
Amazon Athena

User Guide

Amazon's trademarks and trade dress may not be used in connection with any product or service that is not Amazon's, in any manner that is likely to cause confusion among customers, or in any manner that disparages or discredits Amazon. All other trademarks not owned by Amazon are the property of their respective owners, who may or may not be affiliated with, connected to, or sponsored by Amazon.

Table of Contents

What is Amazon Athena?	1
When should I use Athena?	1
Accessing Athena	1
Understanding Tables, Databases, and the Data Catalog	2
AWS Service Integrations with Athena	3
Release Notes	6
June 26, 2019	7
May 24, 2019	7
March 05, 2019	7
February 22, 2019	8
February 18, 2019	8
November 20, 2018	9
October 15, 2018	10
October 10, 2018	10
September 6, 2018	10
August 23, 2018	11
August 16, 2018	11
August 7, 2018	12
June 5, 2018	12
Support for Views	12
Improvements and Updates to Error Messages	12
Bug Fixes	13
May 17, 2018	13
April 19, 2018	13
April 6, 2018	14
March 15, 2018	14
February 2, 2018	14
January 19, 2018	14
November 13, 2017	15
November 1, 2017	15
October 19, 2017	15
October 3, 2017	15
September 25, 2017	15
August 14, 2017	16
August 4, 2017	16
June 22, 2017	16
June 8, 2017	16
May 19, 2017	16
Improvements	17
Bug Fixes	17
April 4, 2017	17
Features	17
Improvements	18
Bug Fixes	18
March 24, 2017	18
Features	18
Improvements	18
Bug Fixes	19
February 20, 2017	19
Features	19
Improvements	20
Setting Up	21
Sign Up for AWS	21
To create an AWS account	21

Create an IAM User	21
To create a group for administrators	21
To create an IAM user for yourself, add the user to the administrators group, and create a password for the user	22
Attach Managed Policies for Using Athena	22
Getting Started	23
Prerequisites	23
Step 1: Create a Database	23
Step 2: Create a Table	24
Step 3: Query Data	25
Accessing Amazon Athena	27
Using the Console	27
Using the API	27
Using the CLI	27
Creating Tables and Databases	28
Tables and Databases Creation Process in Athena	28
Requirements for Tables in Athena and Data in Amazon S3	29
Functions Supported	29
Transactional Data Transformations Are Not Supported	29
Operations That Change Table States Are ACID	29
All Tables Are EXTERNAL	30
To create a table using the AWS Glue Data Catalog	30
To create a table using the wizard	30
To create a database using Hive DDL	30
To create a table using Hive DDL	31
Names for Tables, Databases, and Columns	32
Table names and table column names in Athena must be lowercase	32
Athena table, view, database, and column names allow only underscore special characters	32
Names that begin with an underscore	32
Table or view names that include numbers	32
Reserved Keywords	33
List of Reserved Keywords in DDL Statements	33
List of Reserved Keywords in SQL SELECT Statements	33
Examples of Queries with Reserved Words	34
Table Location in Amazon S3	34
Table Location and Partitions	35
Partitioning Data	36
Scenario 1: Data already partitioned and stored on S3 in hive format	36
Scenario 2: Data is not partitioned	38
Columnar Storage Formats	39
Converting to Columnar Formats	40
Overview	40
Before you begin	23
Example: Converting data to Parquet using an EMR cluster	42
Connecting to Data Sources	45
Integration with AWS Glue	45
Using AWS Glue to Connect to Data Sources in Amazon S3	46
Best Practices When Using Athena with AWS Glue	48
Upgrading to the AWS Glue Data Catalog Step-by-Step	56
FAQ: Upgrading to the AWS Glue Data Catalog	58
Using a Hive Metastore	60
Considerations and Limitations	60
Connecting Athena to an Apache Hive Metastore	61
Using Amazon Athena Federated Query (Preview)	62
Considerations and Limitations	62
Deploying a Connector and Connecting to a Data Source	63
Using the AWS Serverless Application Repository	64

Athena Data Source Connectors	65
Writing Federated Queries	67
Writing a Data Source Connector	70
Managing Data Sources	71
Connecting to Amazon Athena with ODBC and JDBC Drivers	71
Using Athena with the JDBC Driver	71
Connecting to Amazon Athena with ODBC	73
Running Queries	76
Query Results and Query History	107
Getting a Query ID	108
Identifying Query Output Files	108
Downloading Query Results Files Using the Athena Console	110
Specifying a Query Result Location	110
Viewing Query History	112
Working with Views	113
When to Use Views?	113
Supported Actions for Views in Athena	114
Considerations for Views	114
Limitations for Views	115
Working with Views in the Console	115
Creating Views	116
Examples of Views	117
Updating Views	118
Deleting Views	118
Creating a Table from Query Results (CTAS)	118
Considerations and Limitations for CTAS Queries	118
Running CTAS Queries in the Console	119
Bucketing vs Partitioning	122
Examples of CTAS Queries	123
Handling Schema Updates	126
Summary: Updates and Data Formats in Athena	127
Index Access in ORC and Parquet	128
Types of Updates	129
Updates in Tables with Partitions	134
Querying Arrays	135
Creating Arrays	136
Concatenating Arrays	137
Converting Array Data Types	138
Finding Lengths	138
Accessing Array Elements	139
Flattening Nested Arrays	140
Creating Arrays from Subqueries	142
Filtering Arrays	143
Sorting Arrays	143
Using Aggregation Functions with Arrays	144
Converting Arrays to Strings	144
Using Arrays to Create Maps	145
Querying Arrays with Complex Types and Nested Structures	146
Querying JSON	151
Best Practices for Reading JSON Data	151
Extracting Data from JSON	153
Searching for Values in JSON Arrays	155
Obtaining Length and Size of JSON Arrays	156
Querying Geospatial Data	157
What is a Geospatial Query?	158
Input Data Formats and Geometry Data Types	158
List of Supported Geospatial Functions	159

Examples: Geospatial Queries	167
Using ML with Athena (Preview)	169
Considerations and Limitations	169
ML with Athena (Preview) Syntax	169
Querying with UDFs (Preview)	170
Considerations and Limitations	171
UDF Query Syntax	171
Creating and Deploying a UDF Using Lambda	173
Querying AWS Service Logs	178
Querying AWS CloudTrail Logs	178
Querying Amazon CloudFront Logs	182
Querying Amazon EMR Logs	183
Querying Classic Load Balancer Logs	187
Querying Network Load Balancer Logs	188
Querying Application Load Balancer Logs	189
Querying Amazon VPC Flow Logs	191
Querying AWS WAF Logs	193
Security	196
Data Protection	196
Encryption at Rest	197
Encryption in Transit	202
Key Management	202
Internet Traffic Privacy	202
Identity and Access Management	203
Managed Policies for User Access	203
Access through JDBC and ODBC Connections	207
Access to Amazon S3	207
Fine-Grained Access to Databases and Tables	207
Access to Encrypted Metadata in the Data Catalog	214
Cross-account Access	214
Access to Workgroups and Tags	215
Allow Access to an Athena Data Connector for External Hive Metastore (Preview)	215
Allow Access to Athena Federated Query (Preview)	217
Allow Access to Athena UDF	221
Allowing Access for ML with Athena (Preview)	225
Enabling Federated Access to the Athena API	226
Logging and Monitoring	229
Compliance Validation	229
Resilience	230
Infrastructure Security	230
Connect to Amazon Athena Using an Interface VPC Endpoint	231
Configuration and Vulnerability Analysis	232
Using Athena with Lake Formation	232
How Lake Formation Data Access Works	233
Considerations and Limitations	234
Managing User Permissions	236
Applying Lake Formation Permissions to Existing Databases and Tables	238
Using Workgroups to Control Query Access and Costs	239
Using Workgroups for Running Queries	239
Benefits of Using Workgroups	239
How Workgroups Work	240
Setting up Workgroups	241
IAM Policies for Accessing Workgroups	242
Workgroup Example Policies	243
Workgroup Settings	247
Managing Workgroups	248
Athena Workgroup APIs	254

