296)

Logging and Monitoring in Amazon RDS

Monitoring is an important part of maintaining the reliability, availability, and performance of Amazon RDS and your AWS solutions. You should collect monitoring data from all of the parts of your AWS solution so that you can more easily debug a multi-point failure if one occurs. AWS provides several tools for monitoring your Amazon RDS resources and responding to potential incidents:

Amazon CloudWatch Alarms

Using Amazon CloudWatch alarms, you watch a single metric over a time period that you specify. If the metric exceeds a given threshold, a notification is sent to an Amazon SNS topic or AWS Auto Scaling policy. CloudWatch alarms do not invoke actions because they are in a particular state. Rather the state must have changed and been maintained for a specified number of periods. For more information, see Monitoring with Amazon CloudWatch (p. 348).

AWS CloudTrail Logs

CloudTrail provides a record of actions taken by a user, role, or an AWS service in Amazon RDS. CloudTrail captures all API calls for Amazon RDS as events, including calls from the console and from code calls to Amazon RDS API operations. Using the information collected by CloudTrail, you can determine the request that was made to Amazon RDS, the IP address from which the request was made, who made the request, when it was made, and additional details. For more information, see Logging Amazon RDS API Calls with AWS CloudTrail (p. 487).

Enhanced Monitoring

Amazon RDS provides metrics in real time for the operating system (OS) that your DB instance runs on. You can view the metrics for your DB instance using the console, or consume the Enhanced Monitoring JSON output from Amazon CloudWatch Logs in a monitoring system of your choice. For more information, see Enhanced Monitoring (p. 362).

Amazon RDS Performance Insights

Performance Insights expands on existing Amazon RDS monitoring features to illustrate your database's performance and help you analyze any issues that affect it. With the Performance Insights dashboard, you can visualize the database load and filter the load by waits, SQL statements, hosts, or users. For more information, see Using Amazon RDS Performance Insights (p. 376).

Database Logs

You can view, download, and watch database logs using the AWS Management Console, AWS CLI, or RDS API. For more information, see Amazon RDS Database Log Files (p. 453).

Amazon RDS Recommendations

Amazon RDS provides automated recommendations for database resources. These recommendations provide best practice guidance by analyzing DB instance configuration, usage, and performance data. For more information, see Using Amazon RDS Recommendations (p. 424).

Amazon RDS Event Notification

Amazon RDS uses the Amazon Simple Notification Service (Amazon SNS) to provide notification when an Amazon RDS event occurs. These notifications can be in any notification form supported by Amazon SNS for an AWS Region, such as an email, a text message, or a call to an HTTP endpoint. For more information, see Using Amazon RDS Event Notification (p. 429).

AWS Trusted Advisor

Trusted Advisor draws upon best practices learned from serving hundreds of thousands of AWS customers. Trusted Advisor inspects your AWS environment and then makes recommendations when opportunities exist to save money, improve system availability and performance, or help close security gaps. All AWS customers have access to five Trusted Advisor checks. Customers with a Business or Enterprise support plan can view all Trusted Advisor checks.

Trusted Advisor has the following Amazon RDS-related checks:

- Amazon RDS Idle DB Instances
- Amazon RDS Security Group Access Risk
- Amazon RDS Backups
- Amazon RDS Multi-AZ

For more information on these checks, see Trusted Advisor Best Practices (Checks).

For more information about monitoring Amazon RDS, see Monitoring an Amazon RDS DB Instance (p. 345).

Compliance Validation for Amazon RDS

Third-party auditors assess the security and compliance of Amazon RDS as part of multiple AWS compliance programs. These include SOC, PCI, FedRAMP, HIPAA, and others.

For a list of AWS services in scope of specific compliance programs, see AWS Services in Scope by Compliance Program. For general information, see AWS Compliance Programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading Reports in AWS Artifact.

Your compliance responsibility when using Amazon RDS is determined by the sensitivity of your data, your organization's compliance objectives, and applicable laws and regulations. AWS provides the following resources to help with compliance:

- Security and Compliance Quick Start Guides – These deployment guides discuss architectural considerations and provide steps for deploying security- and compliance-focused baseline environments on AWS.
- Architecting for HIPAA Security and Compliance Whitepaper – This whitepaper describes how companies can use AWS to create HIPAA-compliant applications.
- AWS Compliance Resources – This collection of workbooks and guides that might apply to your industry and location.
- AWS Config – This AWS service assesses how well your resource configurations comply with internal practices, industry guidelines, and regulations.
- AWS Security Hub – This AWS service provides a comprehensive view of your security state within AWS that helps you check your compliance with security industry standards and best practices.

Resilience in Amazon RDS

The AWS global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency, high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between Availability Zones without interruption. Availability Zones are more highly available, fault tolerant, and scalable than traditional single or multiple data center infrastructures.

For more information about AWS Regions and Availability Zones, see AWS Global Infrastructure.

In addition to the AWS global infrastructure, Amazon RDS offers features to help support your data resiliency and backup needs.

Backup and Restore

Amazon RDS creates and saves automated backups of your DB instance. Amazon RDS creates a storage volume snapshot of your DB instance, backing up the entire DB instance and not just individual databases.

Amazon RDS creates automated backups of your DB instance during the backup window of your DB instance. Amazon RDS saves the automated backups of your DB instance according to the backup retention period that you specify. If necessary, you can recover your database to any point in time during the backup retention period. You can also back up your DB instance manually, by manually creating a DB snapshot.

You can create a DB instance by restoring from this DB snapshot as a disaster recovery solution if the source DB instance fails.

For more information, see Backing Up and Restoring an Amazon RDS DB Instance (p. 290).

Replication

Amazon RDS uses the MariaDB, MySQL, Oracle, and PostgreSQL DB engines' built-in replication functionality to create a special type of DB instance called a read replica from a source DB instance. Updates made to the source DB instance are asynchronously copied to the read replica. You can reduce the load on your source DB instance by routing read queries from your applications to the read replica. Using read replicas, you can elastically scale out beyond the capacity constraints of a single DB instance for read-heavy database workloads. You can promote a read replica to a standalone instance as a disaster recovery solution if the source DB instance fails. For some DB engines, Amazon RDS also supports other replication options.

For more information, see Working with Read Replicas (p. 250).

Failover

Amazon RDS provides high availability and failover support for DB instances using Multi-AZ deployments. Amazon RDS uses several different technologies to provide failover support. Multi-AZ deployments for Oracle, PostgreSQL, MySQL, and MariaDB DB instances use Amazon's failover technology. SQL Server DB instances use SQL Server Database Mirroring (DBM).

For more information, see High Availability (Multi-AZ) for Amazon RDS (p. 41).

Infrastructure Security in Amazon RDS

As a managed service, Amazon RDS is protected by the AWS global network security procedures that are described in the Amazon Web Services: Overview of Security Processes whitepaper.

You use AWS published API calls to access Amazon RDS through the network. Clients must support Transport Layer Security (TLS) 1.0. We recommend TLS 1.2 or later. Clients must also support cipher suites with perfect forward secrecy (PFS) such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Ephemeral Diffie-Hellman (ECDHE). Most modern systems such as Java 7 and later support these modes.

Additionally, requests must be signed by using an access key ID and a secret access key that is associated with an IAM principal. Or you can use the AWS Security Token Service (AWS STS) to generate temporary security credentials to sign requests.

In addition, Amazon RDS offers features to help support infrastructure security.

Security Groups

Security groups control the access that traffic has in and out of a DB instance. By default, network access is turned off to a DB instance. You can specify rules in a security group that allow access from an IP address range, port, or security group. After ingress rules are configured, the same rules apply to all DB instances that are associated with that security group.

For more information, see Controlling Access with Security Groups (p. 1414).

Public Accessibility

When you launch a DB instance inside a virtual private cloud (VPC) based on the Amazon VPC service, you can turn on or off public accessibility for that instance. To designate whether the DB instance that you create has a DNS name that resolves to a public IP address, you use the *Public accessibility* parameter. By using this parameter, you can designate whether there is public access to the DB instance. You can modify a DB instance to turn on or off public accessibility by modifying the *Public accessibility* parameter.

For more information, see Hiding a DB Instance in a VPC from the Internet (p. 1443).

Security Best Practices for Amazon RDS

Use AWS Identity and Access Management (IAM) accounts to control access to Amazon RDS API operations, especially operations that create, modify, or delete Amazon RDS resources. Such resources include DB instances, security groups, and parameter groups. Also use IAM to control actions that perform common administrative actions such as backing up and restoring DB instances.

- Create an individual IAM user for each person who manages Amazon RDS resources, including yourself. Don't use AWS root credentials to manage Amazon RDS resources.
- Grant each user the minimum set of permissions required to perform his or her duties.
- Use IAM groups to effectively manage permissions for multiple users.
- Rotate your IAM credentials regularly.
- Configure AWS Secrets Manager to automatically rotate the secrets for Amazon RDS. For more information, see Rotating Your AWS Secrets Manager Secrets in the *AWS Secrets Manager User Guide*. You can also retrieve the credential from AWS Secrets Manager programmatically. For more information, see Retrieving the Secret Value in the *AWS Secrets Manager User Guide*.

For more information about IAM, see AWS Identity and Access Management. For information on IAM best practices, see IAM Best Practices.

Use the AWS Management Console, the AWS CLI, or the RDS API to change the password for your master user. If you use another tool, such as a SQL client, to change the master user password, it might result in privileges being revoked for the user unintentionally.

Controlling Access with Security Groups

Security groups control the access that traffic has in and out of a DB instance. Three types of security groups are used with Amazon RDS: VPC security groups, DB security groups, and EC2-Classic security groups. In simple terms, these work as follows:

- A VPC security group controls access to DB instances and EC2 instances inside a VPC.
- A DB security group controls access to EC2-Classic DB instances that are not in a VPC.
- An EC2-Classic security group controls access to an EC2 instance. For more information about EC2-Classic security groups, see EC2-Classic in the Amazon EC2 documentation.

By default, network access is disabled for a DB instance. You can specify rules in a security group that allow access from an IP address range, port, or security group. Once ingress rules are configured, the same rules apply to all DB instances that are associated with that security group. You can specify up to 20 rules in a security group.

VPC Security Groups

Each VPC security group rule enables a specific source to access a DB instance in a VPC that is associated with that VPC security group. The source can be a range of addresses (for example, 203.0.113.0/24), or another VPC security group. By specifying a VPC security group as the source, you allow incoming traffic from all instances (typically application servers) that use the source VPC security group. VPC security groups can have rules that govern both inbound and outbound traffic, though the outbound traffic rules typically do not apply to DB instances. Outbound traffic rules only apply if the DB instance acts as a client. For example, outbound traffic rules apply to an Oracle DB instance with outbound database links. You must use the Amazon EC2 API or the **Security Group** option on the VPC Console to create VPC security groups.

When you create rules for your VPC security group that allow access to the instances in your VPC, you must specify a port for each range of addresses that the rule allows access for. For example, if you want to enable SSH access to instances in the VPC, then you create a rule allowing access to TCP port 22 for the specified range of addresses.

You can configure multiple VPC security groups that allow access to different ports for different instances in your VPC. For example, you can create a VPC security group that allows access to TCP port 80 for web servers in your VPC. You can then create another VPC security group that allows access to TCP port 3306 for RDS MySQL DB instances in your VPC.

For more information on VPC security groups, see Security Groups in the *Amazon Virtual Private Cloud User Guide*.

DB Security Groups

DB security groups are used with DB instances that are not in a VPC and on the EC2-Classic platform. Each DB security group rule enables a specific source to access a DB instance that is associated with that DB security group. The source can be a range of addresses (for example, 203.0.113.0/24), or an EC2-

Classic security group. When you specify an EC2-Classic security group as the source, you allow incoming traffic from all EC2 instances that use that EC2-Classic security group. DB security group rules apply to inbound traffic only; outbound traffic is not currently permitted for DB instances.

You don't need to specify a destination port number when you create DB security group rules. The port number defined for the DB instance is used as the destination port number for all rules defined for the DB security group. DB security groups can be created using the Amazon RDS API operations or the Amazon RDS page of the AWS Management Console.

For more information about working with DB security groups, see Working with DB Security Groups (EC2-Classic Platform) (p. 1419).

DB Security Groups vs. VPC Security Groups

The following table shows the key differences between DB security groups and VPC security groups.

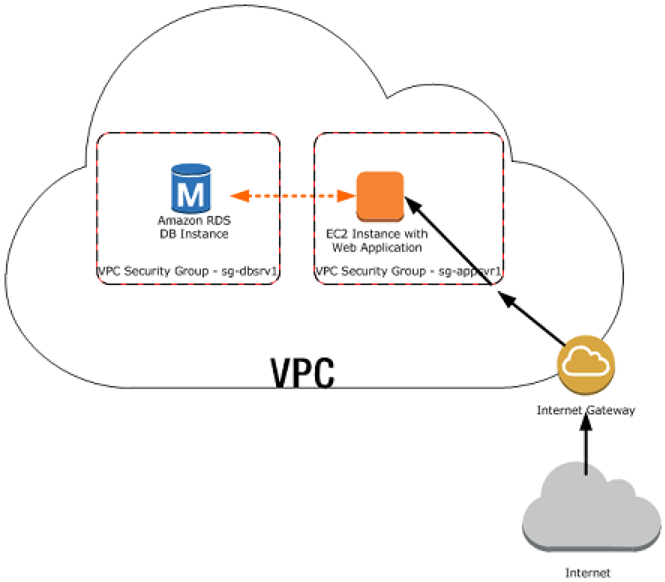
DB Security Group	VPC Security Group
Controls access to DB instances outside a VPC.	Controls access to DB instances in VPC.
Uses Amazon RDS API operations or the Amazon RDS page of the AWS Management Console to create and manage group and rules.	Uses Amazon EC2 API operations or the Amazon VPC page of the AWS Management Console to create and manage group and rules.
When you add a rule to a group, you don't need to specify port number or protocol.	When you add a rule to a group, specify the protocol as TCP. In addition, specify the same port number that you used to create the DB instances (or options) that you plan to add as members to the group.
Groups allow access from EC2-Classic security groups in your AWS account or other accounts.	Groups allow access from other VPC security groups in your VPC only.

Security Group Scenario

A common use of a DB instance in a VPC is to share data with an application server running in an Amazon EC2 instance in the same VPC, which is accessed by a client application outside the VPC. For this scenario, you use the RDS and VPC pages on the AWS Management Console or the RDS and EC2 API operations to create the necessary instances and security groups:

1. Create a VPC security group (for example, `sg-appsrv1`) and define inbound rules that use the IP addresses of the client application as the source. This security group allows your client application to connect to EC2 instances in a VPC that uses this security group.
2. Create an EC2 instance for the application and add the EC2 instance to the VPC security group (`sg-appsrv1`) that you created in the previous step. The EC2 instance in the VPC shares the VPC security group with the DB instance.
3. Create a second VPC security group (for example, `sg-dbsrv1`) and create a new rule by specifying the VPC security group that you created in step 1 (`sg-appsrv1`) as the source.
4. Create a new DB instance and add the DB instance to the VPC security group (`sg-dbsrv1`) that you created in the previous step. When you create the DB instance, use the same port number as the one specified for the VPC security group (`sg-dbsrv1`) rule that you created in step 3.

The following diagram shows this scenario.



For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

Creating a VPC Security Group

You can create a VPC security group for a DB instance by using the VPC console. For information about creating a security group, see Provide Access to Your DB Instance in Your VPC by Creating a Security Group (p. 61) and Security Groups in the *Amazon Virtual Private Cloud User Guide*.

Associating a Security Group with a DB Instance

You can associate a security group with a DB instance by using **Modify** on the RDS console, the `ModifyDBInstance` Amazon RDS API, or the `modify-db-instance` AWS CLI command.

For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220). For security group considerations when you restore a DB instance from a DB snapshot, see Security Group Considerations (p. 303).

Deleting DB VPC Security Groups

DB VPC security groups are an RDS mechanism to synchronize security information with a VPC security group. However, this synchronization is no longer required, because RDS has been updated to use VPC security group information directly.

Note
DB VPC security groups are deprecated, and they are different from DB security groups, VPC security groups, and EC2-Classic security groups.

We strongly recommend that you delete any DB VPC security groups that you currently use. If you don't delete your DB VPC security groups, you might encounter unintended behaviors with your DB instances, which can be as severe as losing access to a DB instance. The unintended behaviors might result from taking an action such as an update to a DB instance, a parameter group, or similar. Such updates cause RDS to resynchronize the DB VPC security group with the VPC security group. This resynchronization can result in your security information being overwritten with incorrect and outdated security information. This in turn can have a severe impact on your ability to access to your DB instances.

How Can I Determine If I Have a DB VPC Security Group?

Because DB VPC security groups have been deprecated, they don't appear in the RDS console. However, you can call the describe-db-security-groups AWS CLI command or the DescribeDBSecurityGroups API operation to determine if you have any DB VPC security groups.

In this case, you can call the `describe-db-security-groups` AWS CLI command with JSON specified as the output format. If you do, you can identify DB VPC security groups by the VPC identifier on the second line of the output for the security group as shown in the following example.

```
{
    "DBSecurityGroups": [
        {
            "VpcId": "vpc-abcd1234",
            "DBSecurityGroupDescription": "default:vpc-abcd1234",
            "IPRanges": [
                {
                    "Status": "authorized",
                    "CIDRIP": "xxx.xxx.xxx.xxx/n"
                },
                {
                    "Status": "authorized",
                    "CIDRIP": "xxx.xxx.xxx.xxx/n "
                }
            ],
            "OwnerId": "123456789012",
            "EC2SecurityGroups": [],
            "DBSecurityGroupName": "default:vpc-abcd1234"
        }
    ]
}
```

If you run the `DescribeDBSecurityGroups` API operation, then you can identify DB VPC security groups using the `<VpcId>` response element as shown in the following example.

```
<DBSecurityGroup>
  <EC2SecurityGroups/>
  <DBSecurityGroupDescription>default:vpc-abcd1234</DBSecurityGroupDescription>
  <IPRanges>
    <IPRange>
      <CIDRIP>xxx.xxx.xxx.xxx/n</CIDRIP>
      <Status>authorized</Status>
    </IPRange>
    <IPRange>
      <CIDRIP>xxx.xxx.xxx.xxx/n</CIDRIP>
      <Status>authorized</Status>
    </IPRange>
  </IPRanges>
  <VpcId>vpc-abcd1234</VpcId>
  <OwnerId>123456789012</OwnerId>
  <DBSecurityGroupName>default:vpc-abcd1234</DBSecurityGroupName>
</DBSecurityGroup>
```

How Do I Delete a DB VPC Security Group?

Because DB VPC security groups don't appear in the RDS console, you must call the delete-db-security-group AWS CLI command or the DeleteDBSecurityGroup API operation to delete a DB VPC security group.

After you delete a DB VPC security group, your DB instances in your VPC continue to be secured by the VPC security group for that VPC. The DB VPC security group that was deleted was merely a copy of the VPC security group information.

Review Your AWS CloudFormation Templates

Older versions of AWS CloudFormation templates can contain instructions to create a DB VPC security group. Because DB VPC security groups are not yet fully deprecated, they can still be created. Make sure that any AWS CloudFormation templates that you use to provision a DB instance with security settings don't also create a DB VPC security group. Don't use AWS CloudFormation templates that create an RDS `DBSecurityGroup` with an `EC2VpcId` as shown in the following example.

```
{
  "DbSecurityByEC2SecurityGroup" : {
    "Type" : "AWS::RDS::DBSecurityGroup",
    "Properties" : {
       "GroupDescription" : "Ingress for security group",
       "EC2VpcId" : "MyVPC",
       "DBSecurityGroupIngress" : [ {
          "EC2SecurityGroupId" : "sg-b0ff1111",
          "EC2SecurityGroupOwnerId" : "111122223333"
       }, {
          "EC2SecurityGroupId" : "sg-ffd722222",
          "EC2SecurityGroupOwnerId" : "111122223333"
       } ]
    }
  }
}
```

Instead, add security information for your DB instances in a VPC using VPC security groups, as shown in the following example.

```
{
  "DBInstance" : {
    "Type": "AWS::RDS::DBInstance",
    "Properties": {
      "DBName"            : { "Ref" : "DBName" },
      "Engine"            : "MySQL",
      "MultiAZ"           : { "Ref": "MultiAZDatabase" },
      "MasterUsername"    : { "Ref" : "<master_username>" },
      "DBInstanceClass"   : { "Ref" : "DBClass" },
      "AllocatedStorage"  : { "Ref" : "DBAllocatedStorage" },
      "MasterUserPassword": { "Ref" : "<master_password>" },
      "VPCSecurityGroups" : [ { "Fn::GetAtt": [ "VPCSecurityGroup", "GroupId" ] } ]
    }
  }
}
```

Working with DB Security Groups (EC2-Classic Platform)

By default, network access is turned off to a DB instance. You can specify rules in a *security group* that allows access from an IP address range, port, or security group. Once ingress rules are configured, the same rules apply to all DB instances that are associated with that security group. You can specify up to 20 rules in a security group.

Amazon RDS supports two different kinds of security groups. The one you use depends on which Amazon RDS platform you are on:

- **VPC security groups** – for the EC2-VPC platform.
- **DB security groups** – for the EC2-Classic platform.

You are most likely on the EC2-VPC platform (and must use VPC security groups) if any of the following are true:

- If you are a new Amazon RDS customer.
- If you have never created a DB instance before.
- If you are creating a DB instance in an AWS Region you have not used before.

Otherwise, if you are on the EC2-Classic platform, you use DB security groups to manage access to your Amazon RDS DB instances. For more information about the differences between DB security groups and VPC security groups, see Controlling Access with Security Groups (p. 1414).

> **Note**
> To determine which platform you are on, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).
> If you are on the EC2-VPC platform, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

Topics

Creating a DB Security Group

To create a DB security group, you need to provide a name and a description.

Console

To create a DB security group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

Note
If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

3. Choose **Create DB Security Group**.
4. Type the name and description of the new DB security group in the **Name** and **Description** text boxes. The security group name can't contain spaces and can't start with a number.
5. Choose **Yes, Create**.

   The DB security group is created.

   A newly created DB security group doesn't provide access to a DB instance by default. You must specify a range of IP addresses or an EC2-Classic security group that can have access to the DB instance. To specify IP addresses or an EC2-Classic security group for a DB security group, see Authorizing Network Access to a DB Security Group from an IP Range (p. 1423).

AWS CLI

To create a DB security group, use the AWS CLI command `create-db-security-group`.

Example

For Linux, macOS, or Unix:

```
aws rds create-db-security-group \
    --db-security-group-name mydbsecuritygroup \
    --db-security-group-description "My new security group"
```

For Windows:

```
aws rds create-db-security-group ^
    --db-security-group-name mydbsecuritygroup ^
    --db-security-group-description "My new security group"
```

A newly created DB security group doesn't provide access to a DB instance by default. You must specify a range of IP addresses or an EC2-Classic security group that can have access to the DB instance. To specify IP addresses or an EC2-Classic security group for a DB security group, see Authorizing Network Access to a DB Security Group from an IP Range (p. 1423).

API

To create a DB security group, call the Amazon RDS function `CreateDBSecurityGroup` with the following parameters:

- `DBSecurityGroupName = `*`mydbsecuritygroup`*
- `Description = `*`"My new security group"`*

Example

```
https://rds.amazonaws.com/
    ?Action=CreateDBSecurityGroup
    &DBSecurityGroupName=mydbsecuritygroup
    &Description=My%20new%20db%20security%20group
    &Version=2012-01-15
    &SignatureVersion=2
```

```
    &SignatureMethod=HmacSHA256
    &Timestamp=2012-01-20T22%3A06%3A23.624Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

A newly created DB security group doesn't provide access to a DB instance by default. You must specify a range of IP addresses or an EC2-Classic security group that can have access to the DB instance. To specify IP addresses or an EC2-Classic security group for a DB security group, see Authorizing Network Access to a DB Security Group from an IP Range (p. 1423).

Listing Available DB Security Groups

You can list which DB security groups have been created for your AWS account.

Console

To list all available DB security groups for an AWS account

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

   The available DB security groups appear in the **DB Security Groups** list.

   > **Note**
   > If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).

AWS CLI

To list all available DB security groups for an AWS account, Use the AWS CLI command `describe-db-security-groups` with no parameters.

Example

```
aws rds describe-db-security-groups
```

API

To list all available DB security groups for an AWS account, call `DescribeDBSecurityGroups` with no parameters.

Example

```
https://rds.amazonaws.com/
    ?Action=DescribeDBSecurityGroups
    &MaxRecords=100
    &Version=2009-10-16
    &SignatureVersion=2
    &SignatureMethod=HmacSHA256
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Viewing a DB Security Group

You can view detailed information about your DB security group to see what IP ranges have been authorized.

Console

To view properties of a specific DB security group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

   Note
   If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
3. Select the details icon for the DB security group you want to view. The detailed information for the DB security group is displayed.

AWS CLI

To view the properties of a specific DB security group use the AWS CLI `describe-db-security-groups`. Specify the DB security group you want to view.

Example

For Linux, macOS, or Unix:

```
aws rds describe-db-security-groups \
    --db-security-group-name mydbsecuritygroup
```

For Windows:

```
aws rds describe-db-security-groups ^
    --db-security-group-name mydbsecuritygroup
```

API

To view properties of a specific DB security group, call `DescribeDBSecurityGroups` with the following parameters:

- `DBSecurityGroupName=mydbsecuritygroup`

Example

```
https://rds.amazonaws.com/
    ?Action=DescribeDBSecurityGroups
    &DBSecurityGroupName=mydbsecuritygroup
    &Version=2009-10-16
    &SignatureVersion=2
    &SignatureMethod=HmacSHA256
    &Timestamp=2009-10-16T22%3A23%3A07.107Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Associating a DB Security Group with a DB Instance

You can associate a DB security group with a DB instance using the RDS console's **Modify** option, the `ModifyDBInstance` Amazon RDS API, or the AWS CLI `modify-db-instance` command.

For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Authorizing Network Access to a DB Security Group from an IP Range

By default, network access is turned off to a DB instance. If you want to access a DB instance that is not in a VPC, you must set access rules for a DB security group to allow access from specific EC2-Classic security groups or CIDR IP ranges. You then must associate that DB instance with that DB security group. This process is called *ingress*. Once ingress is configured for a DB security group, the same ingress rules apply to all DB instances associated with that DB security group.

> **Warning**
> Talk with your network administrator if you are intending to access a DB instance behind a firewall to determine the IP addresses you should use.

In following example, you configure a DB security group with an ingress rule for a CIDR IP range.

Console

To configure a DB security group with an ingress rule for a CIDR IP range

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

   > **Note**
   > If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
3. Select the details icon for the DB security group you want to authorize.
4. In the details page for your security group, select *CIDR/IP* from the **Connection Type** drop-down list, type the CIDR range for the ingress rule you want to add to this DB security group into the **CIDR** text box, and choose **Authorize**.

   > **Tip**
   > The AWS Management Console displays a CIDR IP based on your connection below the CIDR text field. If you are not accessing the DB instance from behind a firewall, you can use this CIDR IP.
5. The status of the ingress rule is **authorizing** until the new ingress rule has been applied to all DB instances that are associated with the DB security group that you modified. After the ingress rule has been successfully applied, the status changes to **authorized**.

AWS CLI

To configure a DB security group with an ingress rule for a CIDR IP range, use the AWS CLI command `authorize-db-security-group-ingress`.

Example

For Linux, macOS, or Unix:

```
aws rds authorize-db-security-group-ingress \
    --db-security-group-name mydbsecuritygroup \
    --cidrip 192.168.1.10/27
```

For Windows:

```
aws rds authorize-db-security-group-ingress ^
    --db-security-group-name mydbsecuritygroup ^
    --cidrip 192.168.1.10/27
```

The command should produce output similar to the following.