Troubleshooting Workgroups	254
Controlling Costs and Monitoring Queries with CloudWatch Metrics	256
Enabling CloudWatch Query Metrics	256
Monitoring Athena Queries with CloudWatch Metrics	256
Setting Data Usage Control Limits	258
Tagging Workgroups	262
Tag Basics	262
Tag Restrictions	263
Working with Tags Using the Console	263
Displaying Tags for Individual Workgroups	263
Adding and Deleting Tags on an Individual Workgroup	263
Working with Tags Using the API Actions	265
Tag-Based IAM Access Control Policies	266
Tag Policy Examples	266
Monitoring Logs and Troubleshooting	269
Logging Amazon Athena API Calls with AWS CloudTrail	269
Athena Information in CloudTrail	269
Understanding Athena Log File Entries	270
Troubleshooting	272
SerDe Reference	273
Using a SerDe	273
To Use a SerDe in Queries	273
Supported SerDes and Data Formats	274
Avro SerDe	275
RegexSerDe for Processing Apache Web Server Logs	277
CloudTrail SerDe	278
OpenCSVSerDe for Processing CSV	280
Grok SerDe	282
JSON SerDe Libraries	285
LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files	288
ORC SerDe	293
Parquet SerDe	296
Compression Formats	298
SQL Reference	299
Supported Data Types	299
DML Queries, Functions, and Operators	300
SELECT	300
INSERT INTO	303
Presto Functions	306
DDL Statements	306
Unsupported DDL	307
ALTER DATABASE SET DBPROPERTIES	308
ALTER TABLE ADD PARTITION	309
ALTER TABLE DROP PARTITION	310
ALTER TABLE RENAME PARTITION	310
ALTER TABLE SET LOCATION	311
ALTER TABLE SET TBLPROPERTIES	311
CREATE DATABASE	312
CREATE TABLE	313
CREATE TABLE AS	316
CREATE VIEW	318
DESCRIBE TABLE	318
DESCRIBE VIEW	319
DROP DATABASE	319
DROP TABLE	320
DROP VIEW	320
MSCK REPAIR TABLE	321

SHOW COLUMNS	321
SHOW CREATE TABLE	321
SHOW CREATE VIEW	322
SHOW DATABASES	322
SHOW PARTITIONS	322
SHOW TABLES	323
SHOW TBLPROPERTIES	323
SHOW VIEWS	324
Considerations and Limitations	324
Code Samples, Service Limits, and Previous JDBC Driver	326
Code Samples	326
Constants	326
Create a Client to Access Athena	327
Start Query Execution	327
Stop Query Execution	330
List Query Executions	331
Create a Named Query	332
Delete a Named Query	332
List Named Queries	333
Earlier Version JDBC Drivers	334
Instructions for JDBC Driver version 1.1.0	335
Service Limits	339
Document History	341
AWS Glossary	347

What is Amazon Athena?

Amazon Athena is an interactive query service that makes it easy to analyze data directly in Amazon Simple Storage Service (Amazon S3) using standard SQL. With a few actions in the AWS Management Console, you can point Athena at your data stored in Amazon S3 and begin using standard SQL to run ad-hoc queries and get results in seconds.

Athena is serverless, so there is no infrastructure to set up or manage, and you pay only for the queries you run. Athena scales automatically—executing queries in parallel—so results are fast, even with large datasets and complex queries.

Topics

- [When should I use Athena? \(p. 1\)](#)
- [Accessing Athena \(p. 1\)](#)
- [Understanding Tables, Databases, and the Data Catalog \(p. 2\)](#)
- [AWS Service Integrations with Athena \(p. 3\)](#)

When should I use Athena?

Athena helps you analyze unstructured, semi-structured, and structured data stored in Amazon S3. Examples include CSV, JSON, or columnar data formats such as Apache Parquet and Apache ORC. You can use Athena to run ad-hoc queries using ANSI SQL, without the need to aggregate or load the data into Athena.

Athena integrates with Amazon QuickSight for easy data visualization. You can use Athena to generate reports or to explore data with business intelligence tools or SQL clients connected with a JDBC or an ODBC driver. For more information, see [What is Amazon QuickSight](#) in the *Amazon QuickSight User Guide* and [Connecting to Amazon Athena with ODBC and JDBC Drivers \(p. 71\)](#).

Athena integrates with the AWS Glue Data Catalog, which offers a persistent metadata store for your data in Amazon S3. This allows you to create tables and query data in Athena based on a central metadata store available throughout your AWS account and integrated with the ETL and data discovery features of AWS Glue. For more information, see [Integration with AWS Glue \(p. 45\)](#) and [What is AWS Glue in the AWS Glue Developer Guide](#).

For a list of AWS services that Athena leverages or integrates with, see [the section called “AWS Service Integrations with Athena” \(p. 3\)](#).

Accessing Athena

You can access Athena using the AWS Management Console, through a JDBC or ODBC connection, using the Athena API, or using the Athena CLI.

- To get started with the console, see [Getting Started \(p. 23\)](#).
- To learn how to use JDBC or ODBC drivers, see [Connecting to Amazon Athena with JDBC \(p. 71\)](#) and [Connecting to Amazon Athena with ODBC \(p. 73\)](#).
- To use the Athena API, see the [Amazon Athena API Reference](#).

- To use the CLI, [install the AWS CLI](#) and then type `aws athena help` from the command line to see available commands. For information about available commands, see the [AWS Athena command line reference](#).

Understanding Tables, Databases, and the Data Catalog

In Athena, tables and databases are containers for the metadata definitions that define a schema for underlying source data. For each dataset, a table needs to exist in Athena. The metadata in the table tells Athena where the data is located in Amazon S3, and specifies the structure of the data, for example, column names, data types, and the name of the table. Databases are a logical grouping of tables, and also hold only metadata and schema information for a dataset.

For each dataset that you'd like to query, Athena must have an underlying table it will use for obtaining and returning query results. Therefore, before querying data, a table must be registered in Athena. The registration occurs when you either create tables automatically or manually.

Regardless of how the tables are created, the tables creation process registers the dataset with Athena. This registration occurs either in the AWS Glue Data Catalog, or in the internal Athena data catalog and enables Athena to run queries on the data.

- To create a table automatically, use an AWS Glue crawler from within Athena. For more information about AWS Glue and crawlers, see [Integration with AWS Glue \(p. 45\)](#). When AWS Glue creates a table, it registers it in its own AWS Glue Data Catalog. Athena uses the AWS Glue Data Catalog to store and retrieve this metadata, using it when you run queries to analyze the underlying dataset.

The AWS Glue Data Catalog is accessible throughout your AWS account. Other AWS services can share the AWS Glue Data Catalog, so you can see databases and tables created throughout your organization using Athena and vice versa. In addition, AWS Glue lets you automatically discover data schema and extract, transform, and load (ETL) data.

Note

You use the internal Athena data catalog in regions where AWS Glue is not available and where the AWS Glue Data Catalog cannot be used.

- To create a table manually:
 - Use the Athena console to run the **Create Table Wizard**.
 - Use the Athena console to write Hive DDL statements in the Query Editor.
 - Use the Athena API or CLI to execute a SQL query string with DDL statements.
 - Use the Athena JDBC or ODBC driver.

When you create tables and databases manually, Athena uses HiveQL data definition language (DDL) statements such as `CREATE TABLE`, `CREATE DATABASE`, and `DROP TABLE` under the hood to create tables and databases in the AWS Glue Data Catalog, or in its internal data catalog in those regions where AWS Glue is not available.

Note

If you have tables in Athena created before August 14, 2017, they were created in an Athena-managed data catalog that exists side-by-side with the AWS Glue Data Catalog until you choose to update. For more information, see [Upgrading to the AWS Glue Data Catalog Step-by-Step \(p. 56\)](#).

When you query an existing table, under the hood, Amazon Athena uses Presto, a distributed SQL engine. We have examples with sample data within Athena to show you how to create a table and then

issue a query against it using Athena. Athena also has a tutorial in the console that helps you get started creating a table based on data that is stored in Amazon S3.

- For a step-by-step tutorial on creating a table and writing queries in the Athena Query Editor, see [Getting Started \(p. 23\)](#).
- Run the Athena tutorial in the console. This launches automatically if you log in to <https://console.aws.amazon.com/athena/> for the first time. You can also choose **Tutorial** in the console to launch it.

AWS Service Integrations with Athena

You can query data from other AWS services in Athena. Athena leverages several AWS services. For more information, see the following table.

Note

To see the list of supported regions for each service, see [Regions and Endpoints](#) in the *Amazon Web Services General Reference*.

AWS Service	Topic	Description
AWS CloudTrail	Querying AWS CloudTrail Logs (p. 178)	<p>Using Athena with CloudTrail logs is a powerful way to enhance your analysis of AWS service activity. For example, you can use queries to identify trends and further isolate activity by attribute, such as source IP address or user.</p> <p>You can automatically create tables for querying logs directly from the CloudTrail console, and use those tables to run queries in Athena. For more information, see Creating a Table for CloudTrail Logs in the CloudTrail Console (p. 180).</p>
Amazon CloudFront	Querying Amazon CloudFront Logs (p. 182)	Use Athena to query Amazon CloudFront.
Elastic Load Balancing	<ul style="list-style-type: none">• Querying Application Load Balancer Logs (p. 189)• Querying Classic Load Balancer Logs (p. 187)	<p>Querying Application Load Balancer logs allows you to see the source of traffic, latency, and bytes transferred to and from Elastic Load Balancing instances and backend applications. See Creating the Table for ALB Logs (p. 190)</p> <p>Query Classic Load Balancer logs to analyze and understand traffic patterns to and from Elastic Load Balancing instances and backend applications. You can see the source of traffic,</p>

AWS Service	Topic	Description
		latency, and bytes transferred. See Creating the Table for ELB Logs (p. 187) .
Amazon Virtual Private Cloud	Querying Amazon VPC Flow Logs (p. 191)	Amazon Virtual Private Cloud flow logs capture information about the IP traffic going to and from network interfaces in a VPC. Query the logs in Athena to investigate network traffic patterns and identify threats and risks across your Amazon VPC network.
AWS CloudFormation	AWS::Athena::NamedQuery in the <i>AWS CloudFormation User Guide</i> .	Create named queries with AWS CloudFormation and run them in Athena. Named queries allow you to map a query name to a query and then call the query multiple times referencing it by its name. For information, see CreateNamedQuery in the <i>Amazon Athena API Reference</i> , and AWS::Athena::NamedQuery in the <i>AWS CloudFormation User Guide</i> .
AWS Glue Data Catalog	Integration with AWS Glue (p. 45)	Athena integrates with the AWS Glue Data Catalog, which offers a persistent metadata store for your data in Amazon S3. This allows you to create tables and query data in Athena based on a central metadata store available throughout your AWS account and integrated with the ETL and data discovery features of AWS Glue. For more information, see Integration with AWS Glue (p. 45) and What is AWS Glue in the <i>AWS Glue Developer Guide</i> .

AWS Service	Topic	Description
Amazon QuickSight	Connecting to Amazon Athena with ODBC and JDBC Drivers (p. 71)	Athena integrates with Amazon QuickSight for easy data visualization. You can use Athena to generate reports or to explore data with business intelligence tools or SQL clients connected with a JDBC or an ODBC driver. For more information, see What is Amazon QuickSight in the <i>Amazon QuickSight User Guide</i> and Connecting to Amazon Athena with ODBC and JDBC Drivers (p. 71) .
IAM	Actions for Amazon Athena	You can use Athena API actions in IAM permission policies. See Actions for Amazon Athena and Identity and Access Management in Athena (p. 203) .

Release Notes

Describes Amazon Athena features, improvements, and bug fixes by release date.

Contents

- [June 26, 2019 \(p. 7\)](#)
- [May 24, 2019 \(p. 7\)](#)
- [March 05, 2019 \(p. 7\)](#)
- [February 22, 2019 \(p. 8\)](#)
- [February 18, 2019 \(p. 8\)](#)
- [November 20, 2018 \(p. 9\)](#)
- [October 15, 2018 \(p. 10\)](#)
- [October 10, 2018 \(p. 10\)](#)
- [September 6, 2018 \(p. 10\)](#)
- [August 23, 2018 \(p. 11\)](#)
- [August 16, 2018 \(p. 11\)](#)
- [August 7, 2018 \(p. 12\)](#)
- [June 5, 2018 \(p. 12\)](#)
 - Support for Views (p. 12)
 - Improvements and Updates to Error Messages (p. 12)
 - Bug Fixes (p. 13)
- [May 17, 2018 \(p. 13\)](#)
- [April 19, 2018 \(p. 13\)](#)
- [April 6, 2018 \(p. 14\)](#)
- [March 15, 2018 \(p. 14\)](#)
- [February 2, 2018 \(p. 14\)](#)
- [January 19, 2018 \(p. 14\)](#)
- [November 13, 2017 \(p. 15\)](#)
- [November 1, 2017 \(p. 15\)](#)
- [October 19, 2017 \(p. 15\)](#)
- [October 3, 2017 \(p. 15\)](#)
- [September 25, 2017 \(p. 15\)](#)
- [August 14, 2017 \(p. 16\)](#)
- [August 4, 2017 \(p. 16\)](#)
- [June 22, 2017 \(p. 16\)](#)
- [June 8, 2017 \(p. 16\)](#)
- [May 19, 2017 \(p. 16\)](#)
 - Improvements (p. 17)
 - Bug Fixes (p. 17)
- [April 4, 2017 \(p. 17\)](#)
 - Features (p. 17)
 - Improvements (p. 18)
 - Bug Fixes (p. 18)
- [March 24, 2017 \(p. 18\)](#)
 - Features (p. 18)

- [Improvements \(p. 18\)](#)
- [Bug Fixes \(p. 19\)](#)
- [February 20, 2017 \(p. 19\)](#)
 - [Features \(p. 19\)](#)
 - [Improvements \(p. 20\)](#)

June 26, 2019

Amazon Athena is now available in the EU (Stockholm) Region. For a list of supported Regions, see [AWS Regions and Endpoints](#).

May 24, 2019

Published on 2019-05-24

Amazon Athena is now available in the AWS GovCloud (US-East) and AWS GovCloud (US-West) Regions. For a list of supported Regions, see [AWS Regions and Endpoints](#).

March 05, 2019

Published on 2019-03-05

Amazon Athena is now available in the Canada (Central) Region. For a list of supported Regions, see [AWS Regions and Endpoints](#). Released the new version of the ODBC driver with support for Athena workgroups. For more information, see the [ODBC Driver Release Notes](#).

To download the ODBC driver version 1.0.5 and its documentation, see [Connecting to Amazon Athena with ODBC \(p. 73\)](#). For information about this version, see the [ODBC Driver Release Notes](#).