```
SECGROUP  mydbsecuritygroup  My new DBSecurityGroup
IP-RANGE  192.168.1.10/27  authorizing
```

API

To configure a DB security group with an ingress rule for a CIDR IP range, call the Amazon RDS API `AuthorizeDBSecurityGroupIngress` with the following parameters:

- `DBSecurityGroupName = mydbsecuritygroup`
- `CIDRIP = 192.168.1.10/27`

Example

```
https://rds.amazonaws.com/
 ?Action=AuthorizeDBSecurityGroupIngress
 &CIDRIP=192.168.1.10%2F27
 &DBSecurityGroupName=mydbsecuritygroup
 &Version=2009-10-16
 &Action=AuthorizeDBSecurityGroupIngress
 &SignatureVersion=2
 &SignatureMethod=HmacSHA256
 &Timestamp=2009-10-22T17%3A10%3A50.274Z
 &AWSAccessKeyId=<AWS Access Key ID>
 &Signature=<Signature>
```

Authorizing Network Access to a DB Instance from an Amazon EC2 Instance

If you want to access your DB instance from an Amazon EC2 instance, you must first determine if your EC2 instance and DB instance are in a VPC. If you are using a default VPC, you can assign the same EC2 or VPC security group that you used for your EC2 instance when you create or modify the DB instance that the EC2 instance accesses.

If your DB instance and EC2 instance are not in a VPC, you must configure the DB instance's security group with an ingress rule that allows traffic from the Amazon EC2 instance. You do this by adding the EC2-Classic security group for the EC2 instance to the DB security group for the DB instance. In this example, you add an ingress rule to a DB security group for an EC2-Classic security group.

Important

- Adding an ingress rule to a DB security group for an EC2-Classic security group only grants access to your DB instances from Amazon EC2 instances associated with that EC2-Classic security group.
- You can't authorize an EC2-Classic security group that is in a different AWS Region than your DB instance. You can authorize an IP range, or specify an EC2-Classic security group in the same AWS Region that refers to IP address in another AWS Region. If you specify an IP range, we recommend that you use the private IP address of your Amazon EC2 instance, which provides a more direct network route from your Amazon EC2 instance to your Amazon RDS DB instance, and doesn't incur network charges for data sent outside of the Amazon network.

Console

To add an EC2-Classic security group to a DB security group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

   Note
   If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
3. Select the details icon for the DB security group you want to grant access.
4. In the details page for your security group, choose **EC2 Security Group** for **Connection Type**, and then select the EC2-Classic security group you want to use. Then choose **Authorize**.
5. The status of the ingress rule is **authorizing** until the new ingress rule has been applied to all DB instances that are associated with the DB security group that you modified. After the ingress rule has been successfully applied, the status changes to **authorized**.

AWS CLI

To grant access to an EC2-Classic security group, use the AWS CLI command `authorize-db-security-group-ingress`.

Example

For Linux, macOS, or Unix:

```
aws rds authorize-db-security-group-ingress \
    --db-security-group-name default  \
    --ec2-security-group-name myec2group \
    --ec2-security-group-owner-id 987654321021
```

For Windows:

```
aws rds authorize-db-security-group-ingress ^
    --db-security-group-name default  ^
    --ec2-security-group-name myec2group ^
    --ec2-security-group-owner-id 987654321021
```

The command should produce output similar to the following:

```
SECGROUP  Name     Description
SECGROUP  default  default
      EC2-SECGROUP  myec2group  987654321021  authorizing
```

API

To authorize network access to an EC2-Classic security group, call that Amazon RDS API function, https://docs.aws.amazon.com/AmazonRDS/latest/APIReference/API_AuthorizeDBSecurityGroupIngress.html`AuthorizeDBSecurityGroupIngress` with the following parameters:

- `EC2SecurityGroupName` = *`myec2group`*
- `EC2SecurityGroupOwnerId` = *`987654321021`*

Example

```
https://rds.amazonaws.com/
    ?Action=AuthorizeDBSecurityGroupIngress
    &EC2SecurityGroupOwnerId=987654321021
    &EC2SecurityGroupName=myec2group
    &Version=2009-10-16
    &SignatureVersion=2
    &SignatureMethod=HmacSHA256
    &Timestamp=2009-10-22T17%3A10%3A50.274Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Revoking Network Access to a DB Instance from an IP Range

You can easily revoke network access from a CIDR IP range to DB instances belonging to a DB security group by revoking the associated CIDR IP ingress rule.

In this example, you revoke an ingress rule for a CIDR IP range on a DB security group.

Console

To revoke an ingress rule for a CIDR IP range on a DB Security Group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. From the navigation pane, choose **Security Groups**.

   Note
   If you are on the EC2-VPC platform, the **Security Groups** option does not appear in the navigation pane. In this case, you must use VPC security groups instead of DB security groups. For more information about using a VPC, see Amazon Virtual Private Cloud VPCs and Amazon RDS (p. 1433).
3. Select the details icon for the DB security group that has the ingress rule you want to revoke.
4. In the details page for your security group, choose **Remove** next to the ingress rule you want to revoke.
5. The status of the ingress rule is **revoking** until the ingress rule has been removed from all DB instances that are associated with the DB security group that you modified. After the ingress rule has been removed, the ingress rule is removed from the DB security group.

AWS CLI

To revoke an ingress rule for a CIDR IP range on a DB security group, use the AWS CLI command `revoke-db-security-group-ingress`.

Example

For Linux, macOS, or Unix:

```
aws rds revoke-db-security-group-ingress \
    --db-security-group-name mydbsecuritygroup \
    --cidrip 192.168.1.1/27
```

For Windows:

```
aws rds revoke-db-security-group-ingress ^
    --db-security-group-name mydbsecuritygroup ^
    --cidrip 192.168.1.1/27
```

The command should produce output similar to the following.

```
SECGROUP  mydbsecuritygroup  My new DBSecurityGroup
  IP-RANGE  192.168.1.1/27  revoking
```

API

To revoke an ingress rule for a CIDR IP range on a DB security group, call the Amazon RDS API operation https://docs.aws.amazon.com/AmazonRDS/latest/APIReference/API_RevokeDBSecurityGroupIngress.html`RevokeDBSecurityGroupIngress` with the following parameters:

- `DBSecurityGroupName` = *`mydbsecuritygroup`*
- `CIDRIP` = *`192.168.1.10/27`*

Example

```
https://rds.amazonaws.com/
    ?Action=RevokeDBSecurityGroupIngress
    &DBSecurityGroupName=mydbsecuritygroup
    &CIDRIP=192.168.1.10%2F27
    &Version=2009-10-16
    &SignatureVersion=2&SignatureMethod=HmacSHA256
    &Timestamp=2009-10-22T22%3A32%3A12.515Z
    &AWSAccessKeyId=<AWS Access Key ID>
    &Signature=<Signature>
```

Master User Account Privileges

When you create a new DB instance, the default master user that you use gets certain privileges for that DB instance. The following table shows the privileges and database roles the master user gets for each of the database engines.

Important
We strongly recommend that you do not use the master user directly in your applications. Instead, adhere to the best practice of using a database user created with the minimal privileges required for your application.

Note
If you accidentally delete the permissions for the master user, you can restore them by modifying the DB instance and setting a new master user password. For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Database Engine	System Privilege	Database Role
MySQL and MariaDB	SELECT, INSERT, UPDATE, DELETE, CREATE, DROP, RELOAD, PROCESS, REFERENCES, INDEX, ALTER, SHOW DATABASES, CREATE TEMPORARY TABLES, LOCK TABLES, EXECUTE, REPLICATION CLIENT, CREATE VIEW, SHOW VIEW, CREATE ROUTINE, ALTER ROUTINE, CREATE USER, EVENT, TRIGGER ON *.* WITH GRANT OPTION, REPLICATION SLAVE (only for Amazon RDS MySQL versions 5.6, 5.7 and 8.0, Amazon RDS MariaDB)	—

Database Engine	System Privilege	Database Role
PostgreSQL	CREATE ROLE, CREATE DB, PASSWORD VALID UNTIL INFINITY, CREATE EXTENSION, ALTER EXTENSION, DROP EXTENSION, CREATE TABLESPACE, ALTER < OBJECT> OWNER, CHECKPOINT, PG_CANCEL_BACKEND(), PG_TERMINATE_BACKEND(), SELECT PG_STAT_REPLICATION, EXECUTE PG_STAT_STATEMENTS_RESET(), OWN POSTGRES_FDW_HANDLER(), OWN POSTGRES_FDW_VALIDATOR(), OWN POSTGRES_FDW, EXECUTE PG_BUFFERCACHE_PAGES(), SELECT PG_BUFFERCACHE	RDS_SUPERUSER
Oracle	ALTER DATABASE LINK, ALTER PUBLIC DATABASE LINK, DROP ANY DIRECTORY, EXEMPT ACCESS POLICY, EXEMPT IDENTITY POLICY, GRANT ANY OBJECT PRIVILEGE, RESTRICTED SESSION, EXEMPT REDACTION POLICY	AQ_ADMINISTRATOR_ROLE, AQ_USER_ROLE, CONNECT, CTXAPP, DBA, EXECUTE_CATALOG_ROLE, RECOVERY_CATALOG_OWNER, RESOURCE, SELECT_CATALOG_ROLE
Microsoft SQL Server	ADMINISTER BULK OPERATIONS, ALTER ANY CONNECTION, ALTER ANY LINKED SERVER, ALTER ANY LOGIN, ALTER SERVER STATE, ALTER TRACE, CONNECT SQL, CREATE ANY DATABASE, VIEW ANY DATABASE, VIEW ANY DEFINITION, VIEW SERVER STATE, ALTER ANY SERVER ROLE, ALTER ANY USER, ALTER ON ROLE SQLAgentOperatorRole	DB_OWNER (Database Level Role) PROCESSADMIN (Server Level Role) SETUPADMIN(Server Level Role) SQLAgentUserRole(Server Level Role)

Using Service-Linked Roles for Amazon RDS

Amazon RDS uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to Amazon RDS. Service-linked roles are predefined by Amazon RDS and include all the permissions that the service requires to call other AWS services on your behalf.

A service-linked role makes using Amazon RDS easier because you don’t have to manually add the necessary permissions. Amazon RDS defines the permissions of its service-linked roles, and unless defined otherwise, only Amazon RDS can assume its roles. The defined permissions include the trust policy and the permissions policy, and that permissions policy cannot be attached to any other IAM entity.

You can delete the roles only after first deleting their related resources. This protects your Amazon RDS resources because you can't inadvertently remove permission to access the resources.

For information about other services that support service-linked roles, see AWS Services That Work with IAM and look for the services that have **Yes** in the **Service-Linked Role** column. Choose a **Yes** with a link to view the service-linked role documentation for that service.

Service-Linked Role Permissions for Amazon RDS

Amazon RDS uses the service-linked role named **AWSServiceRoleForRDS** – to allow Amazon RDS to call AWS services on behalf of your DB instances.

The AWSServiceRoleForRDS service-linked role trusts the following services to assume the role:

- `rds.amazonaws.com`

The role permissions policy allows Amazon RDS to complete the following actions on the specified resources:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ec2:AuthorizeSecurityGroupIngress",
                "ec2:CreateNetworkInterface",
                "ec2:CreateSecurityGroup",
                "ec2:DeleteNetworkInterface",
                "ec2:DeleteSecurityGroup",
                "ec2:DescribeAvailabilityZones",
                "ec2:DescribeInternetGateways",
                "ec2:DescribeSecurityGroups",
                "ec2:DescribeSubnets",
                "ec2:DescribeVpcAttribute",
                "ec2:DescribeVpcs",
                "ec2:ModifyNetworkInterfaceAttribute",
                "ec2:ModifyVpcEndpoint",
                "ec2:RevokeSecurityGroupIngress",
                "ec2:CreateVpcEndpoint",
                "ec2:DescribeVpcEndpoints",
                "ec2:DeleteVpcEndpoints",
                "ec2:AssignPrivateIpAddresses",
                "ec2:UnassignPrivateIpAddresses"
            ],
            "Resource": "*"
```

```
        },
        {
            "Effect": "Allow",
            "Action": [
                "sns:Publish"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "logs:CreateLogGroup"
            ],
            "Resource": [
                "arn:aws:logs:*:*:log-group:/aws/rds/*",
                "arn:aws:logs:*:*:log-group:/aws/docdb/*",
                "arn:aws:logs:*:*:log-group:/aws/neptune/*"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "logs:CreateLogStream",
                "logs:PutLogEvents",
                "logs:DescribeLogStreams"
            ],
            "Resource": [
                "arn:aws:logs:*:*:log-group:/aws/rds/*:log-stream:*",
                "arn:aws:logs:*:*:log-group:/aws/docdb/*:log-stream:*",
                "arn:aws:logs:*:*:log-group:/aws/neptune/*:log-stream:*"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "kinesis:CreateStream",
                "kinesis:PutRecord",
                "kinesis:PutRecords",
                "kinesis:DescribeStream",
                "kinesis:SplitShard",
                "kinesis:MergeShards",
                "kinesis:DeleteStream",
                "kinesis:UpdateShardCount"
            ],
            "Resource": [
                "arn:aws:kinesis:*:*:stream/aws-rds-das-*"
            ]
        }
    ]
}
```

Note

You must configure permissions to allow an IAM entity (such as a user, group, or role) to create, edit, or delete a service-linked role. If you encounter the following error message:

Unable to create the resource. Verify that you have permission to create service linked role. Otherwise wait and try again later.

Make sure you have the following permissions enabled:

```
{
    "Action": "iam:CreateServiceLinkedRole",
    "Effect": "Allow",
    "Resource": "arn:aws:iam::*:role/aws-service-role/rds.amazonaws.com/
AWSServiceRoleForRDS",
```

```
    "Condition": {
        "StringLike": {
            "iam:AWSServiceName":"rds.amazonaws.com"
        }
    }
}
```

For more information, see Service-Linked Role Permissions in the *IAM User Guide*.

Creating a Service-Linked Role for Amazon RDS

You don't need to manually create a service-linked role. When you create a DB instance, Amazon RDS creates the service-linked role for you.

> **Important**
> If you were using the Amazon RDS service before December 1, 2017, when it began supporting service-linked roles, then Amazon RDS created the AWSServiceRoleForRDS role in your account. To learn more, see A New Role Appeared in My AWS Account.

If you delete this service-linked role, and then need to create it again, you can use the same process to recreate the role in your account. When you create a DB instance, Amazon RDS creates the service-linked role for you again.

Editing a Service-Linked Role for Amazon RDS

Amazon RDS does not allow you to edit the AWSServiceRoleForRDS service-linked role. After you create a service-linked role, you cannot change the name of the role because various entities might reference the role. However, you can edit the description of the role using IAM. For more information, see Editing a Service-Linked Role in the *IAM User Guide*.

Deleting a Service-Linked Role for Amazon RDS

If you no longer need to use a feature or service that requires a service-linked role, we recommend that you delete that role. That way you don't have an unused entity that is not actively monitored or maintained. However, you must delete all of your DB instances before you can delete the service-linked role.

Cleaning Up a Service-Linked Role

Before you can use IAM to delete a service-linked role, you must first confirm that the role has no active sessions and remove any resources used by the role.

To check whether the service-linked role has an active session in the IAM console

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane of the IAM console, choose **Roles**. Then choose the name (not the check box) of the AWSServiceRoleForRDS role.
3. On the **Summary** page for the chosen role, choose the **Access Advisor** tab.
4. On the **Access Advisor** tab, review recent activity for the service-linked role.

   > **Note**
   > If you are unsure whether Amazon RDS is using the AWSServiceRoleForRDS role, you can try to delete the role. If the service is using the role, then the deletion fails and you can view the AWS Regions where the role is being used. If the role is being used, then you must wait

for the session to end before you can delete the role. You cannot revoke the session for a service-linked role.

If you want to remove the AWSServiceRoleForRDS role, you must first delete *all* of your DB instances .

Deleting All of Your Instances

Use one of these procedures to delete each of your instances.

To delete an instance (console)

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Databases**.
3. Choose the instance that you want to delete.
4. For **Actions**, choose **Delete**.
5. If you are prompted for **Create final Snapshot?**, choose **Yes** or **No**.
6. If you chose **Yes** in the previous step, for **Final snapshot name** enter the name of your final snapshot.
7. Choose **Delete**.

To delete an instance (CLI)

See `delete-db-instance` in the *AWS CLI Command Reference*.

To delete an instance (API)

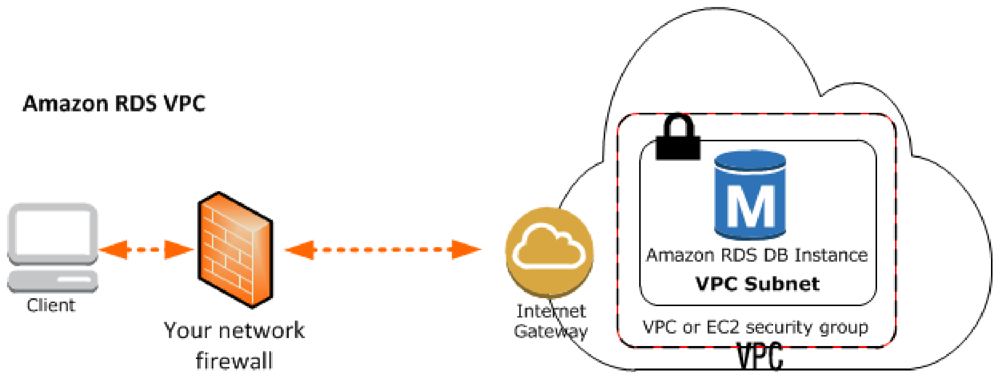
See `DeleteDBInstance` in the *Amazon RDS API Reference*.

You can use the IAM console, the IAM CLI, or the IAM API to delete the AWSServiceRoleForRDS service-linked role. For more information, see Deleting a Service-Linked Role in the *IAM User Guide*.

Amazon Virtual Private Cloud VPCs and Amazon RDS

There are two Amazon Elastic Compute Cloud (EC2) platforms that host Amazon RDS DB instances, *EC2-VPC* and *EC2-Classic*. Amazon Virtual Private Cloud (Amazon VPC) enables you to launch AWS resources, such as Amazon RDS DB instances, into a virtual private cloud (VPC).

When you use an Amazon VPC, you have control over your virtual networking environment: you can choose your own IP address range, create subnets, and configure routing and access control lists. The basic functionality of Amazon RDS is the same whether your DB instance is running in an Amazon VPC or not: Amazon RDS manages backups, software patching, automatic failure detection, and recovery. There is no additional cost to run your DB instance in an Amazon VPC.



Accounts that support only the *EC2-VPC* platform have a default VPC. All new DB instances are created in the default VPC unless you specify otherwise. If you are a new Amazon RDS customer, if you have never created a DB instance before, or if you are creating a DB instance in an AWS Region you have not used before, you are most likely on the *EC2-VPC* platform and have a default VPC.

Some legacy DB instances on the *EC2-Classic* platform are not in a VPC. The legacy *EC2-Classic* platform does not have a default VPC, but as is true for either platform, you can create your own VPC and specify that a DB instance be located in that VPC.

Topics

This documentation only discusses VPC functionality relevant to Amazon RDS DB instances. For more information about Amazon VPC, see Amazon VPC Getting Started Guide and Amazon VPC User Guide. For information about using a network address translation (NAT) gateway, see NAT Gateways in the *Amazon Virtual Private Cloud User Guide*.

Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform

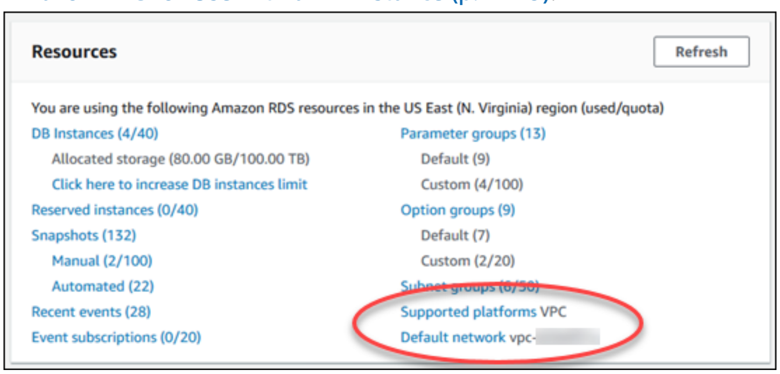
Your AWS account and the AWS Region you choose determines which of the two RDS platforms your DB instance is created on: *EC2-Classic* or *EC2-VPC*. The type of platform determines if you have a default VPC, and which type of security group you use to provide access to your DB instance. The legacy *EC2-Classic* platform is the original platform used by Amazon RDS; if you are on this platform and want to use a VPC, you must create the VPC using the Amazon VPC console or Amazon VPC API. Accounts that only support the *EC2-VPC* platform have a default VPC where all DB instances are created, and you must use either an EC2 or VPC security group to provide access to the DB instance.

Note

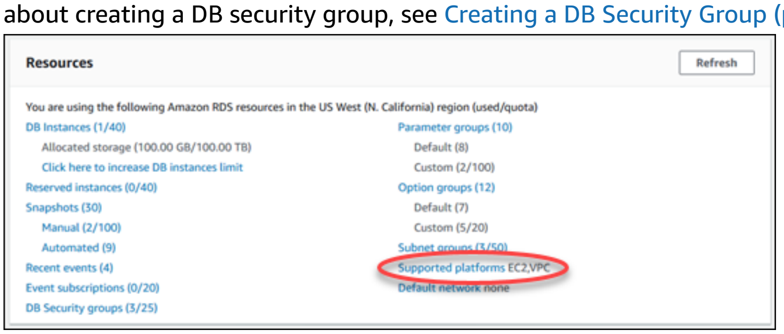
If you are a new Amazon RDS customer, if you have never created a DB instance before, or if you are creating a DB instance in an AWS Region you have not used before, in almost all cases you are on the *EC2-VPC* platform and have a default VPC.

You can tell which platform your AWS account in a given AWS Region is using by looking at the dashboard on the RDS console or EC2 console. If you are a new Amazon RDS customer, if you have never created a DB instance before, or if you are creating a DB instance in an AWS Region you have not used before, you might be redirected to the first-run console page and not see the home page following.

If **Supported Platforms** indicates `VPC`, as shown following, your AWS account in the current AWS Region uses the *EC2-VPC* platform, and uses a default VPC. The name of the default VPC is shown below the supported platform. To provide access to a DB instance created on the *EC2-VPC* platform, you must create a VPC security group. For information about creating a VPC security group, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).



If **Supported Platforms** indicates `EC2,VPC`, as shown following, your AWS account in the current AWS Region uses the *EC2-Classic* platform, and you do not have a default VPC. To provide access to a DB instance created on the *EC2-Classic* platform, you must create a DB security group. For information about creating a DB security group, see Creating a DB Security Group (p. 1419).



Note

- You can create a VPC on the *EC2-Classic* platform, but one is not created for you by default as it is on accounts that support the *EC2-VPC* platform.
- If you are interested in moving an existing DB instance into a VPC, you can use the AWS Management Console to do it easily. For more information. see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

Scenarios for Accessing a DB Instance in a VPC

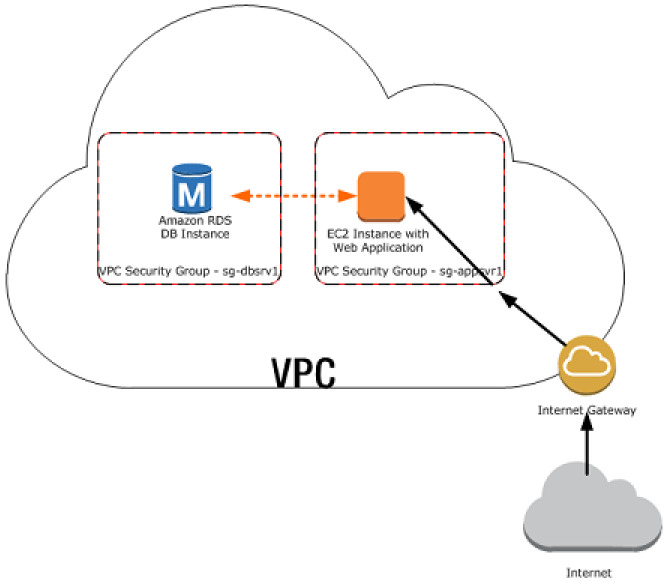
Amazon RDS supports the following scenarios for accessing a DB instance:

DB Instance	Accessed By
In a VPC	An EC2 Instance in the Same VPC (p. 1435)
	An EC2 Instance in a Different VPC (p. 1437)
	An EC2 Instance Not in a VPC (p. 1437)
	A Client Application Through the Internet (p. 1438)
Not in a VPC	An EC2 Instance in a VPC (p. 1439)
	An EC2 Instance Not in a VPC (p. 1440)
	A Client Application Through the Internet (p. 1441)

A DB Instance in a VPC Accessed by an EC2 Instance in the Same VPC

A common use of a DB instance in a VPC is to share data with an application server that is running in an EC2 instance in the same VPC. This is the user scenario created if you use AWS Elastic Beanstalk to create an EC2 instance and a DB instance in the same VPC.

The following diagram shows this scenario.



The simplest way to manage access between EC2 instances and DB instances in the same VPC is to do the following:

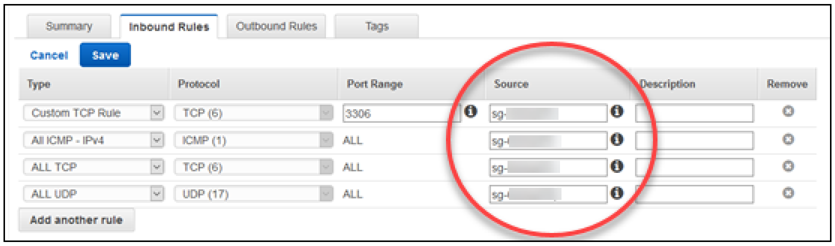
- Create a VPC security group for your DB instances to be in. This security group can be used to restrict access to the DB instances. For example, you can create a custom rule for this security group that allows TCP access using the port you assigned to the DB instance when you created it and an IP address you use to access the DB instance for development or other purposes.
- Create a VPC security group for your EC2 instances (web servers and clients) to be in. This security group can, if needed, allow access to the EC2 instance from the internet by using the VPC's routing table. For example, you can set rules on this security group to allow TCP access to the EC2 instance over port 22.
- Create custom rules in the security group for your DB instances that allow connections from the security group you created for your EC2 instances. This would allow any member of the security group to access the DB instances.

For a tutorial that shows you how to create a VPC with both public and private subnets for this scenario, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).

To create a rule in a VPC security group that allows connections from another security group, do the following:

1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc.
2. In the navigation pane, choose **Security Groups**.
3. Choose or create a security group for which you want to allow access to members of another security group. In the scenario preceding, this is the security group that you use for your DB instances. Choose the **Inbound Rules** tab, and then choose **Edit rule**.
4. On the **Edit inbound rules** page, choose **Add Rule**.
5. From **Type**, choose one of the **All ICMP** options. In the **Source** box, start typing the ID of the security group; this provides you with a list of security groups. Choose the security group with members that you want to have access to the resources protected by this security group. In the scenario preceding, this is the security group that you use for your EC2 instance.

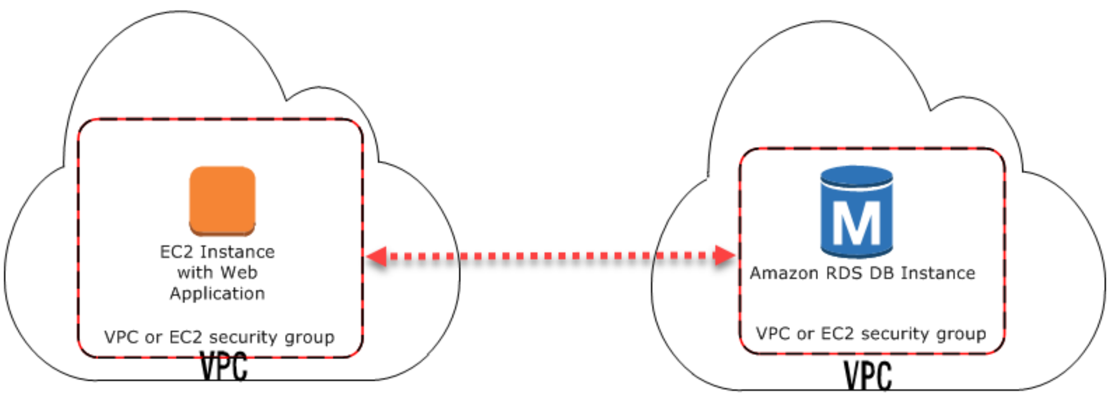
6. Repeat the steps for the TCP protocol by creating a rule with **All TCP** as the **Type** and your security group in the **Source** box. If you intend to use the UDP protocol, create a rule with **All UDP** as the **Type** and your security group in the **Source** box.
7. Create a custom TCP rule that permits access via the port you used when you created your DB instance, such as port 3306 for MySQL. Enter your security group or an IP address to use in the **Source** box.
8. Choose **Save** when you are done.



A DB Instance in a VPC Accessed by an EC2 Instance in a Different VPC

When your DB instance is in a different VPC from the EC2 instance you are using to access it, you can use VPC peering to access the DB instance.

The following diagram shows this scenario.

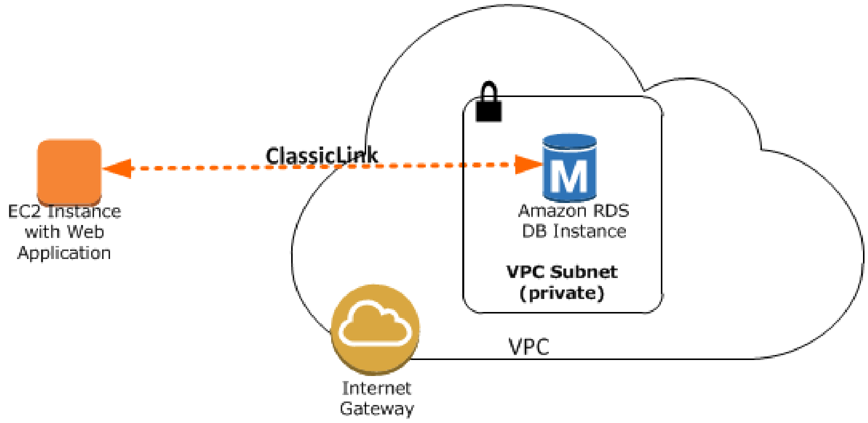


A VPC peering connection is a networking connection between two VPCs that enables you to route traffic between them using private IP addresses. Instances in either VPC can communicate with each other as if they are within the same network. You can create a VPC peering connection between your own VPCs, with a VPC in another AWS account, or with a VPC in a different AWS Region. To learn more about VPC peering, see VPC Peering in the *Amazon Virtual Private Cloud User Guide*.

A DB Instance in a VPC Accessed by an EC2 Instance Not in a VPC

You can communicate between an Amazon RDS DB instance that is in a VPC and an EC2 instance that is not in an Amazon VPC by using *ClassicLink*. When you use Classic Link, an application on the EC2 instance can connect to the DB instance by using the endpoint for the DB instance. ClassicLink is available at no charge.

The following diagram shows this scenario.



Using ClassicLink, you can connect an EC2 instance to a logically isolated database where you define the IP address range and control the access control lists (ACLs) to manage network traffic. You don't have to use public IP addresses or tunneling to communicate with the DB instance in the VPC. This arrangement provides you with higher throughput and lower latency connectivity for inter-instance communications.

To enable ClassicLink between a DB instance in a VPC and an EC2 instance not in a VPC

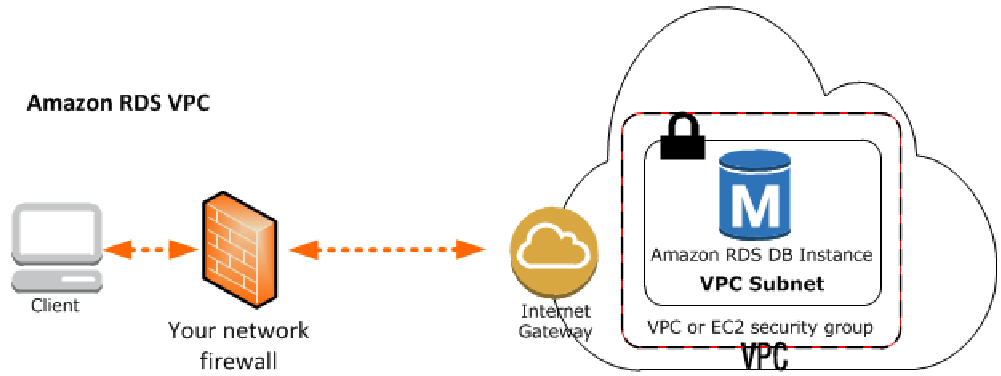
1. Sign in to the AWS Management Console and open the Amazon VPC console at https://console.aws.amazon.com/vpc.
2. In the navigation pane, choose **Your VPCs**.
3. Choose the VPC used by the DB instance.
4. In **Actions**, choose **Enable ClassicLink**. In the confirmation dialog box, choose **Yes, Enable**.
5. On the EC2 console, choose the EC2 instance you want to connect to the DB instance in the VPC.
6. In **Actions**, choose **ClassicLink**, and then choose **Link to VPC**.
7. On the **Link to VPC** page, choose the security group you want to use, and then choose **Link to VPC**.

> **Note**
> The ClassicLink features are only visible in the consoles for accounts and regions that support EC2-Classic. For more information, see ClassicLink in the *Amazon EC2 User Guide for Linux Instances.*

A DB Instance in a VPC Accessed by a Client Application Through the Internet

To access a DB instance in a VPC from a client application through the internet, you configure a VPC with a single public subnet, and an internet gateway to enable communication over the internet.

The following diagram shows this scenario.



We recommend the following configuration:

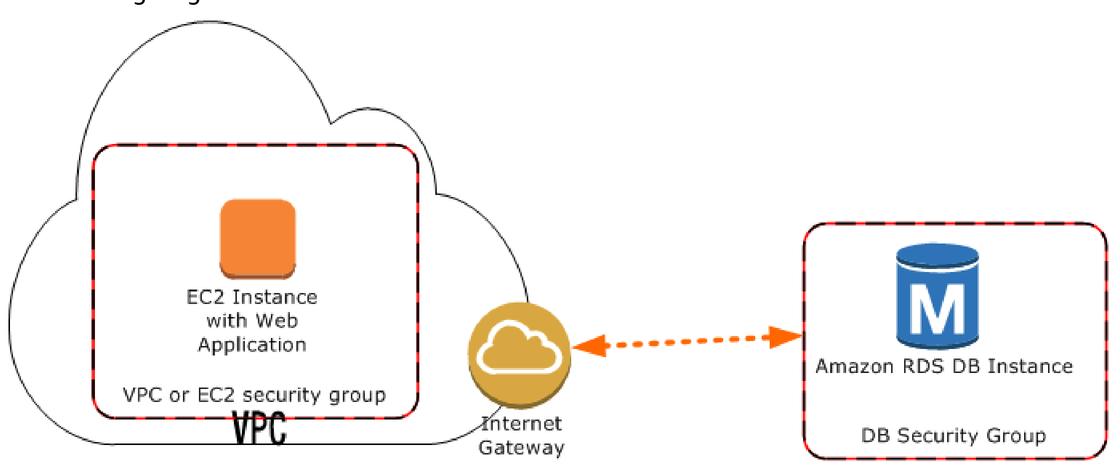
- A VPC of size /16 (for example CIDR: 10.0.0.0/16). This size provides 65,536 private IP addresses.
- A subnet of size /24 (for example CIDR: 10.0.0.0/24). This size provides 256 private IP addresses.
- An Amazon RDS DB instance that is associated with the VPC and the subnet. Amazon RDS assigns an IP address within the subnet to your DB instance.
- An internet gateway which connects the VPC to the internet and to other AWS products.
- A security group associated with the DB instance. The security group's inbound rules allow your client application to access to your DB instance.

For information about creating a DB instance in a VPC, see Creating a DB Instance in a VPC (p. 1444).

A DB Instance Not in a VPC Accessed by an EC2 Instance in a VPC

In the case where you have an EC2 instance in a VPC and an RDS DB instance not in a VPC, you can connect them over the public internet.

The following diagram shows this scenario.



Note
ClassicLink, as described in A DB Instance in a VPC Accessed by an EC2 Instance Not in a VPC (p. 1437), is not available for this scenario.

To connect your DB instance and your EC2 instance over the public internet, do the following:

- Ensure that the EC2 instance is in a public subnet in the VPC.
- Ensure that the RDS DB instance was marked as publicly accessible.
- A note about network ACLs here. A network ACL is like a firewall for your entire subnet. Therefore, all instances in that subnet are subject to network ACL rules. By default, network ACLs allow all traffic and you generally don't need to worry about them, unless you particularly want to add rules as an extra layer of security. A security group, on the other hand, is associated with individual instances, and you do need to worry about security group rules.
- Add the necessary ingress rules to the DB security group for the RDS DB instance.

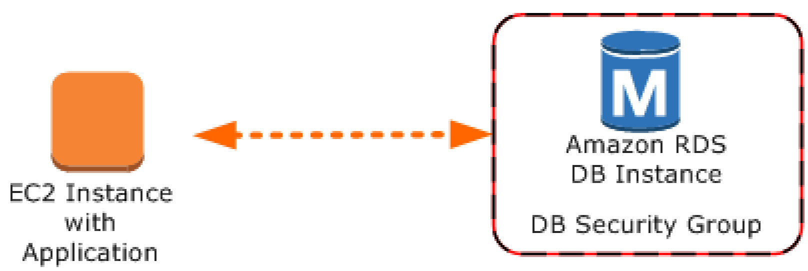
  An ingress rule specifies a network port and a CIDR/IP range. For example, you can add an ingress rule that allows port 3306 to connect to a MySQL RDS DB instance, and a CIDR/IP range of `203.0.113.25/32`. For more information, see Authorizing Network Access to a DB Security Group from an IP Range (p. 1423).

> **Note**
> If you are interested in moving an existing DB instance into a VPC, you can use the AWS Management Console to do it easily. For more information. see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

A DB Instance Not in a VPC Accessed by an EC2 Instance Not in a VPC

When neither your DB instance nor an application on an EC2 instance are in a VPC, you can access the DB instance by using its endpoint and port.

The following diagram shows this scenario.



You must create a security group for the DB instance that permits access from the port you specified when creating the DB instance. For example, you could use a connection string similar to this connection string used with *sqlplus* to access an Oracle DB instance:

```
PROMPT>sqlplus 'mydbusr@(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=<endpoint>)
    (PORT=<port number>))(CONNECT_DATA=(SID=<database name>)))'
```

For more information, see the following documentation.

Database Engine	Relevant Documentation
MariaDB	Connecting to a DB Instance Running the MariaDB Database Engine (p. 509)
Microsoft SQL Server	Connecting to a DB Instance Running the Microsoft SQL Server Database Engine (p. 560)
MySQL	Connecting to a DB Instance Running the MySQL Database Engine (p. 722)
Oracle	Connecting to a DB Instance Running the Oracle Database Engine (p. 874)
PostgreSQL	Connecting to a DB Instance Running the PostgreSQL Database Engine (p. 1226)

Note
If you are interested in moving an existing DB instance into a VPC, you can use the AWS Management Console to do it easily. For more information. see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

A DB Instance Not in a VPC Accessed by a Client Application Through the Internet

New Amazon RDS customers can only create a DB instance in a VPC. However, you might need to connect to an existing Amazon RDS DB instance that is not in a VPC from a client application through the internet.

The following diagram shows this scenario.

In this scenario, you must ensure that the DB security group for the RDS DB instance includes the necessary ingress rules for your client application to connect. An ingress rule specifies a network port and a CIDR/IP range. For example, you can add an ingress rule that allows port 3306 to connect to a MySQL RDS DB instance, and a CIDR/IP range of `203.0.113.25/32`. For more information, see Authorizing Network Access to a DB Security Group from an IP Range (p. 1423).

Warning
If you intend to access a DB instance behind a firewall, talk with your network administrator to determine the IP addresses you should use.

Note
If you are interested in moving an existing DB instance into a VPC, you can use the AWS Management Console to do it easily. For more information. see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

Working with a DB Instance in a VPC

Unless you are working with a legacy DB instance, your DB instance is in a virtual private cloud (VPC). A VPC is a virtual network that is logically isolated from other virtual networks in the AWS Cloud. Amazon VPC lets you launch AWS resources, such as an Amazon RDS DB instance or Amazon EC2 instance, into a VPC. The VPC can either be a default VPC that comes with your account or one that you create. All VPCs are associated with your AWS account.

Your default VPC has three subnets you can use to isolate resources inside the VPC. The default VPC also has an internet gateway that can be used to provide access to resources inside the VPC from outside the VPC.

For a list of scenarios involving Amazon RDS DB instances in a VPC and outside of a VPC, see Scenarios for Accessing a DB Instance in a VPC (p. 1435).

For a tutorial that shows you how to create a VPC that you can use with a common Amazon RDS scenario, see Tutorial: Create an Amazon VPC for Use with a DB Instance (p. 1449).

To learn how to work with DB instances inside a VPC, see the following:

Topics

Working with a DB Instance in a VPC

Here are some tips on working with a DB instance in a VPC:

- Your VPC must have at least two subnets. These subnets must be in two different Availability Zones in the AWS Region where you want to deploy your DB instance. A subnet is a segment of a VPC's IP address range that you can specify and that lets you group instances based on your security and operational needs.

  Note
  The DB subnet group for a Local Zone can have only one subnet.
- If you want your DB instance in the VPC to be publicly accessible, you must enable the VPC attributes *DNS hostnames* and *DNS resolution*.
- Your VPC must have a DB subnet group that you create (for more information, see the next section). You create a DB subnet group by specifying the subnets you created. Amazon RDS uses that DB subnet group and your preferred Availability Zone to choose a subnet and an IP address within that subnet to assign to your DB instance.
- Your VPC must have a VPC security group that allows access to the DB instance.
- The CIDR blocks in each of your subnets must be large enough to accommodate spare IP addresses for Amazon RDS to use during maintenance activities, including failover and compute scaling.
- A VPC can have an *instance tenancy* attribute of either *default* or *dedicated*. All default VPCs have the instance tenancy attribute set to default, and a default VPC can support any DB instance class.

  If you choose to have your DB instance in a dedicated VPC where the instance tenancy attribute is set to dedicated, the DB instance class of your DB instance must be one of the approved Amazon EC2 dedicated instance types. For example, the m3.medium EC2 dedicated instance corresponds to the db.m3.medium DB instance class. For information about instance tenancy in a VPC, go to Using EC2 Dedicated Instances in the *Amazon Virtual Private Cloud User Guide*.

For more information about the instance types that can be in a dedicated instance, see Amazon EC2 Dedicated Instances on the EC2 pricing page.

- When an option group is assigned to a DB instance, it is linked to the supported platform the DB instance is on, either VPC or EC2-Classic (non-VPC). Furthermore, if a DB instance is in a VPC, the option group associated with the DB instance is linked to that VPC. This linkage means that you cannot use the option group assigned to a DB instance if you attempt to restore the DB instance into a different VPC or onto a different platform.
- If you restore a DB instance into a different VPC or onto a different platform, you must either assign the default option group to the DB instance, assign an option group that is linked to that VPC or platform, or create a new option group and assign it to the DB instance. With persistent or permanent options, such as Oracle TDE, you must create a new option group that includes the persistent or permanent option when restoring a DB instance into a different VPC.

Working with DB Subnet Groups

Subnets are segments of a VPC's IP address range that you designate to group your resources based on security and operational needs. A DB subnet group is a collection of subnets (typically private) that you create in a VPC and that you then designate for your DB instances. A DB subnet group allows you to specify a particular VPC when creating DB instances using the CLI or API; if you use the console, you can just choose the VPC and subnets you want to use.

Each DB subnet group should have subnets in at least two Availability Zones in a given AWS Region. When creating a DB instance in a VPC, you must choose a DB subnet group. Amazon RDS uses that DB subnet group and your preferred Availability Zone to choose a subnet and an IP address within that subnet to associate with your DB instance. If the primary DB instance of a Multi-AZ deployment fails, Amazon RDS can promote the corresponding standby and subsequently create a new standby using an IP address of the subnet in one of the other Availability Zones.

> **Note**
> The DB subnet group for a Local Zone can have only one subnet.

When Amazon RDS creates a DB instance in a VPC, it assigns a network interface to your DB instance by using an IP address from your DB subnet group. However, we strongly recommend that you use the DNS name to connect to your DB instance because the underlying IP address changes during failover.

> **Note**
> For each DB instance that you run in a VPC, make sure to reserve at least one address in each subnet in the DB subnet group for use by Amazon RDS for recovery actions.

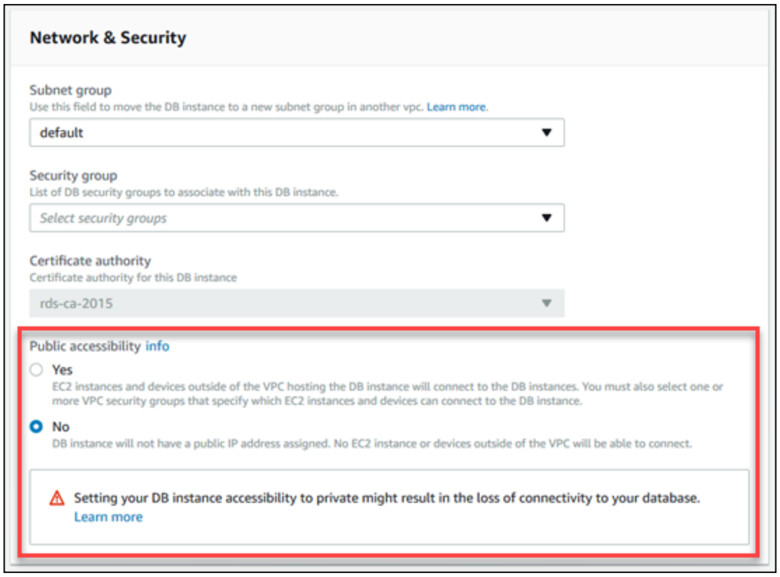
Hiding a DB Instance in a VPC from the Internet

One common Amazon RDS scenario is to have a VPC in which you have an EC2 instance with a public-facing web application and a DB instance with a database that is not publicly accessible. For example, you can create a VPC that has a public subnet and a private subnet. Amazon EC2 instances that function as web servers can be deployed in the public subnet, and the DB instances are deployed in the private subnet. In such a deployment, only the web servers have access to the DB instances. For an illustration of this scenario, see A DB Instance in a VPC Accessed by an EC2 Instance in the Same VPC (p. 1435).

When you launch a DB instance inside a VPC, the DB instance has a private IP address for traffic inside the VPC. This private IP address isn't publicly accessible. You can use the *Public accessibility* option to designate whether the DB instance also has a public IP address in addition to the private IP address. If the DB instance is designated as publicly accessible, its DNS endpoint resolves to the private IP address from within the DB instance's VPC, and to the public IP address from outside of the DB instance's VPC. Access to the DB instance is ultimately controlled by the security group it uses, and that public access is not permitted if the security group assigned to the DB instance doesn't permit it.

You can modify a DB instance to turn on or off public accessibility by modifying the *Public accessibility* option. This parameter is modified just like any other DB instance parameter. For more information, see the modifying section for your DB engine.

The following illustration shows the **Public accessibility** option in the **Network & Security** section.



For information about modifying a DB instance to set the **Public accessibility** option, see Modifying an Amazon RDS DB Instance (p. 220).

Creating a DB Instance in a VPC

The following procedures help you create a DB instance in a VPC. If your account has a default VPC, you can begin with step 3 because the VPC and DB subnet group have already been created for you. If your AWS account doesn't have a default VPC, or if you want to create an additional VPC, you can create a new VPC.

If you don't know if you have a default VPC, see Determining Whether You Are Using the EC2-VPC or EC2-Classic Platform (p. 1434).

> **Note**
> If you want your DB instance in the VPC to be publicly accessible, you must update the DNS information for the VPC by enabling the VPC attributes *DNS hostnames* and *DNS resolution*. For information about updating the DNS information for a VPC instance, see Updating DNS Support for Your VPC.

Follow these steps to create a DB instance in a VPC:

Step 1: Create a VPC

If your AWS account does not have a default VPC or if you want to create an additional VPC, follow the instructions for creating a new VPC. See Create a VPC with Private and Public Subnets (p. 1449), or see Step 1: Create a VPC in the Amazon VPC documentation.

Step 2: Add Subnets to the VPC

Once you have created a VPC, you need to create subnets in at least two Availability Zones. You use these subnets when you create a DB subnet group. If you have a default VPC, a subnet is automatically created for you in each Availability Zone in the AWS Region.

For instructions on how to create subnets in a VPC, see Create a VPC with Private and Public Subnets (p. 1449).

Step 3: Create a DB Subnet Group

A DB subnet group is a collection of subnets (typically private) that you create for a VPC and that you then designate for your DB instances. A DB subnet group allows you to specify a particular VPC when you create DB instances using the CLI or API. If you use the console, you can just choose the VPC and subnets you want to use. Each DB subnet group must have at least one subnet in at least two Availability Zones in the AWS Region.

For a DB instance to be publicly accessible, the subnets in the DB subnet group must have an internet gateway. For more information about internet gateways for subnets, see Internet Gateways in the Amazon VPC documentation.

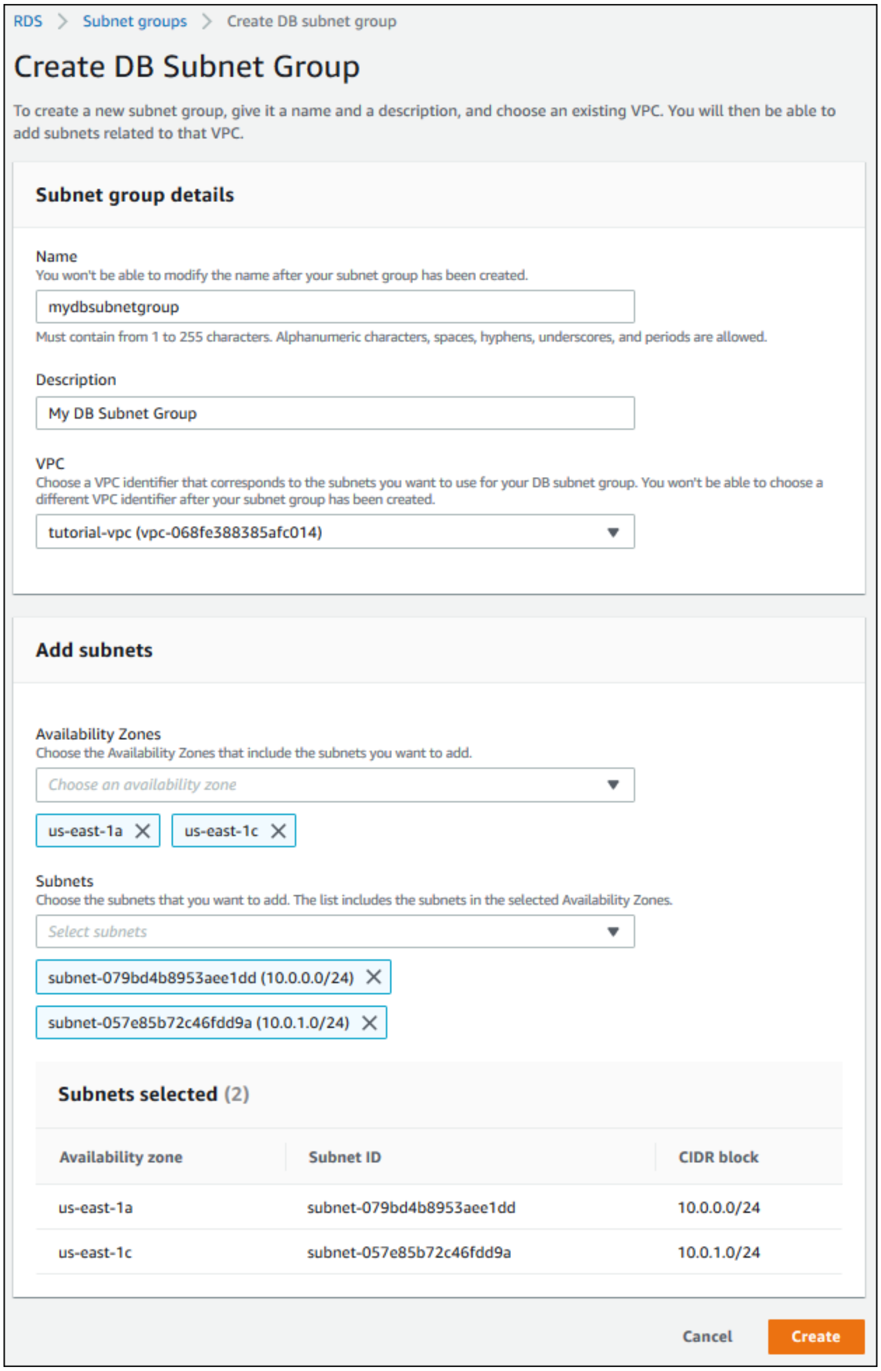
> **Note**
> The DB subnet group for a Local Zone can have only one subnet.

When you create a DB instance in a VPC, make sure to choose a DB subnet group. Amazon RDS then uses that DB subnet group and your preferred Availability Zone to choose a subnet and an IP address within that subnet. Amazon RDS creates and associates an Elastic Network Interface to your DB instance with that IP address. For Multi-AZ deployments, defining a subnet for two or more Availability Zones in an AWS Region allows Amazon RDS to create a new standby in another Availability Zone should the need arise. You need to do this even for Single-AZ deployments, just in case you want to convert them to Multi-AZ deployments at some point.

In this step, you create a DB subnet group and add the subnets that you created for your VPC.

To create a DB subnet group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the navigation pane, choose **Subnet groups**.
3. Choose **Create DB Subnet Group**.
4. For **Name**, type the name of your DB subnet group.
5. For **Description**, type a description for your DB subnet group.
6. For **VPC**, choose the VPC that you created.
7. In the **Add subnets** section, choose the Availability Zones that include the subnets from **Availability Zones**, and then choose the subnets from **Subnets**.



> **Note**
> If you have enabled a Local Zone, you can choose an Availability Zone group on the **Create DB subnet group** page. In this case, choose the **Availability Zone group**, **Availability Zones**, and **Subnets**.

8. Choose **Create**.

   Your new DB subnet group appears in the DB subnet groups list on the RDS console. You can choose the DB subnet group to see details, including all of the subnets associated with the group, in the details pane at the bottom of the window.

Step 4: Create a VPC Security Group

Before you create your DB instance, you must create a VPC security group to associate with your DB instance. For instructions on how to create a security group for your DB instance, see Create a VPC Security Group for a Private DB Instance (p. 1452), or see Security Groups for Your VPC in the Amazon VPC documentation.

Step 5: Create a DB Instance in the VPC

In this step, you create a DB instance and use the VPC name, the DB subnet group, and the VPC security group you created in the previous steps.

> **Note**
> If you want your DB instance in the VPC to be publicly accessible, you must enable the VPC attributes *DNS hostnames* and *DNS resolution*. For information on updating the DNS information for a VPC instance, see Updating DNS Support for Your VPC.

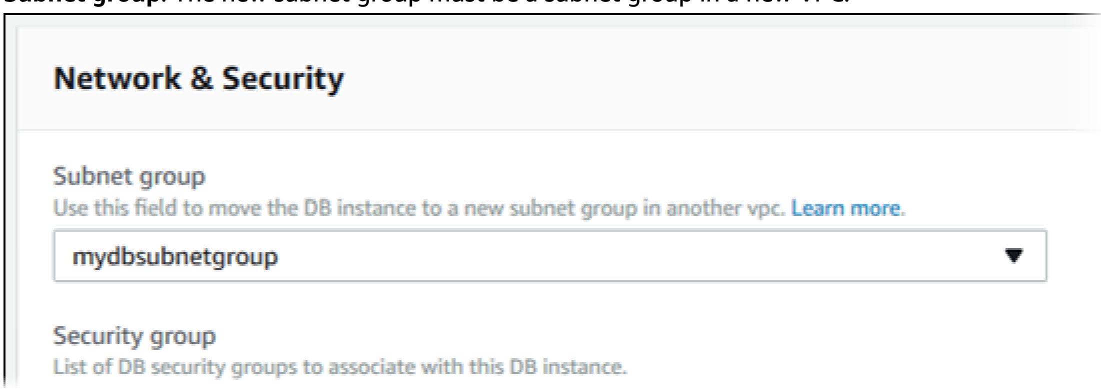
For details on how to create a DB instance, see Creating an Amazon RDS DB Instance (p. 136).

When prompted in the **Network & Security** section, enter the VPC name, the DB subnet group, and the VPC security group you created in the previous steps.

Updating the VPC for a DB Instance

You can use the AWS Management Console to move your DB instance to a different VPC.

For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220). In the **Network & Security** section of the modify page, shown following, enter the new subnet group for **Subnet group**. The new subnet group must be a subnet group in a new VPC.



Moving a DB Instance Not in a VPC into a VPC

Some legacy DB instances on the EC2-Classic platform are not in a VPC. If your DB instance is not in a VPC, you can use the AWS Management Console to easily move your DB instance into a VPC. Before you can move a DB instance not in a VPC, into a VPC, you must create the VPC.

Follow these steps to create a VPC for your DB instance.

- Step 1: Create a VPC (p. 1444)
- Step 2: Add Subnets to the VPC (p. 1445)
- Step 3: Create a DB Subnet Group (p. 1445)
- Step 4: Create a VPC Security Group (p. 1447)

After you create the VPC, follow these steps to move your DB instance into the VPC.

- Updating the VPC for a DB Instance (p. 1447)

The following are some limitations to moving your DB instance into the VPC.

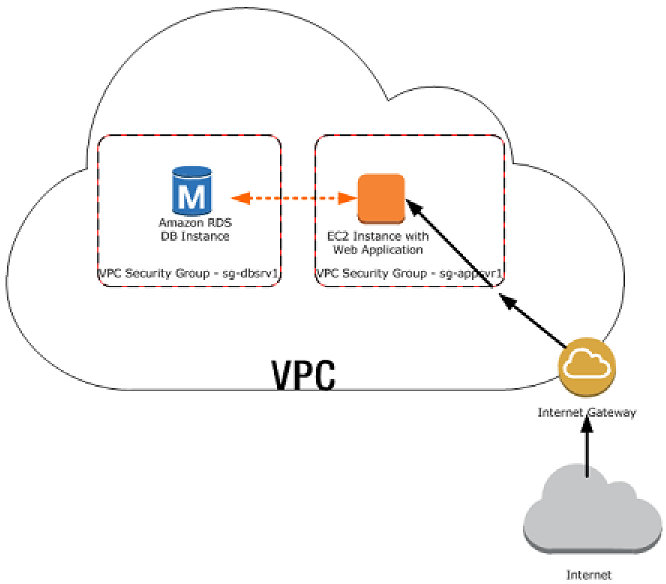
- Moving a Multi-AZ DB instance not in a VPC into a VPC is not currently supported.
- Moving a DB instance with read replicas not in a VPC into a VPC is not currently supported.

If you move your DB instance into a VPC, and you are using a custom option group with your DB instance, then you need to change the option group that is associated with your DB instance. Option groups are platform-specific, and moving to a VPC is a change in platform. To use a custom option group in this case, assign the default VPC option group to the DB instance, assign an option group that is used by other DB instances in the VPC you are moving to, or create a new option group and assign it to the DB instance. For more information, see Working with Option Groups (p. 186).

Tutorial: Create an Amazon VPC for Use with a DB Instance

A common scenario includes a DB instance in an Amazon VPC, that shares data with a web server that is running in the same VPC. In this tutorial you create the VPC for this scenario.

The following diagram shows this scenario. For information about other scenarios, see Scenarios for Accessing a DB Instance in a VPC (p. 1435).



Because your DB instance only needs to be available to your web server, and not to the public Internet, you create a VPC with both public and private subnets. The web server is hosted in the public subnet, so that it can reach the public Internet. The DB instance is hosted in a private subnet. The web server is able to connect to the DB instance because it is hosted within the same VPC, but the DB instance is not available to the public Internet, providing greater security.

> **Note**
> For a tutorial that shows you how to create a web server for this VPC scenario, see Tutorial: Create a Web Server and an Amazon RDS Database (p. 100).

Create a VPC with Private and Public Subnets

Use the following procedure to create a VPC with both public and private subnets.

To create a VPC and subnets

1. Open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. In the top-right corner of the AWS Management Console, choose the region to create your VPC in. This example uses the US West (Oregon) region.
3. In the upper-left corner, choose **VPC Dashboard**. To begin creating a VPC, choose **Launch VPC Wizard**.
4. On the **Step 1: Select a VPC Configuration** page, choose **VPC with Public and Private Subnets**, and then choose **Select**.
5. On the **Step 2: VPC with Public and Private Subnets** page, set these values:

   - **IPv4 CIDR block:** `10.0.0.0/16`

- **IPv6 CIDR block:** No IPv6 CIDR Block
- **VPC name:** `tutorial-vpc`
- **Public subnet's IPv4 CIDR:** `10.0.0.0/24`
- **Availability Zone:** `us-west-2a`
- **Public subnet name:** `Tutorial public`
- **Private subnet's IPv4 CIDR:** `10.0.1.0/24`
- **Availability Zone:** `us-west-2a`
- **Private subnet name:** `Tutorial Private 1`
- **Instance type:** `t2.small`

  Important
  If you don't see the **Instance type** box in the console, choose **Use a NAT instance instead**. This link is on the right.

  Note
  If the t2.small instance type is not listed, you can choose a different instance type.
- **Key pair name:** `No key pair`
- **Service endpoints:** Skip this field.
- **Enable DNS hostnames:** `Yes`
- **Hardware tenancy:** `Default`

6. When you're finished, choose **Create VPC**.

Create Additional Subnets

You must have either two private subnets or two public subnets available to create a DB subnet group for a DB instance to use in a VPC. Because the DB instance for this tutorial is private, add a second private subnet to the VPC.

To create an additional subnet

1. Open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. To add the second private subnet to your VPC, choose **VPC Dashboard**, choose **Subnets**, and then choose **Create subnet**.
3. On the **Create subnet** page, set these values:
   - **Name tag:** `Tutorial private 2`
   - **VPC:** Choose the VPC that you created in the previous step, for example: `vpc-`*`identifier`* `(10.0.0.0/16) | tutorial-vpc`
   - **Availability Zone:** `us-west-2b`

     Note
     Choose an Availability Zone that is different from the one that you chose for the first private subnet.
   - **IPv4 CIDR block:** `10.0.2.0/24`
4. When you're finished, choose **Create**. Next, choose **Close** on the confirmation page.
5. To ensure that the second private subnet that you created uses the same route table as the first private subnet, choose **VPC Dashboard**, choose **Subnets**, and then choose the first private subnet that you created for the VPC, `Tutorial private 1`.
6. Below the list of subnets, choose the **Route Table** tab, and note the value for **Route Table**—for example: `rtb-98b613fd`.
7. In the list of subnets, deselect the first private subnet.

8. In the list of subnets, choose the second private subnet `Tutorial private 2`, and choose the **Route Table** tab.
9. If the current route table is not the same as the route table for the first private subnet, choose **Edit route table association**. For **Route Table ID**, choose the route table that you noted earlier—for example: `rtb-98b613fd`. Next, to save your selection, choose **Save**.

Create a VPC Security Group for a Public Web Server

Next you create a security group for public access. To connect to public instances in your VPC, you add inbound rules to your VPC security group that allow traffic to connect from the internet.

To create a VPC security group

1. Open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. Choose **VPC Dashboard**, choose **Security Groups**, and then choose **Create security group**.
3. On the **Create security group** page, set these values:
   - **Security group name:** `tutorial-securitygroup`
   - **Description:** `Tutorial Security Group`
   - **VPC:** Choose the VPC that you created earlier, for example: `vpc-identifier (tutorial-vpc)`
4. Add inbound rules to the security group.
   a. Determine the IP address to use to connect to instances in your VPC. To determine your public IP address, in a different browser window or tab, you can use the service at https://checkip.amazonaws.com. An example of an IP address is `203.0.113.25/32`.

      If you are connecting through an Internet service provider (ISP) or from behind your firewall without a static IP address, you need to find out the range of IP addresses used by client computers.

      Warning
      If you use `0.0.0.0/0`, you enable all IP addresses to access your public instances. This approach is acceptable for a short time in a test environment, but it's unsafe for production environments. In production, you'll authorize only a specific IP address or range of addresses to access your instances.
   b. In the **Inbound rules** section, choose **Add rule**.
   c. Set the following values for your new inbound rule to allow Secure Shell (SSH) access to your EC2 instance. If you do this, you can connect to your EC2 instance to install the web server and other utilities, and to upload content for your web server.
      - **Type:** `SSH`
      - **Source:** The IP address or range from Step a, for example: `203.0.113.25/32`.
   d. Choose **Add rule**.
   e. Set the following values for your new inbound rule to allow HTTP access to your web server.
      - **Type:** `HTTP`
      - **Source:** `0.0.0.0/0`.
5. To create the security group, choose **Create security group**. Next, choose **Close** on the confirmation page.

   Note the security group ID because you need it later in this tutorial.

Create a VPC Security Group for a Private DB Instance

To keep your DB instance private, create a second security group for private access. To connect to private instances in your VPC, you add inbound rules to your VPC security group that allow traffic from your web server only.

To create a VPC security group

1. Open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
2. Choose **VPC Dashboard**, choose **Security Groups**, and then choose **Create security group**.
3. On the **Create security group** page, set these values:
   - **Security group name:** `tutorial-db-securitygroup`
   - **Description:** `Tutorial DB Instance Security Group`
   - **VPC:** Choose the VPC that you created earlier, for example: `vpc-`*`identifier`* `(tutorial-vpc)`
4. Add inbound rules to the security group.
   a. In the **Inbound rules** section, choose **Add rule**.
   b. Set the following values for your new inbound rule to allow MySQL traffic on port 3306 from your EC2 instance. If you do this, you can connect from your web server to your DB instance to store and retrieve data from your web application to your database.
      - **Type:** `MySQL/Aurora`
      - **Source:** The identifier of the `tutorial-securitygroup` security group that you created previously in this tutorial, for example: `sg-9edd5cfb`.
5. To create the security group, choose **Create security group**. Next, choose **Close** on the confirmation page.

Create a DB Subnet Group

A DB subnet group is a collection of subnets that you create in a VPC and that you then designate for your DB instances. A DB subnet group allows you to specify a particular VPC when creating DB instances.

To create a DB subnet group

1. Open the Amazon RDS console at https://console.aws.amazon.com/rds/.

   Note
   Make sure you connect to the Amazon RDS console, not to the Amazon VPC console.
2. In the navigation pane, choose **Subnet groups**.
3. Choose **Create DB Subnet Group**.
4. On the **Create DB subnet group** page, set these values in **Subnet group details**:
   - **Name:** `tutorial-db-subnet-group`
   - **Description:** `Tutorial DB Subnet Group`
   - **VPC:** `tutorial-vpc (vpc-`*`identifier`*`)`
5. In the **Add subnets** section, choose the **Availability Zones** and **Subnets**.

   For this tutorial, choose `us-west-2a` and `us-west-2b` for the **Availability Zones**. Next, choose all of the subnets for **Subnets**.

   Note
   If you have enabled a Local Zone, you can choose an Availability Zone group on the **Create DB subnet group** page. In this case, choose the **Availability Zone group**, **Availability Zones**, and **Subnets**.

6. Choose **Create**.

   Your new DB subnet group appears in the DB subnet groups list on the RDS console. You can click the DB subnet group to see details, including all of the subnets associated with the group, in the details pane at the bottom of the window.

Quotas and Constraints for Amazon RDS

Following, you can find a description of the resource quotas and naming constraints for Amazon RDS.

Topics

Quotas in Amazon RDS

Each AWS account has quotas, for each AWS Region, on the number of Amazon RDS resources that can be created. After a quota for a resource has been reached, additional calls to create that resource fail with an exception.

The following table lists the resources and their quotas per AWS Region.

Resource	Default Quota
Authorizations per DB security group	20
Burst balance (for instances <1 TiB)	3000 IOPS
Cross-region snapshots copy requests	5
DB instances	40
DB security groups	25
DB subnet groups	50
Event subscriptions	20
IAM roles per DB instance	5
Manual snapshots	100
Option groups	20
Parameter groups	50
Read replicas per master	5
Reserved DB instances	40
Rules per security group	20
Rules per virtual private cloud (VPC) security group	50 inbound, 50 outbound

Resource	Default Quota
Subnets per subnet group	20
Tags per resource	50
Total storage for all DB instances	100 TB
VPC security groups	5

Note
By default, you can have up to a total of 40 DB instances. RDS DB instances, Aurora DB instances, Amazon Neptune instances, and Amazon DocumentDB instances apply to this quota. The following limitations apply to the Amazon RDS DB instances:

- 10 for each SQL Server edition (Enterprise, Standard, Web, and Express) under the "license-included" model
- 10 for Oracle under the "license-included" model
- 40 for MySQL, MariaDB, or PostgreSQL
- 40 for Oracle under the "bring-your-own-license" (BYOL) licensing model

If your application requires more DB instances, you can request additional DB instances by opening the Service Quotas console. In the navigation pane, choose **AWS services**. Choose **Amazon Relational Database Service (Amazon RDS)**, choose a quota, and follow the directions to request a quota increase. For more information, see Requesting a Quota Increase in the *Service Quotas User Guide*.
Backups managed by AWS Backup are considered manual snapshots for the manual snapshot quota. For information about AWS Backup, see the *AWS Backup Developer Guide*.

Naming Constraints in Amazon RDS

The following table describes naming constraints in Amazon RDS.

Resource or Item	Constraints
DB instance identifier	Identifiers have these naming constraints: • Must contain 1–63 alphanumeric characters or hyphens. • First character must be a letter. • Can't end with a hyphen or contain two consecutive hyphens. • Must be unique for all DB instances per AWS account, per AWS Region.
Database name	Database name constraints differ for each database engine . For more information, see the available settings when creating each DB instance. **Note** This approach doesn't apply to SQL Server. For SQL Server, you create your databases after you create your DB instance.

Resource or Item	Constraints
Master user name	Master user name constraints differ for each database engine. For more information, see the available settings when creating each DB instance.
Master password	The password for the master database user can include any printable ASCII character except `/`, `"`, `@`, or a space. Master password length constraints differ for each database engine. For more information, see the available settings when creating each DB instance.
DB parameter group name	These names have these constraints: • Must contain 1–255 alphanumeric characters. • First character must be a letter. • Hyphens are allowed, but the name cannot end with a hyphen or contain two consecutive hyphens.
DB subnet group name	These names have these constraints: • Must contain 1–255 characters. • Alphanumeric characters, spaces, hyphens, underscores, and periods are allowed.

Maximum Number of Database Connections

The maximum number of simultaneous database connections varies by the DB engine type and the memory allocation for the DB instance class. The maximum number of connections is set in the parameter group associated with the DB instance, except for Microsoft SQL Server, where it is set in the server properties for the DB instance in SQL Server Managment Studio (SSMS).

> **Note**
> For Oracle, you set the maximum number of user processes and user and system sessions.

Maximum Database Connections

DB Engine	Parameter	Allowed Values	Default Value	Description
MariaDB and MySQL	`max_connections`	1–100000	{DBInstanceClassMemory/12582880}	Number of simultaneous client connections allowed
Oracle	`processes`	80–20000	LEAST({DBInstanceClassMemory/9868951}, 20000)	User processes
	`sessions`	100–65535	–	User and system sessions
PostgreSQL	`max_connections`	6–8388607	LEAST({DBInstanceClassMemory/9531392}, 5000)	Maximum number of concurrent connections
SQL Server	Maximum number of concurrent connections	0–32767	0 (unlimited)	Maximum number of concurrent connections

File Size Limits in Amazon RDS

File size limits apply to certain Amazon RDS DB instances. For more information, see the following engine-specific limits:

- MariaDB File Size Limits in Amazon RDS (p. 502)
- MySQL File Size Limits in Amazon RDS (p. 818)

Troubleshooting for Amazon RDS

Use the following sections to help troubleshoot problems you have with DB instances in Amazon RDS and Aurora.

Topics

For information about debugging problems using the Amazon RDS API, see Troubleshooting Applications on Amazon RDS (p. 1471).

Can't Connect to Amazon RDS DB Instance

When you can't connect to a DB instance, the following are common causes:

- **Inbound rules** – The access rules enforced by your local firewall and the IP addresses authorized to access your DB instance might not match. The problem is most likely the inbound rules in your security group.

  By default, DB instances don't allow access. Access is granted through a security group associated with the VPC that allows traffic into and out of the DB instance. If necessary, add inbound and outbound rules for your particular situation to the security group. You can specify an IP address, a range of IP addresses, or another VPC security group.

  > **Note**
  > When adding a new inbound rule, you can choose **My IP** for **Source** to allow access to the DB instance from the IP address detected in your browser.

  For more information about setting up security groups, see Provide Access to Your DB Instance in Your VPC by Creating a Security Group (p. 61).

  > **Note**
  > Client connections from IP addresses within the range 169.254.0.0/16 aren't permitted. This is the Automatic Private IP Addressing Range (APIPA), which is used for local-link addressing.
- **Public accessibility** – To connect to your DB instance from outside of the VPC, such as by using a client application, the instance must have a public IP address assigned to it.

  To make the instance publicly accessible, modify it and choose **Yes** under **Public accessibility**. For more information, see Hiding a DB Instance in a VPC from the Internet (p. 1443).
- **Port** – The port that you specified when you created the DB instance can't be used to send or receive communications due to your local firewall restrictions. To determine if your network allows the specified port to be used for inbound and outbound communication, check with your network administrator.

- **Availability** – For a newly created DB instance, the DB instance has a status of `creating` until the DB instance is ready to use. When the state changes to `available`, you can connect to the DB instance. Depending on the size of your DB instance, it can take up to 20 minutes before an instance is available.
- **Internet gateway** – For a DB instance to be publicly accessible, the subnets in its DB subnet group must have an internet gateway.

  To configure an internet gateway for a subnet

  1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
  2. In the navigation pane, choose **Databases**, and then choose the name of the DB instance.
  3. In the **Connectivity & security** tab, write down the values of the VPC ID under **VPC** and the subnet ID under **Subnets**.
  4. Open the Amazon VPC console at https://console.aws.amazon.com/vpc/.
  5. In the navigation pane, choose **Internet Gateways**. Verify that there is an internet gateway attached to your VPC. Otherwise, choose **Create Internet Gateway** to create an internet gateway. Select the internet gateway, and then choose **Attach to VPC** and follow the directions to attach it to your VPC.
  6. In the navigation pane, choose **Subnets**, and then select your subnet.
  7. On the **Route Table** tab, verify that there is a route with `0.0.0.0/0` as the destination and the internet gateway for your VPC as the target. If you're connecting to your instance using its IPv6 address, verify that there is a route for all IPv6 traffic (`::/0`) that points to the internet gateway. Otherwise, do the following:

     a. Choose the ID of the route table (rtb-*xxxxxxxx*) to navigate to the route table.
     b. On the **Routes** tab, choose **Edit routes**. Choose **Add route**, use `0.0.0.0/0` as the destination and the internet gateway as the target. For IPv6, choose **Add route**, use `::/0` as the destination and the internet gateway as the target.
     c. Choose **Save routes**.

  For more information, see Working with a DB Instance in a VPC (p. 1442).

For engine-specific connection issues, see the following topics:

- Troubleshooting Connections to Your SQL Server DB Instance (p. 567)
- Troubleshooting Connections to Your Oracle DB Instance (p. 880)
- Troubleshooting Connections to Your PostgreSQL Instance (p. 1229)
- Maximum MySQL and MariaDB Connections (p. 1464)

Testing a Connection to a DB Instance

You can test your connection to a DB instance using common Linux or Microsoft Windows tools.

From a Linux or Unix terminal, you can test the connection by entering the following (replace *`DB-instance-endpoint`* with the endpoint and *`port`* with the port of your DB instance).