To use workgroups with the ODBC driver, set the new connection property, `Workgroup`, in the connection string as shown in the following example:

```
Driver=Simba Athena ODBC
Driver;AwsRegion=[Region];S3OutputLocation=[S3Path];AuthenticationType=IAM
Credentials;UID=[YourAccessKey];PWD=[YourSecretKey];Workgroup=[WorkgroupName]
```

For more information, search for "workgroup" in the [ODBC Driver Installation and Configuration Guide version 1.0.5](#). There are no changes to the ODBC driver connection string when you use tags on workgroups. To use tags, upgrade to the latest version of the ODBC driver, which is this current version.

This driver version lets you use [Athena API workgroup actions \(p. 254\)](#) to create and manage workgroups, and [Athena API tag actions \(p. 265\)](#) to add, list, or remove tags on workgroups. Before you begin, make sure that you have resource-level permissions in IAM for actions on workgroups and tags.

For more information, see:

- [Using Workgroups for Running Queries \(p. 239\)](#) and [Workgroup Example Policies \(p. 243\)](#).
- [Tagging Workgroups \(p. 262\)](#) and [Tag-Based IAM Access Control Policies \(p. 266\)](#).

If you use the JDBC driver or the AWS SDK, upgrade to the latest version of the driver and SDK, both of which already include support for workgroups and tags in Athena. For more information, see [Using Athena with the JDBC Driver \(p. 71\)](#).

February 22, 2019

Published on 2019-02-22

Added tag support for workgroups in Amazon Athena. A tag consists of a key and a value, both of which you define. When you tag a workgroup, you assign custom metadata to it. You can add tags to workgroups to help categorize them, using [AWS tagging best practices](#). You can use tags to restrict access to workgroups, and to track costs. For example, create a workgroup for each cost center. Then, by adding tags to these workgroups, you can track your Athena spending for each cost center. For more information, see [Using Tags for Billing](#) in the [AWS Billing and Cost Management User Guide](#).

You can work with tags by using the Athena console or the API operations. For more information, see [Tagging Workgroups \(p. 262\)](#).

In the Athena console, you can add one or more tags to each of your workgroups, and search by tags. Workgroups are an IAM-controlled resource in Athena. In IAM, you can restrict who can add, remove, or list tags on workgroups that you create. You can also use the `CreateWorkGroup` API operation that has the optional tag parameter for adding one or more tags to the workgroup. To add, remove, or list tags, use `TagResource`, `UntagResource`, and `ListTagsForResource`. For more information, see [Working with Tags Using the API Actions \(p. 262\)](#).

To allow users to add tags when creating workgroups, ensure that you give each user IAM permissions to both the `TagResource` and `CreateWorkGroup` API actions. For more information and examples, see [Tag-Based IAM Access Control Policies \(p. 266\)](#).

There are no changes to the JDBC driver when you use tags on workgroups. If you create new workgroups and use the JDBC driver or the AWS SDK, upgrade to the latest version of the driver and SDK. For information, see [Using Athena with the JDBC Driver \(p. 71\)](#).

February 18, 2019

Published on 2019-02-18

Added ability to control query costs by running queries in workgroups. For information, see [Using Workgroups to Control Query Access and Costs \(p. 239\)](#). Improved the JSON OpenX SerDe used in Athena, fixed an issue where Athena did not ignore objects transitioned to the `GLACIER` storage class, and added examples for querying Network Load Balancer logs.

Made the following changes:

- Added support for workgroups. Use workgroups to separate users, teams, applications, or workloads, and to set limits on amount of data each query or the entire workgroup can process. Because workgroups act as IAM resources, you can use resource-level permissions to control access to a specific workgroup. You can also view query-related metrics in Amazon CloudWatch, control query costs by configuring limits on the amount of data scanned, create thresholds, and trigger actions, such as Amazon SNS alarms, when these thresholds are breached. For more information, see [Using Workgroups for Running Queries \(p. 239\)](#) and [Controlling Costs and Monitoring Queries with CloudWatch Metrics \(p. 256\)](#).

Workgroups are an IAM resource. For a full list of workgroup-related actions, resources, and conditions in IAM, see [Actions, Resources, and Condition Keys for Amazon Athena](#) in the *IAM User Guide*. Before you create new workgroups, make sure that you use [workgroup IAM policies \(p. 242\)](#), and the [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#).

You can start using workgroups in the console, with the [workgroup API operations \(p. 254\)](#), or with the JDBC driver. For a high-level procedure, see [Setting up Workgroups \(p. 241\)](#). To download the JDBC driver with workgroup support, see [Using Athena with the JDBC Driver \(p. 71\)](#).

If you use workgroups with the JDBC driver, you must set the workgroup name in the connection string using the `Workgroup` configuration parameter as in the following example:

```
jdbc:awsathena://AwsRegion=<AWSREGION>;UID=<ACCESSKEY>;  
PWD=<SECRETKEY>;S3OutputLocation=s3://<athena-output>-<AWSREGION>/;  
Workgroup=<WORKGROUPNAME>;
```

There are no changes in the way you run SQL statements or make JDBC API calls to the driver. The driver passes the workgroup name to Athena.

For information about differences introduced with workgroups, see [Athena Workgroup APIs \(p. 254\)](#) and [Troubleshooting Workgroups \(p. 254\)](#).

- Improved the JSON OpenX SerDe used in Athena. The improvements include, but are not limited to, the following:
 - Support for the `ConvertDotsInJsonKeysToUnderscores` property. When set to `TRUE`, it allows the SerDe to replace the dots in key names with underscores. For example, if the JSON dataset contains a key with the name "a.b", you can use this property to define the column name to be "a_b" in Athena. The default is `FALSE`. By default, Athena does not allow dots in column names.
 - Support for the `case.insensitive` property. By default, Athena requires that all keys in your JSON dataset use lowercase. Using `WITH SERDE PROPERTIES ("case.insensitive"=FALSE;)` allows you to use case-sensitive key names in your data. The default is `TRUE`. When set to `TRUE`, the SerDe converts all uppercase columns to lowercase.

For more information, see [the section called "OpenX JSON SerDe" \(p. 286\)](#).

- Fixed an issue where Athena returned "access denied" error messages, when it processed Amazon S3 objects that were archived to Glacier by Amazon S3 lifecycle policies. As a result of fixing this issue, Athena ignores objects transitioned to the `GLACIER` storage class. Athena does not support querying data from the `GLACIER` storage class.

For more information, see [the section called "Requirements for Tables in Athena and Data in Amazon S3" \(p. 29\)](#) and [Transitioning to the GLACIER Storage Class \(Object Archival\)](#) in the *Amazon Simple Storage Service Developer Guide*.

- Added examples for querying Network Load Balancer access logs that receive information about the Transport Layer Security (TLS) requests. For more information, see [the section called "Querying Network Load Balancer Logs" \(p. 188\)](#).

November 20, 2018

Published on 2018-11-20

Released the new versions of the JDBC and ODBC driver with support for federated access to Athena API with the AD FS and SAML 2.0 (Security Assertion Markup Language 2.0). For details, see the [JDBC Driver Release Notes](#) and [ODBC Driver Release Notes](#).

With this release, federated access to Athena is supported for the Active Directory Federation Service (AD FS 3.0). Access is established through the versions of JDBC or ODBC drivers that support SAML 2.0. For information about configuring federated access to the Athena API, see [the section called "Enabling Federated Access to the Athena API" \(p. 226\)](#).

To download the JDBC driver version 2.0.6 and its documentation, see [Using Athena with the JDBC Driver \(p. 71\)](#). For information about this version, see [JDBC Driver Release Notes](#).

To download the ODBC driver version 1.0.4 and its documentation, see [Connecting to Amazon Athena with ODBC \(p. 73\)](#). For information about this version, [ODBC Driver Release Notes](#).