```
nc -zv DB-instance-endpoint port
```

For example, the following shows a sample command and the return value.

```
nc -zv postgresql1.c6c8mn7fake0.us-west-2.rds.amazonaws.com 8299
```

```
  Connection to postgresql1.c6c8mn7fake0.us-west-2.rds.amazonaws.com 8299 port [tcp/vvr-
data] succeeded!
```

Windows users can use Telnet to test the connection to a DB instance. Telnet actions aren't supported other than for testing the connection. If a connection is successful, the action returns no message. If a connection isn't successful, you receive an error message such as the following.

```
C:\>telnet sg-postgresql1.c6c8mntfake0.us-west-2.rds.amazonaws.com 819

  Connecting To sg-postgresql1.c6c8mntfake0.us-west-2.rds.amazonaws.com...Could not open
  connection to the host, on port 819: Connect failed
```

If Telnet actions return success, your security group is properly configured.

Note
Amazon RDS doesn't accept internet control message protocol (ICMP) traffic, including ping.

Troubleshooting Connection Authentication

If you can connect to your DB instance but you get authentication errors, you might want to reset the master user password for the DB instance. You can do this by modifying the RDS instance.

For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Amazon RDS Security Issues

To avoid security issues, never use your master AWS user name and password for a user account. Best practice is to use your master AWS account to create AWS Identity and Access Management (IAM) users and assign those to DB user accounts. You can also use your master account to create other user accounts, if necessary.

For more information on creating IAM users, see Create an IAM User (p. 58).

Error Message "Failed to retrieve account attributes, certain console functions may be impaired."

You can get this error for several reasons. It might be because your account is missing permissions, or your account hasn't been properly set up. If your account is new, you might not have waited for the account to be ready. If this is an existing account, you might lack permissions in your access policies to perform certain actions such as creating a DB instance. To fix the issue, your IAM administrator needs to provide the necessary roles to your account. For more information, see the IAM documentation.

Resetting the DB Instance Owner Role Password

You can reset the assigned permissions for your DB instance by resetting the master password.

For example, if you lock yourself out of the `db_owner` role on your SQL Server database, you can reset the `db_owner` role password by modifying the DB instance master password. By changing the DB instance password, you can regain access to the DB instance. By changing the DB instance password, you can also access databases using the modified password for `db_owner`, and restore privileges for the `db_owner` role that might have been accidentally revoked. You can change the DB instance password by using the Amazon RDS console, the AWS CLI command modify-db-instance, or by using the ModifyDBInstance API operation.

For more information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Amazon RDS DB Instance Outage or Reboot

A DB instance outage can occur when a DB instance is rebooted. It can also occur when the DB instance is put into a state that prevents access to it, and when the database is restarted. A reboot can occur when you either manually reboot your DB instance or change a DB instance setting that requires a reboot before it can take effect.

A DB instance reboot occurs when you change a setting that requires a reboot, or when you manually cause a reboot. A reboot can occur immediately if you change a setting and request that the change take effect immediately or it can occur during the DB instance's maintenance window.

A DB instance reboot occurs immediately when one of the following occurs:

- You change the backup retention period for a DB instance from 0 to a nonzero value or from a nonzero value to 0 and set **Apply Immediately** to `true`.
- You change the DB instance class, and **Apply Immediately** is set to `true`.
- You change the storage type from **Magnetic (Standard)** to **General Purpose (SSD**) or **Provisioned IOPS (SSD)**, or from **Provisioned IOPS (SSD)** or **General Purpose (SSD)** to **Magnetic (Standard)**.

A DB instance reboot occurs during the maintenance window when one of the following occurs:

- You change the backup retention period for a DB instance from 0 to a nonzero value or from a nonzero value to 0, and **Apply Immediately** is set to `false`.
- You change the DB instance class, and **Apply Immediately** is set to `false`.

When you change a static parameter in a DB parameter group, the change doesn't take effect until the DB instance associated with the parameter group is rebooted. The change requires a manual reboot. The DB instance isn't automatically rebooted during the maintenance window.

To see a table that shows DB instance actions and the effect that setting the **Apply Immediately** value has, see Modifying an Amazon RDS DB Instance (p. 220).

Amazon RDS DB Parameter Changes Not Taking Effect

In some cases, you might change a parameter in a DB parameter group but don't see the changes take effect. If so, you likely need to reboot the DB instance associated with the DB parameter group. When you change a dynamic parameter, the change takes effect immediately. When you change a static parameter, the change doesn't take effect until you reboot the DB instance associated with the parameter group.

You can reboot a DB instance using the RDS console or explicitly calling the `RebootDBInstance` API operation (without failover, if the DB instance is in a Multi-AZ deployment). The requirement to reboot the associated DB instance after a static parameter change helps mitigate the risk of a parameter misconfiguration affecting an API call. An example of this might be calling `ModifyDBInstance` to change the DB instance class. For more information, see Modifying Parameters in a DB Parameter Group (p. 204).

Amazon RDS DB Instance Running Out of Storage

If your DB instance runs out of storage space, it might no longer be available. We highly recommend that you constantly monitor the `FreeStorageSpace` metric published in CloudWatch to make sure that your DB instance has enough free storage space.

If your database instance runs out of storage, its status changes to `storage-full`. For example, a call to the `DescribeDBInstances` API operation for a DB instance that has used up its storage outputs the following.

```
aws rds describe-db-instances --db-instance-identifier mydbinstance

DBINSTANCE  mydbinstance  2009-12-22T23:06:11.915Z  db.m3.large  mysql5.6  50  sa
storage-full  mydbinstance.clla4j4jgyph.us-east-1.rds.amazonaws.com  3306
us-east-1b  3
 SECGROUP  default  active
 PARAMGRP  default.mysql5.6  in-sync
```

To recover from this scenario, add more storage space to your instance using the `ModifyDBInstance` API operation or the following AWS CLI command.

For Linux, macOS, or Unix:

```
aws rds modify-db-instance \
    --db-instance-identifier mydbinstance \
    --allocated-storage 60 \
    --apply-immediately
```

For Windows:

```
aws rds modify-db-instance ^
    --db-instance-identifier mydbinstance ^
    --allocated-storage 60 ^
    --apply-immediately
```

```
DBINSTANCE  mydbinstance  2009-12-22T23:06:11.915Z  db.m3.large  mysql5.6  50  sa
storage-full  mydbinstance.clla4j4jgyph.us-east-1.rds.amazonaws.com  3306
us-east-1b  3  60
 SECGROUP  default  active
 PARAMGRP  default.mysql5.6  in-sync
```

Now, when you describe your DB instance, you see that your DB instance has `modifying` status, which indicates the storage is being scaled.

```
aws rds describe-db-instances --db-instance-identifier mydbinstance
```

```
DBINSTANCE  mydbinstance  2009-12-22T23:06:11.915Z  db.m3.large  mysql5.6  50  sa
modifying  mydbinstance.clla4j4jgyph.us-east-1.rds.amazonaws.com
3306  us-east-1b  3  60
 SECGROUP  default  active
 PARAMGRP  default.mysql5.6  in-sync
```

After storage scaling is complete, your DB instance status changes to `available`.

```
aws rds describe-db-instances --db-instance-identifier mydbinstance
```

```
DBINSTANCE  mydbinstance  2009-12-22T23:06:11.915Z  db.m3.large  mysql5.6  60  sa
available  mydbinstance.clla4j4jgyph.us-east-1.rds.amazonaws.com  3306
us-east-1b  3
 SECGROUP  default  active
 PARAMGRP  default.mysql5.6  in-sync
```

You can receive notifications when your storage space is exhausted using the `DescribeEvents` operation. For example, in this scenario, if you make a `DescribeEvents` call after these operations you see the following output.

```
aws rds describe-events --source-type db-instance --source-identifier mydbinstance
```

```
2009-12-22T23:44:14.374Z  mydbinstance  Allocated storage has been exhausted db-instance
2009-12-23T00:14:02.737Z  mydbinstance  Applying modification to allocated storage db-
instance
2009-12-23T00:31:54.764Z  mydbinstance  Finished applying modification to allocated storage
```

Amazon RDS Insufficient DB Instance Capacity

The `InsufficientDBInstanceCapacity` error can be returned when you try to create or modify a DB instance, or when you try to restore a DB instance from a DB snapshot. When this error is returned, the following are common causes:

- The specific DB instance class isn't available in the requested Availability Zone. You can try one of the following to solve the problem:
  - Retry the request with a different DB instance class.
  - Retry the request with a different Availability Zone.
  - Retry the request without specifying an explicit Availability Zone.

  For information about troubleshooting instance capacity issues for Amazon EC2, see Insufficient Instance Capacity in the *Amazon Elastic Compute Cloud User Guide*.
- The DB instance is on the EC2-Classic platform and therefore isn't in a VPC. Some DB instance classes require a VPC. For example, if you're on the EC2-Classic platform and try to increase capacity by switching to a DB instance class that requires a VPC, this error results. For information about Amazon EC2 instance types that are only available in a VPC, see Instance Types Available in EC2-Classic in the *Amazon Elastic Compute Cloud User Guide*. To correct the problem, you can move the DB instance into a VPC. For more information, see Moving a DB Instance Not in a VPC into a VPC (p. 1447).

For information about modifying a DB instance, see Modifying an Amazon RDS DB Instance (p. 220).

Amazon RDS MySQL and MariaDB Issues

You can diagnose and correct issues with MySQL and MariaDB DB instances.

Topics

Maximum MySQL and MariaDB Connections

The maximum number of connections allowed to an RDS MySQL or MariaDB DB instance is based on the amount of memory available for its DB instance class. A DB instance class with more memory available results in a larger number of connections available. For more information on DB instance classes, see DB Instance Classes (p. 7).

The connection limit for a DB instance is set by default to the maximum for the DB instance class. You can limit the number of concurrent connections to any value up to the maximum number of connections allowed. Use the `max_connections` parameter in the parameter group for the DB instance. For more information, see Maximum Number of Database Connections (p. 1456) and Working with DB Parameter Groups (p. 202).

You can retrieve the maximum number of connections allowed for a MySQL or MariaDB DB instance by running the following query.

```
SELECT @@max_connections;
```

You can retrieve the number of active connections to a MySQL or MariaDB DB instance by running the following query.

```
SHOW STATUS WHERE `variable_name` = 'Threads_connected';
```

Diagnosing and Resolving Lag Between Read Replicas

After you create a MySQL or MariaDB read replica and the replica is available, Amazon RDS first replicates the changes made to the source DB instance from the time the read replica create operation started. During this phase, the replication lag time for the read replica is greater than 0. You can monitor this lag time in Amazon CloudWatch by viewing the Amazon RDS `ReplicaLag` metric.

The `ReplicaLag` metric reports the value of the `Seconds_Behind_Master` field of the MySQL or MariaDB `SHOW SLAVE STATUS` command. For more information, see SHOW SLAVE STATUS. When the `ReplicaLag` metric reaches 0, the replica has caught up to the source DB instance. If the `ReplicaLag` metric returns -1, replication might not be active. To troubleshoot a replication error, see Diagnosing and Resolving a MySQL or MariaDB Read Replication Failure (p. 1465). A `ReplicaLag` value of -1 can also mean that the `Seconds_Behind_Master` value can't be determined or is `NULL`.

The `ReplicaLag` metric returns -1 during a network outage or when a patch is applied during the maintenance window. In this case, wait for network connectivity to be restored or for the maintenance window to end before you check the `ReplicaLag` metric again.

The MySQL and MariaDB read replication technology is asynchronous. Thus, you can expect occasional increases for the `BinLogDiskUsage` metric on the source DB instance and for the `ReplicaLag` metric on the read replica. For example, consider a situation where a high volume of write operations to the source DB instance occur in parallel. At the same time, write operations to the read replica are serialized using a single I/O thread. Such a situation can lead to a lag between the source instance and read replica.

For more information about read replicas and MySQL, see Replication Implementation Details in the MySQL documentation. For more information about read replicas and MariaDB, see Replication Overview in the MariaDB documentation.

You can reduce the lag between updates to a source DB instance and the subsequent updates to the read replica by doing the following:

- Set the DB instance class of the read replica to have a storage size comparable to that of the source DB instance.
- Make sure that parameter settings in the DB parameter groups used by the source DB instance and the read replica are compatible. For more information and an example, see the discussion of the `max_allowed_packet` parameter in the next section.
- Disable the query cache. For tables that are modified often, using the query cache can increase replica lag because the cache is locked and refreshed often. If this is the case, you might see less replica lag if you disable the query cache. You can disable the query cache by setting the `query_cache_type parameter` to 0 in the DB parameter group for the DB instance. For more information on the query cache, see Query Cache Configuration.
- Warm the buffer pool on the read replica for InnoDB for MySQL, InnoDB for MariaDB 10.2 or higher, or XtraDB for MariaDB 10.1 or lower. For example, suppose that you have a small set of tables that are being updated often and you're using the InnoDB or XtraDB table schema. In this case, dump those tables on the read replica. Doing this causes the database engine to scan through the rows of those tables from the disk and then cache them in the buffer pool. This approach can reduce replica lag. The following shows an example.

  For Linux, macOS, or Unix:

  ```
  PROMPT> mysqldump \
      -h <endpoint> \
      --port=<port> \
      -u=<username> \
      -p <password> \
      database_name table1 table2 > /dev/null
  ```

  For Windows:

  ```
  PROMPT> mysqldump ^
      -h <endpoint> ^
      --port=<port> ^
      -u=<username> ^
      -p <password> ^
      database_name table1 table2 > /dev/null
  ```

Diagnosing and Resolving a MySQL or MariaDB Read Replication Failure

Amazon RDS monitors the replication status of your read replicas and updates the **Replication State** field of the read replica instance to `Error` if replication stops for any reason. You can review the details of the associated error thrown by the MySQL or MariaDB engines by viewing the **Replication Error** field. Events that indicate the status of the read replica are also generated, including RDS-EVENT-0045 (p. 434), RDS-EVENT-0046 (p. 434), and RDS-EVENT-0047 (p. 432). For more information about events and subscribing to events, see Using Amazon RDS Event Notification (p. 429). If a MySQL error message is returned, check the error in the MySQL error message documentation. If a MariaDB error message is returned, check the error in the MariaDB error message documentation.

Common situations that can cause replication errors include the following:

- The value for the `max_allowed_packet` parameter for a read replica is less than the `max_allowed_packet` parameter for the source DB instance.

  The `max_allowed_packet` parameter is a custom parameter that you can set in a DB parameter group. The `max_allowed_packet` parameter is used to specify the maximum size of data manipulation language (DML) that can be run on the database. If the `max_allowed_packet` value for the source DB instance is smaller than the `max_allowed_packet` value for the read replica, the replication process can throw an error and stop replication. The most common error is `packet bigger than 'max_allowed_packet' bytes`. You can fix the error by having the source and read replica use DB parameter groups with the same `max_allowed_packet` parameter values.
- Writing to tables on a read replica. If you're creating indexes on a read replica, you need to have the `read_only` parameter set to *0* to create the indexes. If you're writing to tables on the read replica, it can break replication.
- Using a nontransactional storage engine such as MyISAM. Read replicas require a transactional storage engine. Replication is only supported for the following storage engines: InnoDB for MySQL, InnoDB for MariaDB 10.2 or higher, or XtraDB for MariaDB 10.1 or lower.

  You can convert a MyISAM table to InnoDB with the following command:

  ```
  alter table <schema>.<table_name> engine=innodb;
  ```
- Using unsafe nondeterministic queries such as `SYSDATE()`. For more information, see Determination of Safe and Unsafe Statements in Binary Logging in the MySQL documentation.

The following steps can help resolve your replication error:

- If you encounter a logical error and you can safely skip the error, follow the steps described in Skipping the Current Replication Error (p. 802). Your MySQL or MariaDB DB instance must be running a version that includes the `mysql_rds_skip_repl_error` procedure. For more information, see mysql.rds_skip_repl_error (p. 835).
- If you encounter a binary log (binlog) position issue, you can change the replica replay position with the `mysql_rds_next_master_log` command. Your MySQL or MariaDB DB instance must be running a version that supports the `mysql_rds_next_master_log` command to change the replica replay position. For version information, see mysql.rds_next_master_log (p. 836).
- If you encounter a temporary performance issue due to high DML load, you can set the `innodb_flush_log_at_trx_commit` parameter to 2 in the DB parameter group on the read replica. Doing this can help the read replica catch up, though it temporarily reduces atomicity, consistency, isolation, and durability (ACID).
- You can delete the read replica and create an instance using the same DB instance identifier. If you do this, the endpoint remains the same as that of your old read replica.

If a replication error is fixed, the **Replication State** changes to **replicating**. For more information, see Troubleshooting a MySQL Read Replica Problem (p. 777).

Creating Triggers with Binary Logging Enabled Requires SUPER Privilege

When trying to create triggers in an RDS MySQL or MariaDB DB instance, you might receive the following error.

```
"You do not have the SUPER privilege and binary logging is enabled"
```

To use triggers when binary logging is enabled requires the SUPER privilege, which is restricted for RDS MySQL and MariaDB DB instances. You can create triggers when binary logging is enabled without the

SUPER privilege by setting the `log_bin_trust_function_creators` parameter to true. To set the `log_bin_trust_function_creators` to true, create a new DB parameter group or modify an existing DB parameter group.

To create a new DB parameter group that allows you to create triggers in your RDS MySQL or MariaDB DB instance with binary logging enabled, use the following CLI commands. To modify an existing parameter group, start with step 2.

To create a new parameter group to allow triggers with binary logging enabled using the CLI

1. Create a new parameter group.

   For Linux, macOS, or Unix:

   ```
   aws rds create-db-parameter-group \
       --db-parameter-group-name allow-triggers \
       --db-parameter-group-family mysql5.5 \
       --description "parameter group allowing triggers"
   ```

   For Windows:

   ```
   aws rds create-db-parameter-group ^
       --db-parameter-group-name allow-triggers ^
       --db-parameter-group-family mysql5.5 ^
       --description "parameter group allowing triggers"
   ```

2. Modify the DB parameter group to allow triggers.

   For Linux, macOS, or Unix:

   ```
   aws rds modify-db-parameter-group \
       --db-parameter-group-name allow-triggers \
       --parameters "ParameterName=log_bin_trust_function_creators, ParameterValue=true,
    ApplyMethod=pending-reboot"
   ```

   For Windows:

   ```
   aws rds modify-db-parameter-group ^
       --db-parameter-group-name allow-triggers ^
       --parameters "ParameterName=log_bin_trust_function_creators, ParameterValue=true,
    ApplyMethod=pending-reboot"
   ```

3. Modify your DB instance to use the new DB parameter group.

   For Linux, macOS, or Unix:

   ```
   aws rds modify-db-instance \
       --db-instance-identifier mydbinstance \
       --db-parameter-group-name allow-triggers \
       --apply-immediately
   ```

   For Windows:

   ```
   aws rds modify-db-instance ^
       --db-instance-identifier mydbinstance ^
       --db-parameter-group-name allow-triggers ^
       --apply-immediately
   ```

4. For the changes to take effect, manually reboot the DB instance.

```
aws rds reboot-db-instance --db-instance-identifier mydbinstance
```

Diagnosing and Resolving Point-In-Time Restore Failures

Restoring a DB Instance That Includes Temporary Tables

When attempting a point-in-time restore (PITR) of your MySQL or MariaDB DB instance, you might encounter the following error.

```
Database instance could not be restored because there has been incompatible database
 activity for restore
functionality. Common examples of incompatible activity include using temporary tables, in-
memory tables,
or using MyISAM tables. In this case, use of Temporary table was detected.
```

PITR relies on both backup snapshots and binary logs (binlogs) from MySQL or MariaDB to restore your DB instance to a particular time. Temporary table information can be unreliable in binlogs and can cause a PITR failure. If you use temporary tables in your MySQL or MariaDB DB instance, you can minimize the possibility of a PITR failure by performing more frequent backups. A PITR failure is most probable in the time between a temporary table's creation and the next backup snapshot.

Restoring a DB Instance That Includes In-Memory Tables

You might encounter a problem when restoring a database that has in-memory tables. In-memory tables are purged during a restart. As a result, your in-memory tables might be empty after a reboot. We recommend that when you use in-memory tables, you architect your solution to handle empty tables in the event of a restart. If you're using in-memory tables with replicated DB instances, you might need to recreate the read replicas after a restart. This might be necessary if a read replica reboots and can't restore data from an empty in-memory table.

For more information about backups and PITR, see Working With Backups (p. 291) and Restoring a DB Instance to a Specified Time (p. 336).

Slave Down or Disabled Error

When you call the `mysql.rds_skip_repl_error` command, you might receive the following error message: `Slave is down or disabled.`

This error message appears because replication is stopped and can't be restarted.

If you need to skip a large number of errors, the replication lag can increase beyond the default retention period for binary log files. In this case, you might encounter a fatal error due to binary log files being purged before they have been replayed on the replica. This purge causes replication to stop, and you can no longer call the `mysql.rds_skip_repl_error` command to skip replication errors.

You can mitigate this issue by increasing the number of hours that binary log files are retained on your replication master. After you have increased the binlog retention time, you can restart replication and call the `mysql.rds_skip_repl_error` command as needed.

To set the binlog retention time, use the mysql.rds_set_configuration (p. 839) procedure. Specify a configuration parameter of 'binlog retention hours' along with the number of hours to retain binlog files on the DB cluster, up to 720 (30 days). The following example sets the retention period for binlog files to 48 hours.

```
CALL mysql.rds_set_configuration('binlog retention hours', 48);
```

Read Replica Create Fails or Replication Breaks With Fatal Error 1236

After changing default parameter values for a MySQL or MariaDB DB instance, you might encounter one of the following problems:

- You can't create a read replica for the DB instance.
- Replication fails with `fatal error 1236`.

Some default parameter values for MySQL and MariaDB DB instances help to make sure that the database is ACID compliant and read replicas are crash-safe. They do this by making sure that each commit is fully synchronized by writing the transaction to the binary log before it's committed. Changing these parameters from their default values to improve performance can cause replication to fail when a transaction hasn't been written to the binary log.

To resolve this issue, set the following parameter values:

- `sync-binlog = 1`
- `innodb_support_xa = 1`
- `innodb_flush_log_at_trx_commit = 1`

Can't Set Backup Retention Period to 0

There are several reasons why you might need to set the backup retention period to 0. For example, you can disable automatic backups immediately by setting the retention period to 0.

In some cases, you might set the value to 0 and receive a message saying that the retention period must be between 1 and 35. In these cases, check to make sure that you haven't set up a read replica for the instance. Read replicas require backups for managing read replica logs, and therefore you can't set a retention period of 0.

Amazon RDS Application Programming Interface (API) Reference

In addition to the AWS Management Console, and the AWS Command Line Interface (AWS CLI), Amazon Relational Database Service (Amazon RDS) also provides an application programming interface (API). You can use the API to automate tasks for managing your DB instances and other objects in Amazon RDS.

- For an alphabetical list of API operations, see Actions.
- For an alphabetical list of data types, see Data Types.
- For a list of common query parameters, see Common Parameters.
- For descriptions of the error codes, see Common Errors.

For more information about the AWS CLI, see AWS Command Line Interface Reference for Amazon RDS.

Topics

Using the Query API

The following sections discuss the parameters and request authentication used with the Query API.

Query Parameters

HTTP Query-based requests are HTTP requests that use the HTTP verb GET or POST and a Query parameter named `Action`.

Each Query request must include some common parameters to handle authentication and selection of an action.

Some operations take lists of parameters. These lists are specified using the `param.n` notation. Values of *n* are integers starting from 1.

For information about Amazon RDS regions and endpoints, go to Amazon Relational Database Service (RDS) in the Regions and Endpoints section of the *Amazon Web Services General Reference*.

Query Request Authentication

You can only send Query requests over HTTPS, and you must include a signature in every Query request. You must use either AWS signature version 4 or signature version 2. For more information, see Signature Version 4 Signing Process and Signature Version 2 Signing Process.

Troubleshooting Applications on Amazon RDS

Amazon RDS provides specific and descriptive errors to help you troubleshoot problems while interacting with the Amazon RDS API.

Topics

For information about troubleshooting for Amazon RDS DB instances, see Troubleshooting for Amazon RDS (p. 1458).

Retrieving Errors

Typically, you want your application to check whether a request generated an error before you spend any time processing results. The easiest way to find out if an error occurred is to look for an `Error` node in the response from the Amazon RDS API.

XPath syntax provides a simple way to search for the presence of an `Error` node, as well as an easy way to retrieve the error code and message. The following code snippet uses Perl and the XML::XPath module to determine if an error occurred during a request. If an error occurred, the code prints the first error code and message in the response.