For more information about SAML 2.0 support in AWS, see [About SAML 2.0 Federation](#) in the *IAM User Guide*.

October 15, 2018

Published on 2018-10-15

If you have upgraded to the AWS Glue Data Catalog, there are two new features that provide support for:

- Encryption of the Data Catalog metadata. If you choose to encrypt metadata in the Data Catalog, you must add specific policies to Athena. For more information, see [Access to Encrypted Metadata in the AWS Glue Data Catalog \(p. 214\)](#).
- Fine-grained permissions to access resources in the AWS Glue Data Catalog. You can now define identity-based (IAM) policies that restrict or allow access to specific databases and tables from the Data Catalog used in Athena. For more information, see [Fine-Grained Access to Databases and Tables in the AWS Glue Data Catalog \(p. 207\)](#).

Note

Data resides in the Amazon S3 buckets, and access to it is governed by the [Amazon S3 Permissions \(p. 207\)](#). To access data in databases and tables, continue to use access control policies to Amazon S3 buckets that store the data.

October 10, 2018

Published on 2018-10-10

Athena supports `CREATE TABLE AS SELECT`, which creates a table from the result of a `SELECT` query statement. For details, see [Creating a Table from Query Results \(CTAS\)](#).

Before you create CTAS queries, it is important to learn about their behavior in the Athena documentation. It contains information about the location for saving query results in Amazon S3, the list of supported formats for storing CTAS query results, the number of partitions you can create, and supported compression formats. For more information, see [Considerations and Limitations for CTAS Queries \(p. 118\)](#).

Use CTAS queries to:

- [Create a table from query results \(p. 118\)](#) in one step.
- [Create CTAS queries in the Athena console \(p. 119\)](#), using [Examples \(p. 123\)](#). For information about syntax, see [CREATE TABLE AS \(p. 316\)](#).
- Transform query results into other storage formats, such as PARQUET, ORC, AVRO, JSON, and TEXTFILE. For more information, see [Considerations and Limitations for CTAS Queries \(p. 118\)](#) and [Columnar Storage Formats \(p. 39\)](#).

September 6, 2018

Published on 2018-09-06

Released the new version of the ODBC driver (version 1.0.3). The new version of the ODBC driver streams results by default, instead of paging through them, allowing business intelligence tools to retrieve large data sets faster. This version also includes improvements, bug fixes, and an updated documentation for "Using SSL with a Proxy Server". For details, see the [Release Notes](#) for the driver.

For downloading the ODBC driver version 1.0.3 and its documentation, see [Connecting to Amazon Athena with ODBC \(p. 73\)](#).

The streaming results feature is available with this new version of the ODBC driver. It is also available with the JDBC driver. For information about streaming results, see the [ODBC Driver Installation and Configuration Guide](#), and search for **UseResultSetStreaming**.

The ODBC driver version 1.0.3 is a drop-in replacement for the previous version of the driver. We recommend that you migrate to the current driver.

Important

To use the ODBC driver version 1.0.3, follow these requirements:

- Keep the port 444 open to outbound traffic.
- Add the `athena:GetQueryResultsStream` policy action to the list of policies for Athena. This policy action is not exposed directly with the API and is only used with the ODBC and JDBC drivers, as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#).

August 23, 2018

Published on 2018-08-23

Added support for these DDL-related features and fixed several bugs, as follows:

- Added support for `BINARY` and `DATE` data types for data in Parquet, and for `DATE` and `TIMESTAMP` data types for data in Avro.
- Added support for `INT` and `DOUBLE` in DDL queries. `INTEGER` is an alias to `INT`, and `DOUBLE PRECISION` is an alias to `DOUBLE`.
- Improved performance of `DROP TABLE` and `DROP DATABASE` queries.
- Removed the creation of `$_folder$` object in Amazon S3 when a data bucket is empty.
- Fixed an issue where `ALTER TABLE ADD PARTITION` threw an error when no partition value was provided.
- Fixed an issue where `DROP TABLE` ignored the database name when checking partitions after the qualified name had been specified in the statement.

For more about the data types supported in Athena, see [Data Types \(p. 299\)](#).

For information about supported data type mappings between types in Athena, the JDBC driver, and Java data types, see the "Data Types" section in the [JDBC Driver Installation and Configuration Guide](#).

August 16, 2018

Published on 2018-08-16

Released the JDBC driver version 2.0.5. The new version of the JDBC driver streams results by default, instead of paging through them, allowing business intelligence tools to retrieve large data sets faster. Compared to the previous version of the JDBC driver, there are the following performance improvements:

- Approximately 2x performance increase when fetching less than 10K rows.
- Approximately 5-6x performance increase when fetching more than 10K rows.

The streaming results feature is available only with the JDBC driver. It is not available with the ODBC driver. You cannot use it with the Athena API. For information about streaming results, see the [JDBC Driver Installation and Configuration Guide](#), and search for **UseResultsetStreaming**.

For downloading the JDBC driver version 2.0.5 and its documentation, see [Using Athena with the JDBC Driver \(p. 71\)](#).

The JDBC driver version 2.0.5 is a drop-in replacement for the previous version of the driver (2.0.2). To ensure that you can use the JDBC driver version 2.0.5, add the `athena:GetQueryResultsStream` policy action to the list of policies for Athena. This policy action is not exposed directly with the API and is only used with the JDBC driver, as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#). For more information about migrating from version 2.0.2 to version 2.0.5 of the driver, see the [JDBC Driver Migration Guide](#).

If you are migrating from a 1.x driver to a 2.x driver, you will need to migrate your existing configurations to the new configuration. We highly recommend that you migrate to the current version of the driver. For more information, see [Using the Previous Version of the JDBC Driver \(p. 334\)](#), and the [JDBC Driver Migration Guide](#).

August 7, 2018

Published on 2018-08-07

You can now store Amazon Virtual Private Cloud flow logs directly in Amazon S3 in a GZIP format, where you can query them in Athena. For information, see [Querying Amazon VPC Flow Logs \(p. 191\)](#) and [Amazon VPC Flow Logs can now be delivered to S3](#).

June 5, 2018

Published on 2018-06-05

Topics

- [Support for Views \(p. 12\)](#)
- [Improvements and Updates to Error Messages \(p. 12\)](#)
- [Bug Fixes \(p. 13\)](#)

Support for Views

Added support for views. You can now use [CREATE VIEW \(p. 318\)](#), [DESCRIBE VIEW \(p. 319\)](#), [DROP VIEW \(p. 320\)](#), [SHOW CREATE VIEW \(p. 322\)](#), and [SHOW VIEWS \(p. 324\)](#) in Athena. The query that defines the view runs each time you reference the view in your query. For more information, see [Working with Views \(p. 113\)](#).

Improvements and Updates to Error Messages

- Included a GSON 2.8.0 library into the CloudTrail SerDe, to solve an issue with the CloudTrail SerDe and enable parsing of JSON strings.
- Enhanced partition schema validation in Athena for Parquet, and, in some cases, for ORC, by allowing reordering of columns. This enables Athena to better deal with changes in schema evolution over time, and with tables added by the AWS Glue Crawler. For more information, see [Handling Schema Updates \(p. 126\)](#).

- Added parsing support for `SHOW VIEWS`.
- Made the following improvements to most common error messages:
 - Replaced an Internal Error message with a descriptive error message when a SerDe fails to parse the column in an Athena query. Previously, Athena issued an internal error in cases of parsing errors. The new error message reads: "HIVE_BAD_DATA: Error parsing field value for field 0: java.lang.String cannot be cast to org.openx.data.jsonserde.json.JSONObject".
 - Improved error messages about insufficient permissions by adding more detail.