```
use XML::XPath;
    my $xp = XML::XPath->new(xml =>$response);
    if ( $xp->find("//Error") )
    {print "There was an error processing your request:\n", " Error code: ",
    $xp->findvalue("//Error[1]/Code"), "\n", " ",
    $xp->findvalue("//Error[1]/Message"), "\n\n"; }
```

Troubleshooting Tips

We recommend the following processes to diagnose and resolve problems with the Amazon RDS API.

- Verify that Amazon RDS is operating normally in the AWS Region you are targeting by visiting http://status.aws.amazon.com.
- Check the structure of your request

  Each Amazon RDS operation has a reference page in the *Amazon RDS API Reference*. Double-check that you are using parameters correctly. In order to give you ideas regarding what might be wrong, look at the sample requests or user scenarios to see if those examples are doing similar operations.
- Check the forum

  Amazon RDS has a development community forum where you can search for solutions to problems others have experienced along the way. To view the forum, go to

  https://forums.aws.amazon.com/

Document History

Current API version: 2014-10-31

The following table describes important changes in each release of the *Amazon RDS User Guide* after May 2018. For notification about updates to this documentation, you can subscribe to an RSS feed.

update-history-change	update-history-description	update-history-date
Amazon RDS for Microsoft SQL Server supports SQL Server Integration Services (SSIS) (p. 1472)	SSIS is a platform for data integration and workflow applications. You can enable SSIS on existing or new DB instances. It's installed on the same DB instance as your database engine. For more information, see Support for SQL Server Integration Services in SQL Server.	May 19, 2020
Amazon RDS for Microsoft SQL Server supports SQL Server Reporting Services (SSRS) (p. 1472)	SSRS is a server-based application used for report generation and distribution. You can enable SSRS on existing or new DB instances. It's installed on the same DB instance as your database engine. For more information, see Support for SQL Server Reporting Services in SQL Server.	May 15, 2020
Amazon RDS for Microsoft SQL Server supports S3 integration on Multi-AZ instances (p. 1472)	You can now use Amazon S3 with SQL Server features such as bulk insert on Multi-AZ DB instances. For more information, see Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3.	May 15, 2020
Amazon RDS for Oracle supports purging the recycle bin (p. 1472)	The `rdsadmin.rdsadmin_util.purge_dba_recyclebin` procedure purges the recycle bin. For more information, see Purging the Recycle Bin.	May 13, 2020
Amazon RDS for Oracle improves manageability of Automatic Workload Repository (AWR) (p. 1472)	The `rdsadmin.rdsadmin_diagnostic_util` procedures generate AWR reports and extract AWR data into dump files. For more information, see Generating Performance Reports with Automatic Workload Repository (AWR).	May 13, 2020

Amazon RDS for Oracle April 2020 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine updates for April 2020. For more information, see Oracle Database Engine Release Notes.	May 13, 2020
Amazon RDS for Microsoft SQL Server supports Microsoft Distributed Transaction Coordinator (MSDTC) (p. 1472)	Amazon RDS for SQL Server supports distributed transactions between hosts. For more information, see Support for Microsoft Distributed Transaction Coordinator in SQL Server.	May 4, 2020
Amazon RDS for PostgreSQL versions 11.7, 10.12, 9.6.17, and 9.5.21 (p. 1472)	Amazon RDS for PostgreSQL supports versions 11.7, 10.12, 9.6.17, and 9.5.21. For more information, see Supported PostgreSQL Database Versions.	April 28, 2020
Amazon RDS for Microsoft SQL Server supports new versions (p. 1472)	You can now create Amazon RDS DB instances running SQL Server versions 2017 CU19 14.00.3281.6, 2016 SP2 CU11 13.00.5598.27, 2014 SP3 CU4 12.00.6329.1, and 2012 SP4 GDR 11.0.7493.4 for all editions. For more information, see Microsoft SQL Server Versions on Amazon RDS.	April 28, 2020
Amazon RDS available in the Europe (Milan) Region (p. 1472)	Amazon RDS is now available in the Europe (Milan) Region. For more information, see Regions and Availability Zones.	April 28, 2020
Amazon RDS support for Local Zones (p. 1472)	You can now launch DB instances into a Local Zone subnet. For more information, see Regions, Availability Zones, and Local Zones.	April 23, 2020
Amazon RDS available in the Africa (Cape Town) Region (p. 1472)	Amazon RDS is now available in the Africa (Cape Town) Region. For more information, see Regions and Availability Zones.	April 22, 2020
Amazon RDS for Microsoft SQL Server supports SQL Server Analysis Services (SSAS) (p. 1472)	SSAS is an online analytical processing (OLAP) and data mining tool that is installed within SQL Server. You can enable SSAS on existing or new DB instances. It's installed on the same DB instance as your database engine. For more information, see Support for SQL Server Analysis Services in SQL Server.	April 17, 2020

Amazon RDS for Oracle supports Oracle APEX version 19.2.v1 (p. 1472)	Amazon RDS for Oracle now supports Oracle Application Express (APEX) version 19.2.v1. For more information, see Oracle Application Express.	April 8, 2020
Amazon RDS Proxy for PostgreSQL (p. 1472)	Amazon RDS Proxy is now available for PostgreSQL. You can use RDS Proxy to reduce the overhead of connection management on your DB instance and also the chance of "too many connections" errors. The RDS Proxy is currently in public preview for PostgreSQL. For more information, see Managing Connections with Amazon RDS Proxy (Preview).	April 8, 2020
Amazon RDS for MariaDB supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running MariaDB version 10.4. For more information, see MariaDB on Amazon RDS Versions.	April 6, 2020
Amazon RDS Performance Insights is available for Amazon RDS for MariaDB 10.4 (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for MariaDB version 10.4.8 and higher 10.4 versions. For more information, see Using Amazon RDS Performance Insights.	April 6, 2020
Amazon RDS for PostgreSQL versions 9.3.x are deprecated (p. 1472)	Amazon RDS for PostgreSQL no longer supports versions 9.3.x. For supported versions, see Supported PostgreSQL Database Versions.	April 3, 2020
Amazon RDS for Microsoft SQL Server supports read replicas (p. 1472)	You can now create read replicas for SQL Server DB instances. For more information, see Working with Read Replicas.	April 3, 2020
Amazon RDS for Microsoft SQL Server supports multifile backups (p. 1472)	You can now back up databases to multiple files using SQL Server native backup and restore. For more information, see Backing Up a Database.	April 2, 2020
Amazon RDS for PostgreSQL supports PostgreSQL 12.2 (p. 1472)	Amazon RDS for PostgreSQL supports version 12.2. For more information, see Supported PostgreSQL Database Versions.	March 31, 2020

Amazon RDS for Oracle integration with AWS License Manager (p. 1472)	Amazon RDS for Oracle is now integrated with AWS License Manager. If you use the Bring Your Own License model, AWS License Manager integration makes it easier to monitor your Oracle license usage within your organization. For more information, see Integrating with AWS License Manager.	March 23, 2020
Support for 64 TiB on db.r5 instances in Amazon RDS for MariaDB and MySQL (p. 1472)	You can now create Amazon RDS DB instances for MariaDB and MySQL that use the db.r5 DB instance class with up to 64 TiB of storage. For more information, see Factors That Affect Storage Performance.	March 18, 2020
Support for MySQL 8.0.17 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 8.0.17. For more information, see MySQL on Amazon RDS Versions.	March 10, 2020
Amazon RDS Performance Insights is available for Amazon RDS for MySQL 8.0 (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for MySQL version 8.0.17 and higher 8.0 versions. For more information, see Using Amazon RDS Performance Insights.	March 10, 2020
Support for MySQL 5.6.46 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 5.6.46. For more information, see MySQL on Amazon RDS Versions.	February 28, 2020
Amazon RDS Performance Insights is available for Amazon RDS for MariaDB 10.3 (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for MariaDB version 10.3.13 and higher 10.3 versions. For more information, see Using Amazon RDS Performance Insights.	February 26, 2020
Support for MySQL 5.7.28 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 5.7.28. For more information, see MySQL on Amazon RDS Versions.	February 20, 2020
Support for MariaDB 10.3.20 (p. 1472)	You can now create Amazon RDS DB instances running MariaDB version 10.3.20. For more information, see MariaDB on Amazon RDS Versions.	February 20, 2020

Amazon RDS for Oracle January 2020 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine updates for January 2020. For more information, see Oracle Database Engine Release Notes.	February 20, 2020
Amazon RDS for Microsoft SQL Server supports a new DB instance class (p. 1472)	You can now create Amazon RDS DB instances running SQL Server that use the db.z1d DB instance class. For more information, see DB Instance Class Support for Microsoft SQL Server.	February 19, 2020
Support for cross-account, cross-VPC Active Directory domains in Amazon RDS SQL Server (p. 1472)	Amazon RDS for Microsoft SQL Server now supports associating DB instances with Active Directory domains owned by different accounts and VPCs. For more information, see Using Windows Authentication with a Microsoft SQL Server DB Instance.	February 13, 2020
Oracle OLAP option (p. 1472)	Amazon RDS for Oracle now supports the On-line Analytical Processing (OLAP) option for Oracle DB instances. You can use Oracle OLAP to analyze large amounts of data by creating dimensional objects and cubes in accordance with the OLAP standard. For more information, see Oracle OLAP.	February 13, 2020
FIPS 140-2 support for Oracle (p. 1472)	Amazon RDS for Oracle supports the Federal Information Processing Standard Publication 140-2 (FIPS 140-2) for SSL/TLS connections. For more information, see FIPS Support.	February 11, 2020
Amazon RDS for PostgreSQL supports new versions (p. 1472)	Amazon RDS for PostgreSQL supports versions 11.6, 10.11, 9.6.16, 9.5.20, and 9.4.25. For more information, see Supported PostgreSQL Database Versions.	February 11, 2020
Amazon RDS for PostgreSQL supports new DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running PostgreSQL that use the db.m5.16xlarge, db.m5.8xlarge, db.r5.16xlarge, and db.r5.8xlarge DB instance classes. For more information, see Supported DB Engines for All Available DB Instance Classes.	February 11, 2020

Performance Insights supports analyzing statistics of running MariaDB and MySQL queries (p. 1472)	You can now analyze statistics of running queries with Performance Insights for MariaDB and MySQL DB instances. For more information, see Analyzing Statistics of Running Queries.	February 4, 2020
Support for exporting DB snapshot data to Amazon S3 for MariaDB, MySQL, and PostgreSQL (p. 1472)	Amazon RDS supports exporting DB snapshot data to Amazon S3 for MariaDB, MySQL, and PostgreSQL. For more information, see Exporting DB Snapshot Data to Amazon S3.	January 23, 2020
Amazon RDS for MySQL supports Kerberos authentication (p. 1472)	You can now use Kerberos authentication to authenticate users when they connect to your Amazon RDS for MySQL DB instances. For more information, see Using Kerberos Authentication for MySQL.	January 21, 2020
Amazon RDS for Oracle October 2019 RU and RUR for Oracle 19c (p. 1472)	Amazon RDS for Oracle has released database engine updates for October 2019 for Oracle 19c. For more information, see Oracle Database Engine Release Notes.	January 9, 2020
Amazon RDS Performance Insights supports viewing more SQL text for Amazon RDS for Microsoft SQL Server (p. 1472)	Amazon RDS Performance Insights now supports viewing more SQL text in the Performance Insights dashboard for Amazon RDS for Microsoft SQL Server DB instances. For more information, see Viewing More SQL Text in the Performance Insights Dashboard.	December 17, 2019
Amazon RDS on AWS Outposts (Preview) (p. 1472)	With Amazon RDS on AWS Outposts, you can create AWS-managed relational databases in your on-premises data centers. RDS on Outposts enables you to run RDS databases on AWS Outposts. For more information, see Amazon RDS on AWS Outposts (Preview).	December 3, 2019

Amazon RDS Proxy (p. 1472)	You can reduce the overhead of connection management on your cluster, and reduce the chance of "too many connections" errors, by using the Amazon RDS Proxy. You associate each proxy with an RDS DB instance or Aurora DB cluster. Then you use the proxy endpoint in the connection string for your application. The Amazon RDS Proxy is currently in a public preview state. It supports the RDS MySQL database engine. For more information, see Managing Connections with Amazon RDS Proxy (Preview).	December 3, 2019
Amazon RDS for Oracle supports cross-region read replicas (p. 1472)	Amazon RDS for Oracle now supports cross-region read replicas with Active Data Guard. For more information, see Working with Read Replicas and Working with Oracle Read Replicas.	November 26, 2019
Performance Insights supports analyzing statistics of running Oracle queries (p. 1472)	You can now analyze statistics of running queries with Performance Insights for Oracle DB instances. For more information, see Analyzing Statistics of Running Queries.	November 25, 2019
Amazon RDS for Microsoft SQL Server supports publishing logs to CloudWatch Logs (p. 1472)	You can configure your Amazon RDS SQL Server DB instance to publish log events directly to Amazon CloudWatch Logs. For more information, see Publishing SQL Server Logs to Amazon CloudWatch Logs.	November 25, 2019
Amazon RDS for Microsoft SQL Server supports new DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running SQL Server that use the db.x1e and db.x1 DB instance classes. For more information, see DB Instance Class Support for Microsoft SQL Server.	November 25, 2019
Amazon RDS for Microsoft SQL Server supports differential and log restores (p. 1472)	You can restore differential backups and logs using SQL Server native backup and restore. For more information, see Using Native Backup and Restore.	November 25, 2019

Multi-AZ supported on Amazon RDS for Microsoft SQL Server in new regions (p. 1472)	Multi-AZ on SQL Server is now available in China, Middle East (Bahrain), and Europe (Stockholm). For more information, see Multi-AZ Deployments for Microsoft SQL Server.	November 22, 2019
Amazon RDS for Microsoft SQL Server now supports bulk insert and S3 integration (p. 1472)	You can transfer files between a SQL Server DB instance and an Amazon S3 bucket. Then you can use Amazon S3 with SQL Server features such as bulk insert. For more information, see Integrating an Amazon RDS for SQL Server DB Instance with Amazon S3.	November 21, 2019
Amazon RDS for Oracle October 2019 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine updates for October 2019. For more information, see Oracle Database Engine Release Notes.	November 19, 2019
Performance Insights counters for Amazon RDS for Microsoft SQL Server (p. 1472)	You can now add performance counters to your Performance Insights charts for Microsoft SQL Server DB instances. For more information, see Performance Insights Counters for Amazon RDS for Microsoft SQL Server.	November 12, 2019
Amazon RDS for Microsoft SQL Server supports new DB instance class sizes (p. 1472)	You can now create Amazon RDS DB instances running SQL Server that use the 8xlarge and 16xlarge instance sizes for the db.m5 and db.r5 DB instance classes. Instance sizes ranging from small to 2xlarge are now available for the db.t3 instance class. For more information, see DB Instance Class Support for Microsoft SQL Server.	November 11, 2019
Support for PostgreSQL snapshot upgrades (p. 1472)	If you have existing manual DB snapshots of your Amazon RDS PostgreSQL DB instances, you can now upgrade them to a later version of the PostgreSQL database engine. For more information, see Upgrading a PostgreSQL DB Snapshot.	November 7, 2019
Amazon RDS for Oracle supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running Oracle version 19.0. For more information, see Oracle 19c with Amazon RDS.	November 7, 2019

Amazon RDS for PostgreSQL version 12.0 in the Database Preview Environment (p. 1472)	Amazon RDS for PostgreSQL now supports PostgreSQL Version 12.0 in the Database Preview Environment. For more information, see PostgreSQL Version 12.0 in the Database Preview Environment.	November 1, 2019
Amazon RDS for PostgreSQL supports Kerberos authentication (p. 1472)	You can now use Kerberos authentication to authenticate users when they connect to your Amazon RDS DB instance running PostgreSQL. For more information, see Using Kerberos Authentication with Amazon RDS for PostgreSQL.	October 28, 2019
OEM Management Agent database tasks for Oracle DB instances (p. 1472)	Amazon RDS for Oracle DB instances now support procedures to invoke certain EMCTL commands on the Management Agent. For more information, see OEM Agent Database Tasks.	October 24, 2019
Amazon RDS for PostgreSQL versions 11.5, 10.10, 9.6.15, 9.5.19, and 9.4.24 (p. 1472)	Amazon RDS for PostgreSQL supports versions 11.5, 10.10, 9.6.15, 9.5.19, and 9.4.24. For more information, see Supported PostgreSQL Database Versions.	October 8, 2019
Amazon RDS for PostgreSQL supports PostgreSQL Transportable Databases (p. 1472)	PostgreSQL Transportable Databases provide an extremely fast method of migrating an RDS PostgreSQL database between two DB instances. For more information, see Transporting PostgreSQL Databases Between DB Instances.	October 8, 2019
Amazon RDS for Oracle supports Kerberos authentication (p. 1472)	You can now use Kerberos authentication to authenticate users when they connect to your Amazon RDS DB instance running Oracle. For more information, see Using Kerberos Authentication with Amazon RDS for Oracle.	September 30, 2019
Amazon RDS for PostgreSQL version 12 Beta 3 in the Database Preview Environment (p. 1472)	Amazon RDS for PostgreSQL now supports PostgreSQL Version 12 Beta 3 in the Database Preview Environment. For more information, see PostgreSQL Version 12 Beta 3 on Amazon RDS in the Database Preview Environment.	August 28, 2019

Support for MySQL 8.0.16 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 8.0.16. For more information, see MySQL on Amazon RDS Versions.	August 19, 2019
Amazon RDS for Oracle supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running Oracle version 18.0. For more information, see Oracle 18c with Amazon RDS.	August 15, 2019
Amazon RDS for Oracle July 2019 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine version 12.2.0.1.ru-2019-07.rur-2019-07.r1 to support the July 2019 Release Update (RU) and Release Update Revision (RUR). Amazon RDS for Oracle has also released database engine versions 12.1.0.2.v17 and 11.2.0.4.v21 to support the July 2019 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	August 8, 2019
Management Agent for OEM 13c Release 3 (p. 1472)	Amazon RDS for Oracle DB instances now support the Management Agent for Oracle Enterprise Manager (OEM) Cloud Control 13c Release 3. For more information, see Oracle Management Agent for Enterprise Manager Cloud Control.	August 7, 2019
Amazon RDS for PostgreSQL version 12 Beta 2 in the Database Preview Environment (p. 1472)	Amazon RDS for PostgreSQL now supports PostgreSQL Version 12 Beta 2 in the Database Preview Environment. For more information, see PostgreSQL Version 12 Beta 2 on Amazon RDS in the Database Preview Environment.	August 6, 2019
Amazon RDS supports server collations for SQL Server (p. 1472)	Amazon RDS for SQL Server supports a selection of collations for new DB instances. For more information, see Collations and Character Sets for Microsoft SQL Server.	July 29, 2019

Amazon RDS for PostgreSQL versions 11.4, 10.9, 9.6.14, 9.5.18, and 9.4.23 (p. 1472)	Amazon RDS for PostgreSQL supports minor versions 11.4, 10.9, 9.6.14, 9.5.18, and 9.4.23. For more information, see Supported PostgreSQL Database Versions.	July 3, 2019
Amazon RDS for Oracle supports Oracle APEX version 19.1.v1 (p. 1472)	Amazon RDS for Oracle now supports Oracle Application Express (APEX) version 19.1.v1. For more information, see Oracle Application Express.	June 28, 2019
Amazon RDS storage autoscaling (p. 1472)	Storage autoscaling for Amazon RDS DB instances enables Amazon RDS to automatically expand the storage associated with a DB instance to reduce the chance of out-of-space conditions. For information about storage autoscaling, see Working with Storage for Amazon RDS DB Instances.	June 20, 2019
Amazon RDS for Oracle supports db.z1d DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running Oracle that use the db.z1d DB instance classes. For more information, see DB Instance Class.	June 13, 2019
Amazon RDS Performance Insights supports viewing more SQL text for Amazon RDS for Oracle (p. 1472)	Amazon RDS Performance Insights now supports viewing more SQL text in the Performance Insights dashboard for Amazon RDS for Oracle DB instances. For more information, see Viewing More SQL Text in the Performance Insights Dashboard.	June 10, 2019
Amazon RDS adds support native restores of SQL Server databases up to 16 TB (p. 1472)	You can now do native restores of up to 16 TB from SQL Server to Amazon RDS. For more information, see Amazon RDS for SQL Server: Limitations and Recommendations.	June 4, 2019
Amazon RDS adds support for Microsoft SQL Server Audit (p. 1472)	Using Amazon RDS for Microsoft SQL Server, you can audit server and database level events using SQL Server Audit, and view the results on your DB instance or send the audit log files directly to Amazon S3. For more information, see SQL Server Audit.	May 23, 2019

Improvements to Amazon RDS recommendations (p. 1472)	Amazon RDS has improved its automated recommendations for database resources. For example, Amazon RDS now provides recommendations for database parameters. For more information, see Using Amazon RDS Recommendations.	May 22, 2019
Support for more databases per DB instance for Amazon RDS SQL Server (p. 1472)	You can create up to 30 databases on each of your DB instances running Microsoft SQL Server. For more information, see Limits for Microsoft SQL Server DB Instances.	May 21, 2019
Support for 64 TiB and 80k IOPS of storage for Amazon RDS for MariaDB, MySQL and PostgreSQL (p. 1472)	You can now create Amazon RDS DB instances for MariaDB, MySQL and PostgreSQL with up to 64 TiB of storage and up to 80,000 provisioned IOPS. For more information, see DB Instance Storage.	May 20, 2019
Amazon RDS for MySQL supports upgrade prechecks (p. 1472)	When you upgrade a DB instance from MySQL 5.7 to MySQL 8.0, Amazon RDS performs prechecks for incompatibilities. For more information, see Prechecks for Upgrades from MySQL 5.7 to 8.0.	May 17, 2019
Support for the MySQL password validation plugin (p. 1472)	You can now use the MySQL `validate_password` plugin for improved security of Amazon RDS for MySQL DB instances. For more information, see Using the Password Validation Plugin.	May 16, 2019
Amazon RDS for Oracle April 2019 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine version 12.2.0.1.ru-2019-04.rur-2019-04.r1 to support the April 2019 Release Update (RU) and Release Update Revision (RUR). Amazon RDS for Oracle has also released database engine versions 12.1.0.2.v16 and 11.2.0.4.v20 to support the April 2019 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	May 16, 2019

Performance Insights counters for Amazon RDS for Oracle (p. 1472)	You can now add performance counters to your Performance Insights charts for Oracle DB instances. For more information, see Performance Insights Counters for Amazon RDS for Oracle.	May 8, 2019
Amazon RDS for PostgreSQL versions 11.2, 10.7, 9.6.12, 9.5.16, and 9.4.21 (p. 1472)	Amazon RDS for PostgreSQL supports minor versions 11.2, 10.7, 9.6.12, 9.5.16, and 9.4.21. For more information, see Supported PostgreSQL Database Versions.	May 1, 2019
Support for per-second billing (p. 1472)	Amazon RDS is now billed in 1-second increments in all AWS Regions except AWS GovCloud (US) for on-demand instances. For more information, see DB Instance Billing for Amazon RDS.	April 25, 2019
Support for importing data from Amazon S3 for Amazon RDS for PostgreSQL (p. 1472)	You can now import data from Amazon S3 file into a table in an RDS PostgreSQL DB instance. For more information, see Importing Amazon S3 Data into an RDS PostgreSQL DB Instance.	April 24, 2019
Support for restoring 5.7 backups from Amazon S3 (p. 1472)	You can now create a backup of your MySQL version 5.7 database, store it on Amazon S3, and then restore the backup file onto a new Amazon RDS DB instance running MySQL. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance.	April 17, 2019
Support for multiple major version upgrades for Amazon RDS for PostgreSQL (p. 1472)	With Amazon RDS for PostgreSQL, you can now choose from multiple major versions when you upgrade the DB engine. This feature enables you to skip ahead to a newer major version when you upgrade select PostgreSQL engine versions. For more information, see Upgrading the PostgreSQL DB Engine.	April 16, 2019
Support for 64 TiB of storage for Amazon RDS for Oracle (p. 1472)	You can now create Amazon RDS DB instances for Oracle with up to 64 TiB of storage and up to 80,000 provisioned IOPS. For more information, see DB Instance Storage.	April 4, 2019

Support for MySQL 8.0.15 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 8.0.15. For more information, see MySQL on Amazon RDS Versions.	April 3, 2019
Support for MariaDB 10.3.13 (p. 1472)	You can now create Amazon RDS DB instances running MariaDB version 10.3.13. For more information, see MariaDB on Amazon RDS Versions.	April 3, 2019
Microsoft SQL Server 2008 R2 deprecated on Amazon RDS (p. 1472)	Support for Microsoft SQL Server 2008 R2 is deprecated, coinciding with the Microsoft plan to terminate extended support for this version on July 9, 2019. Any existing Microsoft SQL Server 2008 R2 snapshots are to be automatically upgraded to the latest minor version of Microsoft SQL Server 2012 starting on June 1, 2019. For more information, see Microsoft SQL Server 2008 R2 Support on Amazon RDS .	April 2, 2019
Always On Availability Groups supported in Microsoft SQL Server 2017 (p. 1472)	You can now use Always On Availability Groups in SQL Server 2017 Enterprise Edition 14.00.3049.1 or later. For more information, see Multi-AZ Deployments for Microsoft SQL Server.	March 29, 2019
View volume metrics (p. 1472)	You can now view metrics for the Amazon Elastic Block Store (Amazon EBS) volumes, which are the physical devices used for database and log storage. For more information, see Viewing Enhanced Monitoring.	March 20, 2019
Support for MySQL 5.7.25 (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 5.7.25. For more information, see MySQL on Amazon RDS Versions.	March 19, 2019
Amazon RDS for Oracle supports RMAN DBA tasks (p. 1472)	Amazon RDS for Oracle now supports Oracle Recovery Manager (RMAN) DBA tasks, including RMAN backups. For more information, see Common DBA Recovery Manager (RMAN) Tasks for Oracle DB Instances.	March 14, 2019

Amazon RDS for PostgreSQL supports version 11.1 (p. 1472)	You can now create Amazon RDS DB instances running PostgreSQL version 11.1. For more information, see PostgreSQL Version 11.1 on Amazon RDS.	March 12, 2019
Multiple-file restore is available in Amazon RDS for SQL Server (p. 1472)	You can now restore from multiple files with Amazon RDS for SQL Server. For more information, see Restoring a Database.	March 11, 2019
MariaDB 10.2.21 (p. 1472)	You can now create Amazon RDS DB instances running MariaDB version 10.2.21. For more information, see MariaDB on Amazon RDS Versions.	March 11, 2019
Amazon RDS for Oracle supports read replicas (p. 1472)	Amazon RDS for Oracle now supports read replicas with Active Data Guard. For more information, see Working with Read Replicas and Working with Oracle Read Replicas.	March 11, 2019
Amazon RDS Performance Insights is available for Amazon RDS for MariaDB (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for MariaDB. For more information, see Using Amazon RDS Performance Insights.	March 11, 2019
MySQL 8.0.13 and 5.7.24 (p. 1472)	You can now create Amazon RDS DB instances running MySQL versions 8.0.13 and 5.7.24. For more information, see MySQL on Amazon RDS Versions.	March 8, 2019
Amazon RDS Performance Insights is available for Amazon RDS for SQL Server (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for SQL Server. For more information, see Using Amazon RDS Performance Insights.	March 4, 2019
Amazon RDS for Oracle supports Amazon S3 integration (p. 1472)	You can now transfer files between an Amazon RDS for Oracle DB instance and an Amazon S3 bucket. For more information, see Integrating Amazon RDS for Oracle and Amazon S3.	February 26, 2019

Amazon RDS for MySQL and Amazon RDS for MariaDB support db.t3 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running MySQL or MariaDB that use the db.t3 DB instance classes. For more information, see DB Instance Class.	February 20, 2019
Amazon RDS for MySQL and Amazon RDS for MariaDB support db.r5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running MySQL or MariaDB that use the db.r5 DB instance classes. For more information, see DB Instance Class.	February 20, 2019
Performance Insights counters for Amazon RDS MySQL and PostgreSQL (p. 1472)	You can now add performance counters to your Performance Insights charts for Amazon RDS MySQL and PostgreSQL DB instances. For more information, see Performance Insights Dashboard Components.	February 19, 2019
Amazon RDS for PostgreSQL now supports adaptive autovacuum parameter tuning (p. 1472)	Adaptive autovacuum parameter tuning with Amazon RDS for PostgreSQL helps prevent transaction ID wraparound by adjusting autovacuum parameter values automatically. For more information, see Reducing the Likelihood of Transaction ID Wraparound.	February 12, 2019
Amazon RDS for Oracle supports Oracle APEX versions 18.1.v1 and 18.2.v1 (p. 1472)	Amazon RDS for Oracle now supports Oracle Application Express (APEX) versions 18.1.v1 and 18.2.v1. For more information, see Oracle Application Express.	February 11, 2019
Amazon RDS for Oracle January 2019 RU, RUR, and PSU (p. 1472)	Amazon RDS for Oracle has released database engine version 12.2.0.1.ru-2019-01.rur-2019-01.r1 to support the January 2019 Release Update (RU) and Release Update Revision (RUR). Amazon RDS for Oracle has also released database engine versions 12.1.0.2.v15 and 11.2.0.4.v19 to support the January 2019 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	February 8, 2019