Bug Fixes

Fixed the following bugs:

- Fixed an issue that enables the internal translation of `REAL` to `FLOAT` data types. This improves integration with the AWS Glue Crawler that returns `FLOAT` data types.
- Fixed an issue where Athena was not converting AVRO `DECIMAL` (a logical type) to a `DECIMAL` type.
- Fixed an issue where Athena did not return results for queries on Parquet data with `WHERE` clauses that referenced values in the `TIMESTAMP` data type.

May 17, 2018

Published on 2018-05-17

Increased query concurrency limits in Athena from five to twenty. This means that you can submit and run up to twenty `DDL` queries and twenty `SELECT` queries at a time. Note that the concurrency limits are separate for `DDL` and `SELECT` queries.

Concurrency limits in Athena are defined as the number of queries that can be submitted to the service concurrently. You can submit up to twenty queries of the same type (`DDL` or `SELECT`) at a time. If you submit a query that exceeds the concurrent query limit, the Athena API displays an error message: "You have exceeded the limit for the number of queries you can run concurrently. Reduce the number of concurrent queries submitted by this account. Contact customer support to request a concurrent query limit increase."

After you submit your queries to Athena, it processes the queries by assigning resources based on the overall service load and the amount of incoming requests. We continuously monitor and make adjustments to the service so that your queries process as fast as possible.

For information, see [Service Limits \(p. 339\)](#). This is a soft limit and you can [request a limit increase](#) for concurrent queries.

April 19, 2018

Published on 2018-04-19

Released the new version of the JDBC driver (version 2.0.2) with support for returning the `ResultSet` data as an `Array` data type, improvements, and bug fixes. For details, see the [Release Notes](#) for the driver.

For information about downloading the new JDBC driver version 2.0.2 and its documentation, see [Using Athena with the JDBC Driver \(p. 71\)](#).

The latest version of the JDBC driver is 2.0.2. If you are migrating from a 1.x driver to a 2.x driver, you will need to migrate your existing configurations to the new configuration. We highly recommend that you migrate to the current driver.

For information about the changes introduced in the new version of the driver, the version differences, and examples, see the [JDBC Driver Migration Guide](#).

For information about the previous version of the JDBC driver, see [Using Athena with the Previous Version of the JDBC Driver \(p. 334\)](#).

April 6, 2018

Published on 2018-04-06

Use auto-complete to type queries in the Athena console.

March 15, 2018

Published on 2018-03-15

Added an ability to automatically create Athena tables for CloudTrail log files directly from the CloudTrail console. For information, see [Creating a Table for CloudTrail Logs in the CloudTrail Console \(p. 180\)](#).

February 2, 2018

Published on 2018-02-12

Added an ability to securely offload intermediate data to disk for memory-intensive queries that use the GROUP BY clause. This improves the reliability of such queries, preventing "Query resource exhausted" errors.

January 19, 2018

Published on 2018-01-19

Athena uses Presto, an open-source distributed query engine, to run queries.

With Athena, there are no versions to manage. We have transparently upgraded the underlying engine in Athena to a version based on Presto version 0.172. No action is required on your end.

With the upgrade, you can now use [Presto 0.172 Functions and Operators](#), including [Presto 0.172 Lambda Expressions](#) in Athena.

Major updates for this release, including the community-contributed fixes, include:

- Support for ignoring headers. You can use the `skip.header.line.count` property when defining tables, to allow Athena to ignore headers. This is currently supported for queries that use the OpenCSV SerDe, and not for Grok or Regex SerDes.
- Support for the `CHAR(n)` data type in `STRING` functions. The range for `CHAR(n)` is [1..255], while the range for `VARCHAR(n)` is [1..65535].
- Support for correlated subqueries.
- Support for Presto Lambda expressions and functions.
- Improved performance of the `DECIMAL` type and operators.
- Support for filtered aggregations, such as `SELECT sum(col_name) FILTER, where id > 0.`

- Push-down predicates for the `DECIMAL`, `TINYINT`, `SMALLINT`, and `REAL` data types.
- Support for quantified comparison predicates: `ALL`, `ANY`, and `SOME`.
- Added functions: `arrays_overlap()`, `array_except()`, `levenshtein_distance()`, `codepoint()`, `skewness()`, `kurtosis()`, and `typeof()`.
- Added a variant of the `from_unixtime()` function that takes a timezone argument.
- Added the `bitwise_and_agg()` and `bitwise_or_agg()` aggregation functions.
- Added the `xxhash64()` and `to_big_endian_64()` functions.
- Added support for escaping double quotes or backslashes using a backslash with a JSON path subscript to the `json_extract()` and `json_extract_scalar()` functions. This changes the semantics of any invocation using a backslash, as backslashes were previously treated as normal characters.

For a complete list of functions and operators, see [SQL Queries, Functions, and Operators \(p. 300\)](#) in this guide, and [Presto 0.172 Functions](#).

Athena does not support all of Presto's features. For more information, see [Limitations \(p. 324\)](#).

November 13, 2017

Published on 2017-11-13

Added support for connecting Athena to the ODBC Driver. For information, see [Connecting to Amazon Athena with ODBC \(p. 73\)](#).

November 1, 2017

Published on 2017-11-01

Added support for querying geospatial data, and for Asia Pacific (Seoul), Asia Pacific (Mumbai), and EU (London) regions. For information, see [Querying Geospatial Data \(p. 157\)](#) and [AWS Regions and Endpoints](#).

October 19, 2017

Published on 2017-10-19

Added support for EU (Frankfurt). For a list of supported regions, see [AWS Regions and Endpoints](#).

October 3, 2017

Published on 2017-10-03

Create named Athena queries with CloudFormation. For more information, see [AWS::Athena::NamedQuery](#) in the [AWS CloudFormation User Guide](#).

September 25, 2017

Published on 2017-09-25

Added support for Asia Pacific (Sydney). For a list of supported regions, see [AWS Regions and Endpoints](#).

August 14, 2017

Published on 2017-08-14

Added integration with the AWS Glue Data Catalog and a migration wizard for updating from the Athena managed data catalog to the AWS Glue Data Catalog. For more information, see [Integration with AWS Glue \(p. 45\)](#).

August 4, 2017

Published on 2017-08-04

Added support for Grok SerDe, which provides easier pattern matching for records in unstructured text files such as logs. For more information, see [Grok SerDe \(p. 282\)](#). Added keyboard shortcuts to scroll through query history using the console (CTRL + ↑/↓ using Windows, CMD + ↑/↓ using Mac).

June 22, 2017

Published on 2017-06-22

Added support for Asia Pacific (Tokyo) and Asia Pacific (Singapore). For a list of supported regions, see [AWS Regions and Endpoints](#).

June 8, 2017

Published on 2017-06-08

Added support for EU (Ireland). For more information, see [AWS Regions and Endpoints](#).

May 19, 2017

Published on 2017-05-19

Added an Amazon Athena API and AWS CLI support for Athena; updated JDBC driver to version 1.1.0; fixed various issues.

- Amazon Athena enables application programming for Athena. For more information, see [Amazon Athena API Reference](#). The latest AWS SDKs include support for the Athena API. For links to documentation and downloads, see the [SDKs](#) section in [Tools for Amazon Web Services](#).
- The AWS CLI includes new commands for Athena. For more information, see the [Amazon Athena API Reference](#).
- A new JDBC driver 1.1.0 is available, which supports the new Athena API as well as the latest features and bug fixes. Download the driver at <https://s3.amazonaws.com/athena-downloads/drivers/AthenaJDBC41-1.1.0.jar>. We recommend upgrading to the latest Athena JDBC driver; however, you may still use the earlier driver version. Earlier driver versions do not support the Athena API. For more information, see [Using Athena with the JDBC Driver \(p. 71\)](#).