Amazon RDS Performance Insights supports viewing more SQL text for Amazon RDS MySQL (p. 1472)	Amazon RDS Performance Insights now supports viewing more SQL text in the Performance Insights dashboard for Amazon RDS MySQL DB instances. For more information, see Viewing More SQL Text in the Performance Insights Dashboard.	February 6, 2019
Amazon RDS for PostgreSQL supports db.t3 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running PostgreSQL that use the db.t3 DB instance classes. For more information, see DB Instance Class.	January 25, 2019
Amazon RDS for Oracle supports db.t3 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running Oracle that use the db.t3 DB instance classes. For more information, see DB Instance Class.	January 25, 2019
Amazon RDS Performance Insights supports viewing more SQL text for Amazon RDS PostgreSQL (p. 1472)	Amazon RDS Performance Insights now supports viewing more SQL text in the Performance Insights dashboard for Amazon RDS PostgreSQL DB instances. For more information, see Viewing More SQL Text in the Performance Insights Dashboard.	January 24, 2019
Amazon RDS for Oracle supports a new version of SQLT (p. 1472)	Amazon RDS for Oracle now supports SQLT version 12.2.180725. For more information, see Oracle SQLT.	January 22, 2019
Amazon RDS for PostgreSQL supports new minor versions (p. 1472)	Amazon RDS for PostgreSQL now supports the following new minor versions: 10.6, 9.6.11, 9.5.15, 9.4.20, and 9.3.25. For more information, see Amazon RDS for PostgreSQL Versions and Extensions.	December 19, 2018
Amazon RDS for PostgreSQL supports db.r5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running PostgreSQL that use the db.r5 DB instance classes. For more information, see DB Instance Class.	December 19, 2018

Amazon RDS for PostgreSQL now supports restricted password management (p. 1472)	Amazon RDS for PostgreSQL enables you to restrict who can manage user passwords and password expiration changes by using the parameter `rds.restrict_password_commands` and the role `rds_password`. For more information, see Restricting Password Management.	December 19, 2018
Amazon RDS for PostgreSQL supports uploading database logs to Amazon CloudWatch Logs (p. 1472)	Amazon RDS for PostgreSQL supports uploading database logs to CloudWatch Logs. For more information, see Publishing PostgreSQL Logs to CloudWatch Logs.	December 10, 2018
Amazon RDS for Oracle supports db.r5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running Oracle that use the db.r5 DB instance classes. For more information, see DB Instance Class.	November 20, 2018
Retain backups when deleting a DB instance (p. 1472)	Amazon RDS supports retaining automated backups when you delete a DB instance. For more information, see Working with Backups.	November 15, 2018
Amazon RDS for PostgreSQL supports db.m5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running PostgreSQL that use the db.m5 DB instance classes. For more information, see DB Instance Class.	November 15, 2018
Amazon RDS for Oracle supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running Oracle version 12.2. For more information, see Oracle 12c Version 12.2.0.1 with Amazon RDS.	November 13, 2018
Amazon RDS for Oracle October 2018 PSU (p. 1472)	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v14 and 11.2.0.4.v18 to support the October 2018 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	November 13, 2018
Amazon RDS for SQL Server supports Always On (p. 1472)	Amazon RDS for SQL Server supports Always On Availability Groups. For more information, see Multi-AZ Deployments for Microsoft SQL Server.	November 8, 2018

Amazon RDS for PostgreSQL supports outbound network access using custom DNS servers (p. 1472)	Amazon RDS for PostgreSQL supports outbound network access using custom DNS servers. For more information, see Using a Custom DNS Server for Outbound Network Access.	November 8, 2018
Amazon RDS for MariaDB, MySQL, and PostgreSQL supports 32 TiB of storage (p. 1472)	You can now create Amazon RDS DB instances with up to 32 TiB of storage for MySQL, MariaDB, and PostgreSQL. For more information, see DB Instance storage.	November 7, 2018
Amazon RDS for Oracle supports extended data types (p. 1472)	You can now enable extended data types on Amazon RDS DB instances running Oracle. With extended data types, the maximum size is 32,767 bytes for the VARCHAR2, NVARCHAR2, and RAW data types. For more information, see Using Extended Data Types.	November 6, 2018
Amazon RDS for Oracle supports db.m5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running Oracle that use the db.m5 DB instance classes. For more information, see DB Instance Class.	November 2, 2018
Amazon RDS for Oracle migration from SE, SE1, or SE2 to EE (p. 1472)	You can now migrate from any Oracle Database Standard Edition (SE, SE1, or SE2) to Oracle Database Enterprise Edition (EE). For more information, see Migrating Between Oracle Editions.	October 31, 2018
Amazon RDS can now stop Multi-AZ instances (p. 1472)	Amazon RDS can now stop a DB instance that is part of a Multi-AZ deployment. Formerly, the stop instance feature had a limitation for multi-AZ instances. For more information, see Stopping an Amazon RDS DB Instance Temporarily.	October 29, 2018
Amazon RDS Performance Insights is available for Amazon RDS Oracle (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS Oracle. For more information, see Using Amazon RDS Performance Insights.	October 29, 2018

Amazon RDS for PostgreSQL supports PostgreSQL version 11 in the Database Preview Environment (p. 1472)	Amazon RDS for PostgreSQL now supports PostgreSQL version 11 in the Database Preview Environment. For more information, see PostgreSQL Version 11 on Amazon RDS in the Database Preview Environment.	October 25, 2018
MySQL supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running MySQL version 8.0. For more information, see MySQL on Amazon RDS Versions.	October 23, 2018
MariaDB supports a new major version (p. 1472)	You can now create Amazon RDS DB instances running MariaDB version 10.3. For more information, see MariaDB on Amazon RDS Versions.	October 23, 2018
Amazon RDS for Oracle supports Oracle JVM (p. 1472)	Amazon RDS for Oracle now supports the Oracle Java Virtual Machine (JVM) option. For more information, see Oracle Java Virtual Machine.	October 16, 2018
Custom parameter group for restore and point in time recovery (p. 1472)	You can now specify a custom parameter group when you restore a snapshot or perform a point in time recovery operation. For more information, see Restoring from a DB Snapshot and Restoring a DB Instance to a Specified Time.	October 15, 2018
Amazon RDS for Oracle supports 32 TiB storage (p. 1472)	You can now create Oracle RDS DB instances with up to 32 TiB of storage. For more information, see DB instance storage.	October 15, 2018
Amazon RDS for MySQL supports GTIDs (p. 1472)	Amazon RDS for MySQL now supports global transaction identifiers (GTIDs), which are unique across all DB instances and in a replication configuration. For more information, see Using GTID-Based Replication for Amazon RDS MySQL.	October 10, 2018
MySQL 5.7.23, 5.6.41, and 5.5.61 (p. 1472)	You can now create Amazon RDS DB instances running MySQL versions 5.7.23, 5.6.41, and 5.5.61. For more information, see MySQL on Amazon RDS Versions.	October 8, 2018

Amazon RDS for PostgreSQL supports new minor versions (p. 1472)	Amazon RDS for PostgreSQL now supports the following new minor versions: 10.5, 9.6.10, 9.5.14, 9.4.19, and 9.3.24. For more information, see Amazon RDS for PostgreSQL Versions and Extensions.	October 4, 2018
Amazon RDS for Oracle supports a new version of SQLT (p. 1472)	Amazon RDS for Oracle now supports SQLT version 12.2.180331. For more information, see Oracle SQLT.	October 4, 2018
Amazon RDS for Oracle July 2018 PSU (p. 1472)	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v13 and 11.2.0.4.v17 to support the July 2018 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	October 3, 2018
Amazon RDS for PostgreSQL now supports IAM authentication (p. 1472)	Amazon RDS for PostgreSQL now supports IAM authentication. For more information see IAM Database Authentication for MySQL and PostgreSQL.	September 27, 2018
You can enable deletion protection for your Amazon RDS DB instances (p. 1472)	When you enable deletion protection for a DB instance, the database cannot be deleted by any user. For more information, see Deleting a DB Instance.	September 26, 2018
Amazon RDS for MySQL and Amazon RDS for MariaDB support db.m5 DB instance classes (p. 1472)	You can now create Amazon RDS DB instances running MySQL or MariaDB that use the db.m5 DB instance classes. For more information, see DB Instance Class.	September 18, 2018
Amazon RDS now supports upgrades to SQL Server 2017 (p. 1472)	You can upgrade your existing DB instance to SQL Server 2017 from any version except SQL Server 2008. To upgrade from SQL Server 2008, first upgrade to one of the other versions first. For information, see Upgrading the Microsoft SQL Server DB Engine.	September 11, 2018

Amazon RDS for PostgreSQL now supports PostgreSQL Version 11 Beta 3 in the Database Preview Environment (p. 1472)	In this release, the Write-Ahead Log (WAL) segment size (wal_segment_size) is now set to 64MB. For more about PostgreSQL version 11 Beta 3, see PostgreSQL 11 Beta 3 Released. For information on the Database Preview Environment, see Working with the Database Preview Environment.	September 7, 2018
Amazon Aurora User Guide (p. 1472)	The *Amazon Aurora User Guide* describes all Amazon Aurora concepts and provides instructions on using the various features with both the console and the command line interface. The *Amazon RDS User Guide* now covers non-Aurora database engines.	August 31, 2018
Amazon RDS Performance Insights is available for Amazon RDS MySQL (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS MySQL. For more information, see Using Amazon RDS Performance Insights.	August 28, 2018
Aurora with PostgreSQL compatibility now supports Aurora Auto Scaling (p. 1472)	Auto Scaling of Aurora replicas is now available for Aurora with PostgreSQL compatibility. For more information, see Using Amazon Aurora Auto Scaling with Aurora Replicas.	August 16, 2018
Aurora Serverless for Aurora MySQL (p. 1472)	Aurora Serverless is an on-demand, autoscaling configuration for Amazon Aurora. For more information, see Using Amazon Aurora Serverless.	August 9, 2018
MySQL 5.7.22 and 5.6.40 (p. 1472)	You can now create Amazon RDS DB instances running MySQL versions 5.7.22 and 5.6.40. For more information, see MySQL on Amazon RDS Versions.	August 6, 2018
Aurora is now available in the China (Ningxia) region (p. 1472)	Aurora MySQL and Aurora PostgreSQL are now available in the China (Ningxia) region. For more information, see Availability for Amazon Aurora MySQL and Availability for Amazon Aurora PostgreSQL.	August 6, 2018

Amazon RDS for MySQL supports delayed replication (p. 1472)	Amazon RDS for MySQL now supports delayed replication as a strategy for disaster recovery. For more information, see Configuring Delayed Replication with MySQL.	August 6, 2018
Amazon RDS Performance Insights is available for Aurora MySQL (p. 1472)	Amazon RDS Performance Insights is now available for Aurora MySQL. For more information, see Using Amazon RDS Performance Insights.	August 6, 2018
Amazon RDS Performance Insights integration with Amazon CloudWatch (p. 1472)	Amazon RDS Performance Insights automatically publishes metrics to Amazon CloudWatch. For more information, see Performance Insights Metrics Published to CloudWatch.	August 6, 2018
Amazon RDS recommendations (p. 1472)	Amazon RDS now provides automated recommendations for database resources. For more information, see Using Amazon RDS Recommendations.	July 25, 2018
Amazon RDS for PostgreSQL supports new minor versions (p. 1472)	Amazon RDS for PostgreSQL now supports the following new minor versions: 10.4, 9.6.9, 9.5.13, 9.4.18, and 9.3.23. For more information, see Amazon RDS for PostgreSQL Versions and Extensions.	July 25, 2018
Incremental snapshot copies across AWS Regions (p. 1472)	Amazon RDS supports incremental snapshot copies across AWS Regions for both unencrypted and encrypted instances. For more information, see Copying Snapshots Across AWS Regions.	July 24, 2018
Amazon RDS Performance Insights is available for Amazon RDS for PostgreSQL (p. 1472)	Amazon RDS Performance Insights is now available for Amazon RDS for PostgreSQL. For more information, see Using Amazon RDS Performance Insights.	July 18, 2018
Amazon RDS for Oracle supports Oracle APEX version 5.1.4.v1 (p. 1472)	Amazon RDS for Oracle now supports Oracle Application Express (APEX) version 5.1.4.v1. For more information, see Oracle Application Express.	July 10, 2018

Amazon RDS for Oracle supports publishing logs to Amazon CloudWatch Logs (p. 1472)	Amazon RDS for Oracle now supports publishing alert, audit, trace, and listener log data to a log group in CloudWatch Logs. For more information, see Publishing Oracle Logs to Amazon CloudWatch Logs.	July 9, 2018
MariaDB 10.2.15, 10.1.34, and 10.0.35 (p. 1472)	You can now create Amazon RDS DB instances running MariaDB versions 10.2.15, 10.1.34, and 10.0.35. For more information, see MariaDB on Amazon RDS Versions.	July 5, 2018
Aurora PostgreSQL 1.2 is available and compatible with PostgreSQL 9.6.8 (p. 1472)	Aurora PostgreSQL 1.2 is now available and is compatible with PostgreSQL 9.6.8. For more information, see Version 1.2.	June 27, 2018
Read replicas for Amazon RDS PostgreSQL support Multi-AZ deployments (p. 1472)	RDS read replicas in Amazon RDS PostgreSQL now support multiple Availability Zones. For more information, see Working with PostgreSQL Read Replicas.	June 25, 2018
Performance Insights available for Aurora PostgreSQL (p. 1472)	Performance Insights is generally available for Aurora PostgreSQL, with support for extended retention of performance data. For more information, see Using Amazon RDS Performance Insights.	June 21, 2018
Aurora PostgreSQL available in western US (Northern California) region (p. 1472)	Aurora PostgreSQL is now available in the western United States (Northern California) region. For more information, see Availability for Amazon Aurora PostgreSQL.	June 11, 2018
Amazon RDS for Oracle now supports CPU configuration (p. 1472)	Amazon RDS for Oracle supports configuring the number of CPU cores and the number of threads for each core for the processor of a DB instance class. For more information, see Configuring the Processor of the DB Instance Class.	June 5, 2018
Amazon RDS for Oracle April 2018 PSU (p. 1472)	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v12 and 11.2.0.4.v16 to support the April 2018 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes.	June 1, 2018

Earlier Updates

The following table describes the important changes in each release of the *Amazon RDS User Guide* before June 2018.

Change	Description	Date Changed
Amazon RDS for PostgreSQL now supports PostgreSQL Version 11 Beta 1 in the Database Preview Environment	PostgreSQL version 11 Beta 1 contains several improvements that are described in PostgreSQL 11 Beta 1 Released! For information on the Database Preview Environment, see Working with the Database Preview Environment (p. 1307).	May 31, 2018
Amazon RDS for Oracle now supports TLS versions 1.0 and 1.2	Amazon RDS for Oracle supports Transport Layer Security (TLS) versions 1.0 and 1.2. For more information, see TLS Versions for the Oracle SSL Option (p. 968).	May 30, 2018
Aurora MySQL supports publishing logs to Amazon CloudWatch Logs	Aurora MySQL now supports publishing general, slow, audit, and error log data to a log group in CloudWatch Logs. For more information, see Publishing Aurora MySQL to CloudWatch Logs.	May 23, 2018
Database Preview Environment for Amazon RDS PostgreSQL	You can now launch a new instance of Amazon RDS PostgreSQL in a preview mode. For more information about the Database Preview Environment see, Working with the Database Preview Environment (p. 1307).	May 22, 2018
Amazon RDS for Oracle DB instances support new DB instance classes	Oracle DB instances now support the db.x1e and db.x1 DB instance classes. For more information, see DB Instance Classes (p. 7) and DB Instance Class Support for Oracle (p. 850).	May 22, 2018
Amazon RDS PostgreSQL now supports postgres_fdw on a read replica.	You can now use postgres_fdw to connect to a remote server from a read replica. For more information see, Accessing External Data with the postgres_fdw Extension (p. 1293).	May 17, 2018
Amazon RDS for Oracle now supports setting sqlnet.ora parameters	You can now set sqlnet.ora parameters with Amazon RDS for Oracle. For more information, see Modifying Oracle sqlnet.ora Parameters (p. 885).	May 10, 2018
Aurora PostgreSQL available in Asia Pacific (Seoul) region.	Aurora PostgreSQL is now available in the Asia Pacific (Seoul) region. For more information, see Availability for Amazon Aurora PostgreSQL.	May 9, 2018
Aurora MySQL supports backtracking	Aurora MySQL now supports "rewinding" a DB cluster to a specific time, without restoring data from a backup. For more information, see Backtracking an Aurora DB Cluster.	May 9, 2018

Change	Description	Date Changed
Aurora MySQL supports encrypted migration and replication from external MySQL	Aurora MySQL now supports encrypted migration and replication from an external MySQL database. For more information, see Migrating Data from an External MySQL Database to an Amazon Aurora MySQL DB Cluster and Replication Between Aurora and MySQL or Between Aurora and Another Aurora DB Cluster.	April 25, 2018
Aurora with PostgreSQL compatibility support for the Copy-on-Write protocol.	You can now clone databases in an Aurora PostgreSQL database cluster. For more information see, Cloning Databases in an Aurora DB Cluster.	April 10, 2018
MariaDB 10.2.12, 10.1.31, and 10.0.34	You can now create Amazon RDS DB instances running MariaDB versions 10.2.12, 10.1.31, and 10.0.34. For more information, see MariaDB on Amazon RDS Versions (p. 499).	March 21, 2018
Aurora PostgreSQL Support for new regions	Aurora PostgreSQL is now available in the EU (London) and Asia Pacific (Singapore) regions. For more information, see Availability for Amazon Aurora PostgreSQL.	March 13, 2018
MySQL 5.7.21, 5.6.39, and 5.5.59	You can now create Amazon RDS DB instances running MySQL versions 5.7.21, 5.6.39, and 5.5.59. For more information, see MySQL on Amazon RDS Versions (p. 713).	March 9, 2018
Amazon RDS for Oracle now supports Oracle REST Data Services	Amazon RDS for Oracle supports Oracle REST Data Services as part of the APEX option. For more information, see Oracle Application Express (p. 927).	March 9, 2018
Amazon Aurora with MySQL compatibility available in new AWS Region	Aurora MySQL is now available in the Asia Pacific (Singapore) region. For the complete list of AWS Regions for Aurora MySQL, see Availability for Amazon Aurora MySQL.	March 6, 2018
Support for PostgreSQL 10.1	Amazon RDS now supports version 10.1 of PostgreSQL. For more information, see PostgreSQL Version 10.1 on Amazon RDS (p. 1316)	February 27, 2018
Oracle January 2018 PSU	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v11 and 11.2.0.4.v15 to support the January 2018 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes (p. 1092).	February 22, 2018
Amazon RDS DB instances running Microsoft SQL Server support change data capture (CDC)	DB instances running Amazon RDS for Microsoft SQL Server now support change data capture (CDC). For more information, see Change Data Capture Support for Microsoft SQL Server DB Instances (p. 553).	February 6, 2018

Change	Description	Date Changed
Aurora MySQL supports a new major version	You can now create Aurora MySQL DB clusters running MySQL version 5.7. For more information, see Amazon Aurora MySQL Database Engine Updates 2018-02-06.	February 6, 2018
Support for PostgreSQL 9.6.6	Amazon RDS PostgreSQL now supports version 9.6.6. This release also includes support for the prefix and orafce extensions. For more information, see PostgreSQL Version 9.6.6 on Amazon RDS (p. 1319).	January 19, 2018
Publish MySQL and MariaDB logs to Amazon CloudWatch Logs	You can now publish MySQL and MariaDB log data to CloudWatch Logs. For more information, see Publishing MySQL Logs to CloudWatch Logs (p. 470) and Publishing MariaDB Logs to Amazon CloudWatch Logs (p. 458).	January 17, 2018
Multi-AZ support for read replicas	You can now create a read replica as a Multi-AZ DB instance. Amazon RDS creates a standby of your replica in another Availability Zone for failover support for the replica. Creating your read replica as a Multi-AZ DB instance is independent of whether the source database is a Multi-AZ DB instance. For more information, see Working with Read Replicas (p. 250).	January 11, 2018
Amazon RDS for MariaDB supports a new major version	You can now create Amazon RDS DB instances running MariaDB version 10.2. For more information, see MariaDB 10.2 Support on Amazon RDS (p. 501).	January 3, 2018
Amazon Aurora with PostgreSQL compatibility available in new AWS Region	Aurora PostgreSQL is now available in the EU (Paris) region. For the complete list of AWS Regions for Aurora PostgreSQL, see Availability for Amazon Aurora PostgreSQL.	December 22, 2017
Aurora PostgreSQL supports new instance types	Aurora PostgreSQL now supports new instance types. For the complete list of instance types, see Choosing the DB Instance Class.	December 20, 2017
Oracle October 2017 PSU	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v10 and 11.2.0.4.v14 to support the October 2017 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes (p. 1092).	December 19, 2017
Amazon Aurora with MySQL compatibility available in new AWS Region	Aurora MySQL is now available in the EU (Paris) region. For the complete list of AWS Regions for Aurora MySQL, see Availability for Amazon Aurora MySQL.	December 18, 2017
Aurora MySQL supports hash joins	This feature can improve query performance when you need to join a large amount of data by using an equijoin. For more information, see Working with Hash Joins in Aurora MySQL.	December 11, 2017

Change	Description	Date Changed
Aurora MySQL supports native functions to invoke AWS Lambda functions	You can call the native functions `lambda_sync` and `lambda_async` when you use Aurora MySQL. For more information, see Invoking a Lambda Function from an Amazon Aurora MySQL DB Cluster.	December 11, 2017
Added Aurora PostgreSQL HIPAA eligibility	Aurora PostgreSQL now supports building HIPAA compliant applications. For more information, see Working with Amazon Aurora PostgreSQL.	December 6, 2017
Additional AWS Regions available for Amazon Aurora with PostgreSQL compatibility	Amazon Aurora with PostgreSQL compatibility is now available in four new AWS Regions. For more information, see Availability for Amazon Aurora PostgreSQL.	November 22, 2017
Modify storage for Amazon RDS DB instances running Microsoft SQL Server	You can now modify the storage of your Amazon RDS DB instances running SQL Server. For more information, see Modifying an Amazon RDS DB Instance (p. 220).	November 21, 2017
Amazon RDS supports 16 TiB storage for Linux-based engines	You can now create MySQL, MariaDB, PostgreSQL, and Oracle RDS DB instances with up to 16 TiB of storage. For more information, see Amazon RDS DB Instance Storage (p. 29).	November 21, 2017
Amazon RDS supports fast scale up of storage	You can now add storage to MySQL, MariaDB, PostgreSQL, and Oracle RDS DB instances in a few minutes. For more information, see Amazon RDS DB Instance Storage (p. 29).	November 21, 2017
Amazon RDS supports MariaDB versions 10.1.26 and 10.0.32	You can now create Amazon RDS DB instances running MariaDB versions 10.1.26 and 10.0.32. For more information, see MariaDB on Amazon RDS Versions (p. 499).	November 20, 2017
Amazon RDS for Microsoft SQL Server now supports new DB instance classes	You can now create Amazon RDS DB instances running SQL Server that use the db.r4 and db.m4.16xlarge DB instance classes. For more information, see DB Instance Class Support for Microsoft SQL Server (p. 546).	November 20, 2017
Amazon RDS for MySQL and MariaDB now supports new DB instance classes	You can now create Amazon RDS DB instances running MySQL and MariaDB that use the db.r4, db.m4.16xlarge, db.t2.xlarge, and db.t2.2xlarge DB instance classes. For more information, see DB Instance Classes (p. 7).	November 20, 2017
SQL Server 2017	You can now create Amazon RDS DB instances running Microsoft SQL Server 2017. You can also create DB instances running SQL Server 2016 SP1 CU5. For more information, see Microsoft SQL Server on Amazon RDS (p. 542).	November 17, 2017

Change	Description	Date Changed
Restore MySQL backups from Amazon S3	You can now create a backup of your on-premises database, store it on Amazon S3, and then restore the backup file onto a new Amazon RDS DB instance running MySQL. For more information, see Restoring a Backup into an Amazon RDS MySQL DB Instance (p. 747).	November 17, 2017
Auto Scaling with Aurora Replicas	Amazon Aurora MySQL now supports Aurora Auto Scaling. Aurora Auto Scaling dynamically adjusts the number of Aurora Replicas based on increases or decreases in connectivity or workload. For more information, see Using Amazon Aurora Auto Scaling with Aurora Replicas.	November 17, 2017
Oracle default edition support	Amazon RDS for Oracle DB instances now supports setting the default edition for the DB instance. For more information, see Setting the Default Edition for a DB Instance (p. 1019).	November 3, 2017
Oracle DB instance file validation	Amazon RDS for Oracle DB instances now supports validating DB instance files with the Oracle Recovery Manager (RMAN) logical validation utility. For more information, see Validating DB Instance Files (p. 1035).	November 3, 2017
Oracle July 2017 PSU	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v9 and 11.2.0.4.v13 to support the July 2017 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes (p. 1092).	November 3, 2017
Management Agent for OEM 13c	Amazon RDS Oracle DB instances now support the Management Agent for Oracle Enterprise Manager (OEM) Cloud Control 13c. For more information, see Oracle Management Agent for Enterprise Manager Cloud Control (p. 941).	November 1, 2017
PostgreSQL 9.6.5, 9.5.9, 9.4.14, and 9.3.19	You can now create Amazon RDS DB instances running PostgreSQL versions 9.6.5., 9.5.9, 9.4.14, and 9.3.19. For more information, see Supported PostgreSQL Database Versions (p. 1310).	November 1, 2017
Storage reconfiguration for Microsoft SQL Server snapshots	You can now reconfigure the storage when you restore a snapshot to an Amazon RDS DB instance running Microsoft SQL Server. For more information, see Restoring from a DB Snapshot (p. 303).	October 26, 2017
Asynchronous key prefetch for Aurora with MySQL compatibility	Asynchronous key prefetch (AKP) improves the performance of noncached index joins, by prefetching keys in memory ahead of when they are needed. For more information, see Working with Asynchronous Key Prefetch in Amazon Aurora.	October 26, 2017
MySQL 5.7.19, 5.6.37, and 5.5.57	You can now create Amazon RDS DB instances running MySQL versions 5.7.19, 5.6.37, and 5.5.57. For more information, see MySQL on Amazon RDS Versions (p. 713).	October 25, 2017

Change	Description	Date Changed
General availability of Amazon Aurora with PostgreSQL compatibility	Amazon Aurora with PostgreSQL compatibility makes it simple and cost-effective to set up, operate, and scale your new and existing PostgreSQL deployments, thus freeing you to focus on your business and applications. For more information, see Working with Amazon Aurora PostgreSQL.	October 24, 2017
Amazon RDS for Oracle DB instances support new DB instance classes	Amazon RDS Oracle DB instances now support Memory Optimized Next Generation (db.r4) instance classes. Amazon RDS Oracle DB instances also now support the following new current generation instance classes: db.m4.16xlarge, db.t2.xlarge, and db.t2.2xlarge. For more information, see DB Instance Classes (p. 7) and DB Instance Class Support for Oracle (p. 850).	October 23, 2017
New feature	Your new and existing Reserved Instances can now cover multiple sizes in the same DB instance class. Size-flexible reserved instances are available for DB instances with the same AWS Region, database engine, and instance family, and across AZ configuration. Size-flexible reserved instances are available for the following database engines: Amazon Aurora, MariaDB, MySQL, Oracle (Bring Your Own License), PostgreSQL. For more information, see Size-Flexible Reserved DB Instances (p. 46).	October 11, 2017
New feature	You can now use the Oracle SQLT option to tune a SQL statement for optimal performance. For more information, see Oracle SQLT (p. 979).	September 22, 2017
New feature	If you have existing manual DB snapshots of your Amazon RDS Oracle DB instances, you can now upgrade them to a later version of the Oracle database engine. For more information, see Upgrading an Oracle DB Snapshot (p. 893).	September 20, 2017
New feature	You can now use Oracle Spatial to store, retrieve, update, and query spatial data in your Amazon RDS DB instances running Oracle. For more information, see Oracle Spatial (p. 976).	September 15, 2017
New feature	You can now use Oracle Locator to support internet and wireless service-based applications and partner-based GIS solutions with your Amazon RDS DB instances running Oracle. For more information, see Oracle Locator (p. 957).	September 15, 2017
New feature	You can now use Oracle Multimedia to store, manage, and retrieve images, audio, video, and other heterogeneous media data in your Amazon RDS DB instances running Oracle. For more information, see Oracle Multimedia (p. 960).	September 15, 2017
New feature	You can now export audit logs from your Amazon Aurora MySQL DB clusters to Amazon CloudWatch Logs. For more information, see Publishing Aurora MySQL Logs to Amazon CloudWatch Logs.	September 14, 2017

Change	Description	Date Changed
New feature	Amazon RDS now supports multiple versions of Oracle Application Express (APEX) for your DB instances running Oracle. For more information, see Oracle Application Express (p. 927).	September 13, 2017
New feature	You can now use Amazon Aurora to migrate an unencrypted or encrypted DB snapshot or Amazon RDS MySQL DB instance to an encrypted Aurora MySQL DB cluster. For more information, see Migrating an RDS MySQL Snapshot to Aurora and Migrating Data from a MySQL DB Instance to an Amazon Aurora MySQL DB Cluster by Using an Aurora Read Replica.	September 5, 2017
New feature	You can use Amazon RDS for Microsoft SQL Server databases to build HIPAA-compliant applications. For more information, see Compliance Program Support for Microsoft SQL Server DB Instances (p. 548).	August 31, 2017