- Actions specific to policy statements in earlier versions of Athena have been deprecated. If you upgrade to JDBC driver version 1.1.0 and have customer-managed or inline IAM policies attached to JDBC users, you must update the IAM policies. In contrast, earlier versions of the JDBC driver do not support the Athena API, so you can specify only deprecated actions in policies attached to earlier version JDBC users. For this reason, you shouldn't need to update customer-managed or inline IAM policies.
- These policy-specific actions were used in Athena before the release of the Athena API. Use these deprecated actions in policies **only** with JDBC drivers earlier than version 1.1.0. If you are upgrading the JDBC driver, replace policy statements that allow or deny deprecated actions with the appropriate API actions as listed or errors will occur:

Deprecated Policy-Specific Action	Corresponding Athena API Action
athena:RunQuery	athena:StartQueryExecution
athena:CancelQueryExecution	athena:StopQueryExecution
athena:GetQueryExecutions	athena>ListQueryExecutions

Improvements

- Increased the query string length limit to 256 KB.

Bug Fixes

- Fixed an issue that caused query results to look malformed when scrolling through results in the console.
- Fixed an issue where a \u0000 character string in Amazon S3 data files would cause errors.
- Fixed an issue that caused requests to cancel a query made through the JDBC driver to fail.
- Fixed an issue that caused the AWS CloudTrail SerDe to fail with Amazon S3 data in US East (Ohio).
- Fixed an issue that caused `DROP TABLE` to fail on a partitioned table.

April 4, 2017

Published on 2017-04-04

Added support for Amazon S3 data encryption and released JDBC driver update (version 1.0.1) with encryption support, improvements, and bug fixes.

Features

- Added the following encryption features:
 - Support for querying encrypted data in Amazon S3.
 - Support for encrypting Athena query results.
- A new version of the driver supports new encryption features, adds improvements, and fixes issues.

- Added the ability to add, replace, and change columns using `ALTER TABLE`. For more information, see [Alter Column](#) in the Hive documentation.
- Added support for querying LZO-compressed data.

For more information, see [Encryption at Rest \(p. 197\)](#).

Improvements

- Better JDBC query performance with page-size improvements, returning 1,000 rows instead of 100.
- Added ability to cancel a query using the JDBC driver interface.
- Added ability to specify JDBC options in the JDBC connection URL. For more information, see [Using Athena with the Previous Version of the JDBC Driver \(p. 334\)](#) for the previous version of the driver, and [Connect with the JDBC \(p. 71\)](#), for the most current version.
- Added PROXY setting in the driver, which can now be set using [ClientConfiguration](#) in the AWS SDK for Java.

Bug Fixes

Fixed the following bugs:

- Throttling errors would occur when multiple queries were issued using the JDBC driver interface.
- The JDBC driver would abort when projecting a decimal data type.
- The JDBC driver would return every data type as a string, regardless of how the data type was defined in the table. For example, selecting a column defined as an `INT` data type using `resultSet.GetObject()` would return a `STRING` data type instead of `INT`.
- The JDBC driver would verify credentials at the time a connection was made, rather than at the time a query would run.
- Queries made through the JDBC driver would fail when a schema was specified along with the URL.

March 24, 2017

Published on 2017-03-24

Added the AWS CloudTrail SerDe, improved performance, fixed partition issues.

Features

- Added the AWS CloudTrail SerDe. For more information, see [CloudTrail SerDe \(p. 278\)](#). For detailed usage examples, see the AWS Big Data Blog post, [Analyze Security, Compliance, and Operational Activity Using AWS CloudTrail and Amazon Athena](#).

Improvements

- Improved performance when scanning a large number of partitions.
- Improved performance on `MSCK Repair Table` operation.
- Added ability to query Amazon S3 data stored in regions other than your primary Region. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges.

Bug Fixes

- Fixed a bug where a "table not found error" might occur if no partitions are loaded.
- Fixed a bug to avoid throwing an exception with `ALTER TABLE ADD PARTITION IF NOT EXISTS` queries.
- Fixed a bug in `DROP PARTITIONS`.

February 20, 2017

Published on 2017-02-20

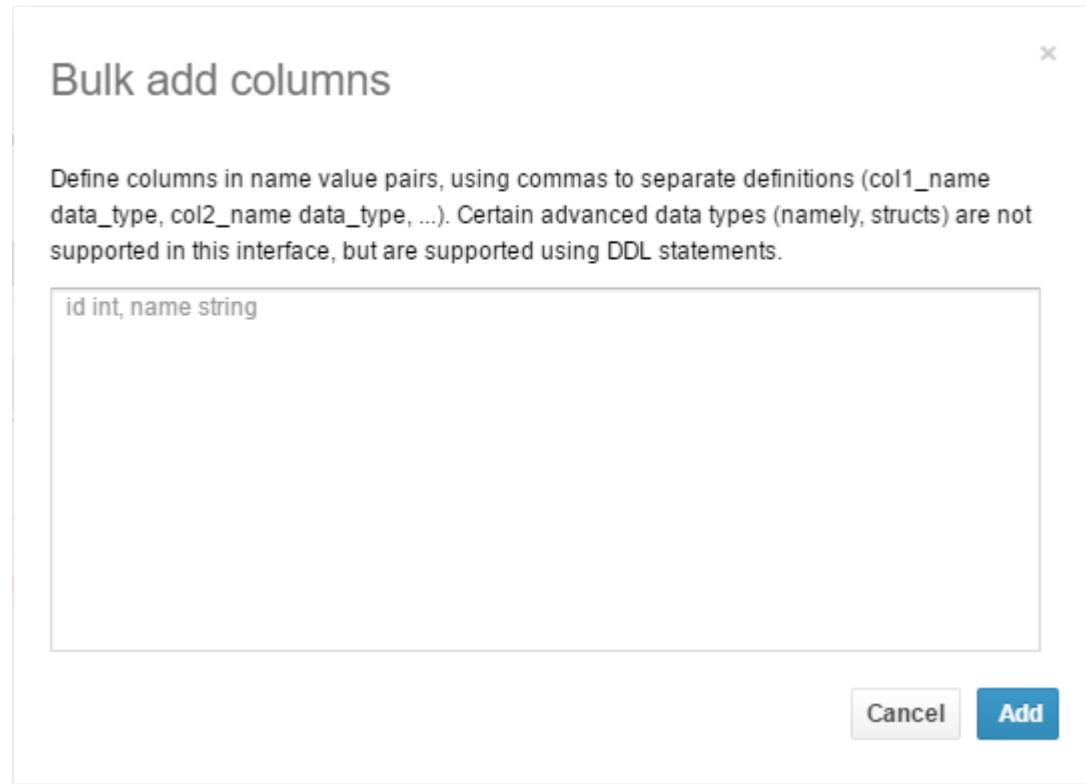
Added support for AvroSerDe and OpenCSVSerDe, US East (Ohio) Region, and bulk editing columns in the console wizard. Improved performance on large Parquet tables.

Features

- **Introduced support for new SerDes:**
 - [Avro SerDe \(p. 275\)](#)
 - [OpenCSVSerDe for Processing CSV \(p. 280\)](#)
- **US East (Ohio) Region (us-east-2) launch.** You can now run queries in this region.
- You can now use the **Add Table** wizard to define table schema in bulk. Choose **Catalog Manager**, **Add table**, and then choose **Bulk add columns** as you walk through the steps to define the table.

The screenshot shows the Amazon Athena interface with the 'Catalog Manager' tab selected. On the left, there's a sidebar with an 'ACTION' button and a '+ Add table' button. The main area is titled 'Databases > Add table' and is divided into three steps: 'Step 1: Name & Location', 'Step 2: Data Format', and 'Step 3: (not visible in the screenshot)'. In Step 1, there are fields for 'Column Name' (with placeholder 'Column Name' and note 'Column name must be single') and 'Column type' (with placeholder 'string' and note 'Type for this column. Certain types are not exposed in this interface'). At the bottom of the wizard, there are two buttons: 'Add a column' and 'Bulk add columns', with 'Bulk add columns' being highlighted by a red box.