New feature	You can now use Amazon RDS for MariaDB databases to build HIPAA-compliant applications. For more information, see MariaDB on Amazon RDS (p. 497).	August 31, 2017
New feature	You can now create Amazon RDS DB instances running Microsoft SQL Server with allocated storage up to 16 TiB, and Provisioned IOPS to storage ranges of 1:1–50:1. For more information, see Amazon RDS DB Instance Storage (p. 29).	August 22, 2017
New feature	You can now use Multi-AZ deployments for DB instances running Microsoft SQL Server in the EU (Frankfurt) region. For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).	August 3, 2017
New feature	You can now create Amazon RDS DB instances running MariaDB versions 10.1.23 and 10.0.31. For more information, see MariaDB on Amazon RDS Versions (p. 499).	July 17, 2017
New feature	Amazon RDS now supports Microsoft SQL Server Enterprise Edition with the License Included model in all AWS Regions. For more information, see Licensing Microsoft SQL Server on Amazon RDS (p. 559).	July 13, 2017
New feature	Amazon RDS for Oracle now supports Linux kernel huge pages for increased database scalability. The use of huge pages results in smaller page tables and less CPU time spent on memory management, increasing the performance of large database instances. You can use huge pages with your Amazon RDS DB instances running all editions of Oracle versions 12.1.0.2 and 11.2.0.4. For more information, see Using Huge Pages with an Oracle DB Instance (p. 867).	July 7, 2017

Change	Description	Date Changed
New feature	Updated to support encryption at rest (EAR) for db.t2.small and db.t2.medium DB instance classes for all non-Aurora DB engines. For more information, see Availability of Amazon RDS Encryption (p. 1359).	June 27, 2017
New feature	Updated to support Amazon Aurora in the Europe (Frankfurt) region. For more information, see Availability for Amazon Aurora MySQL.	June 16, 2017
New feature	You can now specify an option group when you copy a DB snapshot across AWS regions. For more information, see Option Group Considerations (p. 307).	June 12, 2017
New feature	You can now copy DB snapshots created from specialized DB instances across AWS regions. You can copy snapshots from DB instances that use Oracle TDE, Microsoft SQL Server TDE, and Microsoft SQL Server Multi-AZ with Mirroring. For more information, see Copying a DB Snapshot (p. 308).	June 12, 2017
New feature	Amazon Aurora now allows you to quickly and cost-effectively copy all of your databases in an Amazon Aurora DB cluster. For more information, see Cloning Databases in an Aurora DB Cluster.	June 12, 2017
New feature	Amazon RDS now supports Microsoft SQL Server 2016 SP1 CU2. For more information, see Microsoft SQL Server on Amazon RDS (p. 542).	June 7, 2017
New feature	Amazon RDS for Oracle has released database engine versions 12.1.0.2.v8 and 11.2.0.4.v12 to support the April 2017 Oracle Database Patch Set Update (PSU). For more information, see Oracle Database Engine Release Notes (p. 1092).	May 23, 2017
New Feature	Amazon RDS now supports PostgreSQL versions 9.6.2, 9.5.6, 9.4.11, and 9.3.16. For more information, see Supported PostgreSQL Database Versions (p. 1310)	May 3, 2017
Preview	Public preview of Amazon Aurora with PostgreSQL Compatibility. For more information, see Working with Amazon Aurora PostgreSQL.	April 19, 2017
New feature	Amazon Aurora now allows you to execute an ALTER TABLE *tbl_name* ADD COLUMN *col_name* *column_definition* operation nearly instantaneously. The operation completes without requiring the table to be copied and without materially impacting other DML statements. For more information, see Altering Tables in Amazon Aurora Using Fast DDL.	April 5, 2017
New feature	We have added a new monitoring command, SHOW VOLUME STATUS, to display the number of nodes and disks in a volume. For more information, see Displaying Volume Status for an Aurora DB Cluster.	April 5, 2017

Change	Description	Date Changed
New feature	Amazon RDS for Oracle now includes the January 2017 Oracle Database Patch Set Update (PSU). This adds support for database engine versions 12.1.0.2.v7 and 11.2.0.4.v11. For more information, see Oracle Database Engine Release Notes (p. 1092).	March 21, 2017
New feature	You can now use your own custom logic in your custom password verification functions for Oracle on Amazon RDS. For more information, see Creating Custom Functions to Verify Passwords (p. 1007).	March 21, 2017
New feature	You can now access your online and archived redo log files on your Oracle DB instances on Amazon RDS. For more information, see Accessing Transaction Logs (p. 1030).	March 21, 2017
New feature	You can now copy both encrypted and unencrypted DB cluster snapshots between accounts in the same region. For more information, see Copying a DB Cluster Snapshot Across Accounts.	March 7, 2017
New feature	You can now share encrypted DB cluster snapshots between accounts in the same region. For more information, see Sharing a DB Cluster Snapshot.	March 7, 2017
New feature	You can now replicate encrypted Amazon Aurora MySQL DB clusters to create cross-region Aurora Replicas. For more information, see Replicating Aurora MySQL DB Clusters Across AWS Regions.	March 7, 2017
New feature	You can now require that all connections to your DB instance running Microsoft SQL Server use Secure Sockets Layer (SSL). For more information, see Using SSL with a Microsoft SQL Server DB Instance (p. 609).	February 27, 2017
New feature	You can now set your local time zone to one of 15 additional time zones. For more information, see Supported Time Zones (p. 555).	February 27, 2017
New feature	You can now use the Amazon RDS procedure `msdb.dbo.rds_shrink_tempdbfile` to shrink the tempdb database on your DB instances running Microsoft SQL Server. For more information, see Shrinking the tempdb Database (p. 694).	February 17, 2017
New feature	You can now compress your backup file when you export your Enterprise and Standard Edition Microsoft SQL Server database from an Amazon RDS DB instance to Amazon S3. For more information, see Compressing Backup Files (p. 589).	February 17, 2017
New feature	Amazon RDS now supports custom DNS servers to resolve DNS names used in outbound network access on your DB instances running Oracle. For more information, see Setting Up a Custom DNS Server (p. 1010).	January 26, 2017

Change	Description	Date Changed
New feature	Amazon RDS now supports creating an encrypted read replica in another region. For more information, see Creating a Read Replica in a Different AWS Region (p. 257) and CreateDBInstanceReadReplica.	January 23, 2017
New feature	Amazon RDS now supports upgrading a MySQL DB snapshot from MySQL 5.1 to MySQL 5.5. For more information, see Upgrading a MySQL DB Snapshot (p. 739) and ModifyDBSnapshot.	January 20, 2017
New feature	Amazon RDS now supports copying an encrypted DB snapshot to another region for the MariaDB, MySQL, Oracle, PostgreSQL, and Microsoft SQL Server database engines. For more information, see Copying a DB Snapshot (p. 308) and CopyDBSnapshot.	December 20, 2016
New feature	Amazon RDS now supports migrating an Amazon RDS MySQL 5.6 DB snapshot to a new DB instance running MariaDB 10.1. For more information, see Migrating Data from a MySQL DB Snapshot to a MariaDB DB Instance (p. 519).	December 20, 2016
New feature	Amazon Aurora MySQL now supports spatial indexing. Spatial indexing improves query performance on large datasets for queries that use spatial data. For more information, see Amazon Aurora MySQL and Spatial Data.	December 14, 2016
New feature	Amazon RDS for Oracle now includes the October 2016 Oracle Database Patch Set Update (PSU). This adds support for Oracle database engine versions 12.1.0.2.v6 and 11.2.0.4.v10. For more information, see Oracle Database Engine Release Notes (p. 1092).	December 12, 2016
New feature	Amazon RDS now supports outbound network access on your DB instances running Oracle. You can use utl_http, utl_tcp, and utl_smtp to connect from your DB instance to the network. For more information, see Using utl_http, utl_tcp, and utl_smtp with an Oracle DB Instance (p. 870).	December 5, 2016
New feature	Amazon RDS has retired support for MySQL version 5.1. However, you can restore existing MySQL 5.1 snapshots to a MySQL 5.5 instance. For more information, see Supported Storage Engines for MySQL on Amazon RDS (p. 715).	November 15, 2016
New feature	Amazon RDS now supports PostgreSQL version 9.6.1. For more information, see PostgreSQL Version 9.6.1 on Amazon RDS (p. 1321).	November 11, 2016
New feature	Amazon RDS now supports Microsoft SQL Server 2016 RTM CU2. For more information, see Microsoft SQL Server on Amazon RDS (p. 542).	November 4, 2016

Change	Description	Date Changed
New feature	Amazon RDS now supports major version upgrades for DB instances running Oracle. You can now upgrade your Oracle DB instances from 11g to 12c. For more information, see Upgrading the Oracle DB Engine (p. 888).	November 2, 2016
New feature	You can now create DB instances running Microsoft SQL Server 2014 Enterprise Edition. Amazon RDS now supports SQL Server 2014 SP2 for all editions and all regions. For more information, see Microsoft SQL Server on Amazon RDS (p. 542).	October 25, 2016
New feature	Amazon Aurora MySQL now integrates with other AWS services: You can load text or XML data into a table from an Amazon S3 bucket, or invoke an AWS Lambda function from database code. For more information, see Integrating Aurora MySQL with Other AWS Services.	October 18, 2016
New feature	You can now access the tempdb database on your Amazon RDS DB instances running Microsoft SQL Server. You can access the tempdb database by using Transact-SQL through Microsoft SQL Server Management Studio (SSMS), or any other standard SQL client application. For more information, see Accessing the tempdb Database on Microsoft SQL Server DB Instances on Amazon RDS (p. 694).	September 29, 2016
New feature	You can now use the UTL_MAIL package with your Amazon RDS DB instances running Oracle. For more information, see Oracle UTL_MAIL (p. 992).	September 20, 2016
New feature	Amazon RDS for Oracle now includes the July 2016 Oracle Database Patch Set Update (PSU). This adds support for Oracle database engine versions 12.1.0.2.v5, 12.1.0.1.v6, and 11.2.0.4.v9. For more information, see Oracle Database Engine Release Notes (p. 1092).	September 20, 2016
New features	You can now set the time zone of your new Microsoft SQL Server DB instances to a local time zone, to match the time zone of your applications. For more information, see Local Time Zone for Microsoft SQL Server DB Instances (p. 555).	September 19, 2016
New features	Added support for new PostgreSQL versions 9.5.4, 9.4.9, and 9.3.14. Also added support for PostgreSQL logical replication, PostgreSQL event triggers, and RAM disk for the PostgreSQL stats_temp_directory. For more information, see Supported PostgreSQL Database Versions (p. 1310), Logical Replication for PostgreSQL on Amazon RDS (p. 1349), Event Triggers for PostgreSQL on Amazon RDS (p. 1350), and RAM Disk for the stats_temp_directory (p. 1352).	September 14, 2016

Change	Description	Date Changed
New feature	You can now use the Oracle Label Security option to control access to individual table rows in your Amazon RDS DB instances running Oracle 12c. With Oracle Label Security, you can enforce regulatory compliance with a policy-based administration model, and ensure that an access to sensitive data is restricted to only users with the appropriate clearance level. For more information, see Oracle Label Security (p. 954).	September 8, 2016
New feature	You can now connect to an Amazon Aurora DB cluster using the reader endpoint, which load-balances connections across the Aurora Replicas that are available in the DB cluster. As clients request new connections to the reader endpoint, Aurora distributes the connection requests among the Aurora Replicas in the DB cluster. This functionality can help balance your read workload across multiple Aurora Replicas in your DB cluster. For more information, see Amazon Aurora Endpoints.	September 8, 2016
New feature	You can now support the Oracle Enterprise Manager Cloud Control on your Amazon RDS DB instances running Oracle. You can enable the Management Agent on your DB instances, and share data with your Oracle Management Service (OMS). For more information, see Oracle Management Agent for Enterprise Manager Cloud Control (p. 941).	September 1, 2016
New feature	This release adds support to get an ARN for a resource. For more information, see Getting an Existing ARN (p. 274).	August 23, 2016
New feature	You can now assign up to 50 tags for each Amazon RDS resource, for managing your resources and tracking costs. For more information, see Tagging Amazon RDS Resources (p. 266).	August 19, 2016
New feature	Amazon RDS now supports the License Included model for Oracle Standard Edition Two. For more information, see Creating an Amazon RDS DB Instance (p. 136). You can now change the license model of your Amazon RDS DB instances running Microsoft SQL Server and Oracle. For more information, see Licensing Microsoft SQL Server on Amazon RDS (p. 559) and Oracle Licensing (p. 847).	August 5, 2016
New feature	You can now use the AWS Management Console to easily move your DB instance to a different VPC, or to a different subnet group in the same VPC. For more information, see Updating the VPC for a DB Instance (p. 1447). If your DB instance is not in a VPC, you can now use the AWS Management Console to easily move your DB instance into a VPC. For more information, see Moving a DB Instance Not in a VPC into a VPC (p. 1447).	August 4, 2016

Change	Description	Date Changed
New feature	Amazon RDS now supports native backup and restore for Microsoft SQL Server databases using full backup files (.bak files). You can now easily migrate SQL Server databases to Amazon RDS, and import and export databases in a single, easily-portable file, using Amazon S3 for storage, and AWS KMS for encryption. For more information, see Importing and Exporting SQL Server Databases (p. 576).	July 27, 2016
New feature	You can now copy the source files from a MySQL database to an Amazon Simple Storage Service (Amazon S3) bucket, and then restore an Amazon Aurora DB cluster from those files. This option can be considerably faster than migrating data using `mysqldump`. For more information, see Migrating Data from an External MySQL Database to an Aurora MySQL DB Cluster.	July 20, 2016
New feature	You can now restore an unencrypted Amazon Aurora DB cluster snapshot to create an encrypted Amazon Aurora DB cluster by including an AWS Key Management Service (AWS KMS) encryption key during the restore operation. For more information, see Encrypting Amazon RDS Resources.	June 30, 2016
New feature	Amazon RDS for Oracle now includes the April 2016 Oracle Database Patch Set Update (PSU). This PSU adds support for Oracle database engine versions 12.1.0.2.v4, 12.1.0.1.v5, and 11.2.0.4.v8. For more information, see Oracle Database Engine Release Notes (p. 1092).	June 17, 2016
New feature	You can use the Oracle Repository Creation Utility (RCU) to create a repository on Amazon RDS for Oracle. For more information, see Using the Oracle Repository Creation Utility on Amazon RDS for Oracle (p. 1084).	June 17, 2016
New feature	Adds support for PostgreSQL cross-region read replicas. For more information, see Creating a Read Replica in a Different AWS Region (p. 257).	June 16, 2016
New feature	You can now use the AWS Management Console to easily add Multi-AZ with Mirroring to a Microsoft SQL Server DB instance. For more information, see Adding Multi-AZ to a Microsoft SQL Server DB Instance (p. 603).	June 9, 2016
New feature	You can now use Multi-AZ Deployments Using SQL Server Mirroring in the following additional regions: Asia Pacific (Sydney), Asia Pacific (Tokyo), and South America (Sao Paulo). For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).	June 9, 2016
New feature	Updated to support MariaDB version 10.1. For more information, see MariaDB on Amazon RDS (p. 497).	June 1, 2016

Change	Description	Date Changed
New feature	Updated to support Amazon Aurora cross-region DB clusters that are read replicas. For more information, see Replicating Aurora MySQL DB Clusters Across AWS Regions.	June 1, 2016
New feature	Enhanced Monitoring is now available for Oracle DB instances. For more information, see Enhanced Monitoring (p. 362) and Modifying an Amazon RDS DB Instance (p. 220).	May 27, 2016
New feature	Updated to support manual snapshot sharing for Amazon Aurora DB cluster snapshots. For more information, see Sharing a DB Cluster Snapshot.	May 18, 2016
New feature	You can now use the MariaDB Audit Plugin to log database activity on MariaDB and MySQL database instances. For more information, see Options for MariaDB Database Engine (p. 531) and Options for MySQL DB Instances (p. 794).	April 27, 2016
New feature	In-place, major version upgrades are now available for upgrading from MySQL version 5.6 to version 5.7. For more information, see Upgrading the MySQL DB Engine (p. 733).	April 26, 2016
New feature	Enhanced Monitoring is now available for Microsoft SQL Server DB instances. For more information, see Enhanced Monitoring (p. 362).	April 22, 2016
New feature	Added support for PostgreSQL versions 9.5.2, 9.4.7, and 9.3.12. For more information, see Supported PostgreSQL Database Versions (p. 1310).	April 8, 2016
New feature	Updated to support Oracle database versions 11.2.0.4.v7, 12.1.0.1.v4, and 12.1.0.2.v3 with the January 2016 Oracle Patch Set Updates (PSU). For more information, see Oracle Database Engine Release Notes (p. 1092).	April 1, 2016
New feature	Updated to provide an Amazon Aurora **Clusters** view in the Amazon RDS console. For more information, see Viewing an Aurora DB Cluster.	April 1, 2016
New feature	Updated to support SQL Server Multi-AZ with mirroring in the Asia Pacific (Seoul) region. For more information, see Multi-AZ Deployments for Microsoft SQL Server (p. 603).	March 31, 2016
New feature	Updated to support Amazon Aurora Multi-AZ with mirroring in the Asia Pacific (Seoul) region. For more information, see Availability for Amazon Aurora MySQL.	March 31, 2016
New feature	PostgreSQL DB instances have the ability to require connections to use SSL. For more information, see Using SSL with a PostgreSQL DB Instance (p. 1353).	March 25, 2016

Change	Description	Date Changed
New feature	Enhanced Monitoring is now available for PostgreSQL DB instances. For more information, see Enhanced Monitoring (p. 362).	March 25, 2016
New feature	Microsoft SQL Server DB instances can now use Windows Authentication for user authentication. For more information, see Using Windows Authentication with an Amazon RDS for SQL Server DB Instance (p. 612).	March 23, 2016
New feature	Enhanced Monitoring is now available in the Asia Pacific (Seoul) region. For more information, see Enhanced Monitoring (p. 362).	March 16, 2016
New feature	You can now customize the order in which Aurora Replicas are promoted to primary instance during a failover. For more information, see Fault Tolerance for an Aurora DB Cluster.	March 14, 2016
New feature	Updated to support encryption when migrating to an Aurora DB cluster. For more information, see Migrating Data to an Aurora DB Cluster.	March 2, 2016
New feature	Updated to support local time zone for Aurora DB clusters. For more information, see Local Time Zone for Aurora DB Clusters.	March 1, 2016
New feature	Updated to add support for MySQL version 5.7 for current generation Amazon RDS DB instance classes.	February 22, 2016
New feature	Updated to support *db.r3* and *db.t2* DB instance classes in the AWS GovCloud (US-West) region.	February 11, 2016
New feature	Updated to support encrypting copies of DB snapshots and sharing encrypted DB snapshots. For more information, see Copying a Snapshot (p. 306) and Sharing a DB Snapshot (p. 315).	February 11, 2016
New feature	Updated to support Amazon Aurora in the Asia Pacific (Sydney) region. For more information, see Availability for Amazon Aurora MySQL.	February 11, 2016
New feature	Updated to support SSL for Oracle DB Instances. For more information, see Using SSL with an Oracle DB Instance (p. 853).	February 9, 2016
New feature	Updated to support local time zone for MySQL and MariaDB DB instances. For more information, see Local Time Zone for MySQL DB Instances (p. 720) and Local Time Zone for MariaDB DB Instances (p. 507).	December 21, 2015
New feature	Updated to support Enhanced Monitoring of OS metrics for MySQL and MariaDB instances and Aurora DB clusters. For more information, see Viewing DB Instance Metrics (p. 356).	December 18, 2015

Change	Description	Date Changed
New feature	Updated to support Oracle Standard Edition Two with Bring-Your- Own-License licensing. Also added support for Oracle versions 11.2.0.4.v5, 12.1.0.1.v3, and 12.1.0.2.v2. For more information, see Oracle Database Engine Release Notes (p. 1092).	December 14, 2015
New feature	Updated to support db.t2, db.r3, and db.m4 DB instance classes for MySQL version 5.5. For more information, see DB Instance Classes (p. 7).	December 4, 2015
New feature	Updated to support modifying the database port for an existing DB instance.	December 3, 2015
New feature	Updated to support three new extensions for PostgreSQL versions 9.3.10 and 9.4.5 DB instances. For more information, see Supported PostgreSQL Database Versions (p. 1310).	December 1, 2015
New feature	Updated to support PostgreSQL versions 9.3.10 and 9.4.5 DB instances. For more information, see Supported PostgreSQL Database Versions (p. 1310).	November 27, 2015
New feature	Updated to support major version upgrades of the database engine for PostgreSQL instances. For more information, see Upgrading the PostgreSQL DB Engine for Amazon RDS (p. 1235).	November 19, 2015
New feature	Updated to support modifying the public accessibility of an existing DB instance. Updated to support db.m4 standard DB instance classes.	November 11, 2015
New feature	Updated to support manual DB snapshot sharing. For more information, see Sharing a DB Snapshot (p. 315).	October 28, 2015
New feature	Updated to support Microsoft SQL Server 2014 for the Web, Express, and Standard editions.	October 26, 2015
New feature	Updated to support the MySQL-based MariaDB database engine. For more information, see MariaDB on Amazon RDS (p. 497).	October 7, 2015
New feature	Updated to support Amazon Aurora in the Asia Pacific (Tokyo) region. For more information, see Availability for Amazon Aurora MySQL.	October 7, 2015
New feature	Updated to support db.t2 burst-capable DB instance classes for all DB engines and the addition of the db.t2.large DB instance class. For more information, see DB Instance Classes (p. 7).	September 25, 2015
New feature	Updated to support Oracle DB instances on R3 and T2 DB instance classes. For more information, see DB Instance Classes (p. 7).	August 5, 2015
New feature	Updated to support PostgreSQL versions 9.4.4 and 9.3.9. For more information, see Supported PostgreSQL Database Versions (p. 1310).	July 30, 2015

Change	Description	Date Changed
New feature	Microsoft SQL Server Enterprise Edition is now available with the License Included service model. For more information, see Licensing Microsoft SQL Server on Amazon RDS (p. 559).	July 29, 2015
New feature	Amazon Aurora has officially released. The Amazon Aurora DB engine supports multiple DB instances in a DB cluster. For detailed information, see What Is Amazon Aurora?.	July 27, 2015
New feature	Updated to support copying tags to DB snapshots.	July 20, 2015
New feature	Updated to support Oracle 12c database version "12.1.0.2", including the In-Memory option, Oracle 11g April PSU patches, and improved integration with AWS CloudHSM.	July 20, 2015
New feature	Updated to support increases in storage size for all DB engines and an increase in Provisioned IOPS for SQL Server.	June 18, 2015
New feature	Updated options for reserved DB instances.	June 15, 2015
New feature	Updated to support Oracle version 12c.	April 2, 2015
New feature	Updated to support PostgreSQL versions 9.3.6 and 9.4.1.	March 18, 2015
New feature	Updated to support using Amazon CloudHSM with Oracle DB instances using TDE.	January 8, 2015
New feature	Updated to support encrypting data at rest and new API version 2014-10-31.	January 6, 2015
New feature	Updated to support Oracle version 11.2.0.4.v3 that includes the PSU released in October 2014.	November 20, 2014
New feature	Updated to include the new Amazon DB engine: Aurora. The Amazon Aurora DB engine supports multiple DB instances in a DB cluster. Amazon Aurora is currently in preview release and is subject to change. For detailed information, see What Is Amazon Aurora?.	November 12, 2014
New feature	Updated to support PostgreSQL read replicas.	November 10, 2014
New features	Updated to support Oracle 11.2.0.4v2.	October 16, 2014
New API and features	Updated to support the GP2 storage type and new API version 2014-09-01. Updated to support the ability to copy an existing option or parameter group to create a new option or parameter group.	October 7, 2014
New feature	Updated to support InnoDB Cache Warming for DB instances running MySQL version 5.6.19 and later.	September 3, 2014
New feature	Updated to support SSL certificate verification when connecting to MySQL version 5.6, SQL Server, and PostgreSQL database engines.	August 5, 2014

Change	Description	Date Changed
New feature	Updated to support the db.t2 burst-capable DB instance classes.	August 4, 2014
New feature	Updated to support the db.r3 memory-optimized DB instance classes for use with the MySQL (version 5.6), SQL Server, and PostgreSQL database engines.	May 28, 2014
New feature	Updated to support SQL Server Multi-AZ deployments using SQL Server Mirroring.	May 19, 2014
New feature	Updated to support upgrades from MySQL version 5.5 to version 5.6.	April 23, 2014
New feature	Updated to support Oracle 11.2.0.4.	April 23, 2014
New feature	Updated to support Oracle GoldenGate.	April 3, 2014
New feature	Updated to support the M3 DB instance classes.	February 20, 2014
New feature	Updated to support the Oracle Timezone option.	January 13, 2014
New feature	Updated to support replication between Amazon RDS MySQL DB instances in different regions.	November 26, 2013
New feature	Updated to support the PostgreSQL DB engine.	November 14, 2013
New feature	Updated to support SQL Server transparent data encryption (TDE).	November 7, 2013
New API and new feature	Updated to support cross region DB snapshot copies; new API version, 2013-09-09.	October 31, 2013
New features	Updated to support Oracle Statspack.	September 26, 2013
New features	Updated to support using replication to import or export data between instances of MySQL running in Amazon RDS and instances of MySQL running on-premises or on Amazon EC2.	September 5, 2013
New features	Updated to support the db.cr1.8xlarge DB instance class for MySQL 5.6.	September 4, 2013
New feature	Updated to support replication of read replicas.	August 28, 2013
New feature	Updated to support parallel read replica creation.	July 22, 2013
New feature	Updated to support fine-grained permissions and tagging for all Amazon RDS resources.	July 8, 2013
New feature	Updated to support MySQL 5.6 for new instances, including support for the MySQL 5.6 memcached interface and binary log access.	July 1, 2013
New feature	Updated to support major version upgrades from MySQL 5.1 to MySQL 5.5.	June 20, 2013
New feature	Updated DB parameter groups to allow expressions for parameter values.	June 20, 2013

Change	Description	Date Changed
New API and new feature	Updated to support read replica status; new API version, 2013-05-15.	May 23, 2013
New features	Updated to support Oracle Advanced Security features for native network encryption and Oracle Transparent Data Encryption.	April 18, 2013
New features	Updated to support major version upgrades for SQL Server and additional functionality for Provisioned IOPS.	March 13, 2013
New feature	Updated to support VPC By Default for RDS.	March 11, 2013
New API and feature	Updated to support log access; new API version 2013-02-12	March 4, 2013
New feature	Updated to support RDS event notification subscriptions.	February 4, 2013
New API and feature	Updated to support DB instance renaming and the migration of DB security group members in a VPC to a VPC security group.	January 14, 2013
New feature	Updated for AWS GovCloud (US-West) support.	December 17, 2012
New feature	Updated to support m1.medium and m1.xlarge DB Instance classes.	November 6, 2012
New feature	Updated to support read replica promotion.	October 11, 2012
New feature	Updated to support SSL in Microsoft SQL Server DB Instances.	October 10, 2012
New feature	Updated to support Oracle micro DB Instances.	September 27, 2012
New feature	Updated to support SQL Server 2012.	September 26, 2012
New API and feature	Updated to support provisioned IOPS. API version 2012-09-17.	September 25, 2012
New features	Updated for SQL Server support for DB Instances in VPC and Oracle support for Data Pump.	September 13, 2012
New feature	Updated for support for SQL Server Agent.	August 22, 2012
New feature	Updated for support for tagging of DB Instances.	August 21, 2012
New features	Updated for support for Oracle APEX and XML DB, Oracle time zones, and Oracle DB Instances in a VPC.	August 16, 2012
New features	Updated for support for SQL Server Database Engine Tuning Advisor and Oracle DB Instances in VPC.	July 18, 2012
New feature	Updated for support for option groups and first option, Oracle Enterprise Manager Database Control.	May 29, 2012
New feature	Updated for support for read replicas in Amazon Virtual Private Cloud.	May 17, 2012
New feature	Updated for Microsoft SQL Server support.	May 8, 2012

Change	Description	Date Changed
New features	Updated for support for forced failover, Multi-AZ deployment of Oracle DB Instances, and nondefault character sets for Oracle DB Instances.	May 2, 2012
New feature	Updated for Amazon Virtual Private Cloud (VPC) Support.	February 13, 2012
Updated content	Updated for new Reserved Instance types.	December 19, 2011
New feature	Updated for Oracle engine support.	May 23, 2011
Updated content	Console updates.	May 13, 2011
Updated content	Edited content for shortened backup and maintenance windows.	February 28, 2011
New feature	Added support for MySQL 5.5.	January 31, 2011
New feature	Added support for read replicas.	October 4, 2010
New feature	Added support for AWS Identity and Access Management (IAM).	September 2, 2010
New feature	Added DB Engine Version Management.	August 16, 2010
New feature	Added Reserved DB Instances.	August 16, 2010
New Feature	Amazon RDS now supports SSL connections to your DB Instances.	June 28, 2010
New Guide	This is the first release of the Amazon RDS User Guide.	June 7, 2010

AWS glossary

For the latest AWS terminology, see the AWS glossary in the *AWS General Reference*.