Type name value pairs in the text box and choose **Add**.



Improvements

- Improved performance on large Parquet tables.

Setting Up

If you've already signed up for Amazon Web Services (AWS), you can start using Amazon Athena immediately. If you haven't signed up for AWS, or if you need assistance querying data using Athena, first complete the tasks below:

Sign Up for AWS

When you sign up for AWS, your account is automatically signed up for all services in AWS, including Athena. You are charged only for the services that you use. When you use Athena, you use Amazon S3 to store your data. Athena has no AWS Free Tier pricing.

If you have an AWS account already, skip to the next task. If you don't have an AWS account, use the following procedure to create one.

To create an AWS account

1. Open <http://aws.amazon.com/>, and then choose **Create an AWS Account**.
2. Follow the online instructions. Part of the sign-up procedure involves receiving a phone call and entering a PIN using the phone keypad.

Note your AWS account number, because you need it for the next task.

Create an IAM User

An AWS Identity and Access Management (IAM) user is an account that you create to access services. It is a different user than your main AWS account. As a security best practice, we recommend that you use the IAM user's credentials to access AWS services. Create an IAM user, and then add the user to an IAM group with administrative permissions or and grant this user administrative permissions. You can then access AWS using a special URL and the credentials for the IAM user.

If you signed up for AWS but have not created an IAM user for yourself, you can create one using the IAM console. If you aren't familiar with using the console, see [Working with the AWS Management Console](#).

To create a group for administrators

1. Sign in to the IAM console at <https://console.aws.amazon.com/iam/>.
2. In the navigation pane, choose **Groups**, **Create New Group**.
3. For **Group Name**, type a name for your group, such as **Administrators**, and choose **Next Step**.
4. In the list of policies, select the check box next to the **AdministratorAccess** policy. You can use the **Filter** menu and the **Search** field to filter the list of policies.
5. Choose **Next Step, Create Group**. Your new group is listed under **Group Name**.

To create an IAM user for yourself, add the user to the administrators group, and create a password for the user

1. In the navigation pane, choose **Users**, and then **Create New Users**.
2. For **1**, type a user name.
3. Clear the check box next to **Generate an access key for each user** and then **Create**.
4. In the list of users, select the name (not the check box) of the user you just created. You can use the **Search** field to search for the user name.
5. Choose **Groups, Add User to Groups**.
6. Select the check box next to the administrators and choose **Add to Groups**.
7. Choose the **Security Credentials** tab. Under **Sign-In Credentials**, choose **Manage Password**.
8. Choose **Assign a custom password**. Then type a password in the **Password** and **Confirm Password** fields. When you are finished, choose **Apply**.
9. To sign in as this new IAM user, sign out of the AWS 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_account_alias*.signin.aws.amazon.com/console/
```

It is also possible the sign-in link will use your account name instead of number. To verify the sign-in link for IAM users for your account, open the IAM console and check under **IAM users sign-in link** on the dashboard.

Attach Managed Policies for Using Athena

Attach Athena managed policies to the IAM account you use to access Athena. There are two managed policies for Athena: `AmazonAthenaFullAccess` and `AWSQuicksightAthenaAccess`. These policies grant permissions to Athena to query Amazon S3 as well as write the results of your queries to a separate bucket on your behalf. For more information and step-by-step instructions, see [Attaching Managed Policies](#) in the *AWS Identity and Access Management User Guide*. For information about policy contents, see [IAM Policies for User Access \(p. 203\)](#).

Note

You may need additional permissions to access the underlying dataset in Amazon S3. If you are not the account owner or otherwise have restricted access to a bucket, contact the bucket owner to grant access using a resource-based bucket policy, or contact your account administrator to grant access using an identity-based policy. For more information, see [Amazon S3 Permissions \(p. 207\)](#). If the dataset or Athena query results are encrypted, you may need additional permissions. For more information, see [Configuring Encryption Options \(p. 197\)](#).

Getting Started

This tutorial walks you through using Amazon Athena to query data. You'll create a table based on sample data stored in Amazon Simple Storage Service, query the table, and check the results of the query.

The tutorial is using live resources, so you are charged for the queries that you run. You aren't charged for the sample datasets that you use, but if you upload your own data files to Amazon S3, charges do apply.

Prerequisites

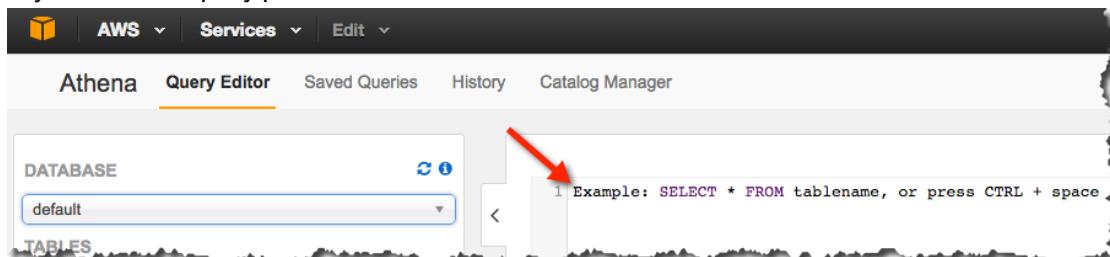
If you have not already done so, sign up for an account in [Setting Up \(p. 21\)](#).

Step 1: Create a Database

You first need to create a database in Athena.

To create a database

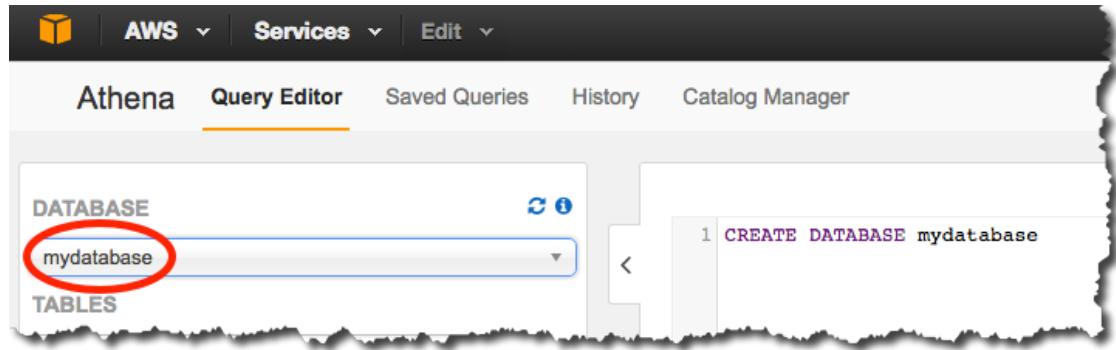
1. Open the Athena console.
2. If this is your first time visiting the Athena console, you'll go to a Getting Started page. Choose **Get Started** to open the Query Editor. If it isn't your first time, the Athena Query Editor opens.
3. In the Athena Query Editor, you see a query pane with an example query. Start typing your query anywhere in the query pane.



4. To create a database named `mydatabase`, enter the following CREATE DATABASE statement, and then choose **Run Query**:

```
CREATE DATABASE mydatabase
```

5. Confirm that the catalog display refreshes and `mydatabase` appears in the **DATABASE** list in the **Catalog** dashboard on the left side.



Step 2: Create a Table

Now that you have a database, you're ready to create a table that's based on the sample data file. You define columns that map to the data, specify how the data is delimited, and provide the location in Amazon S3 for the file.

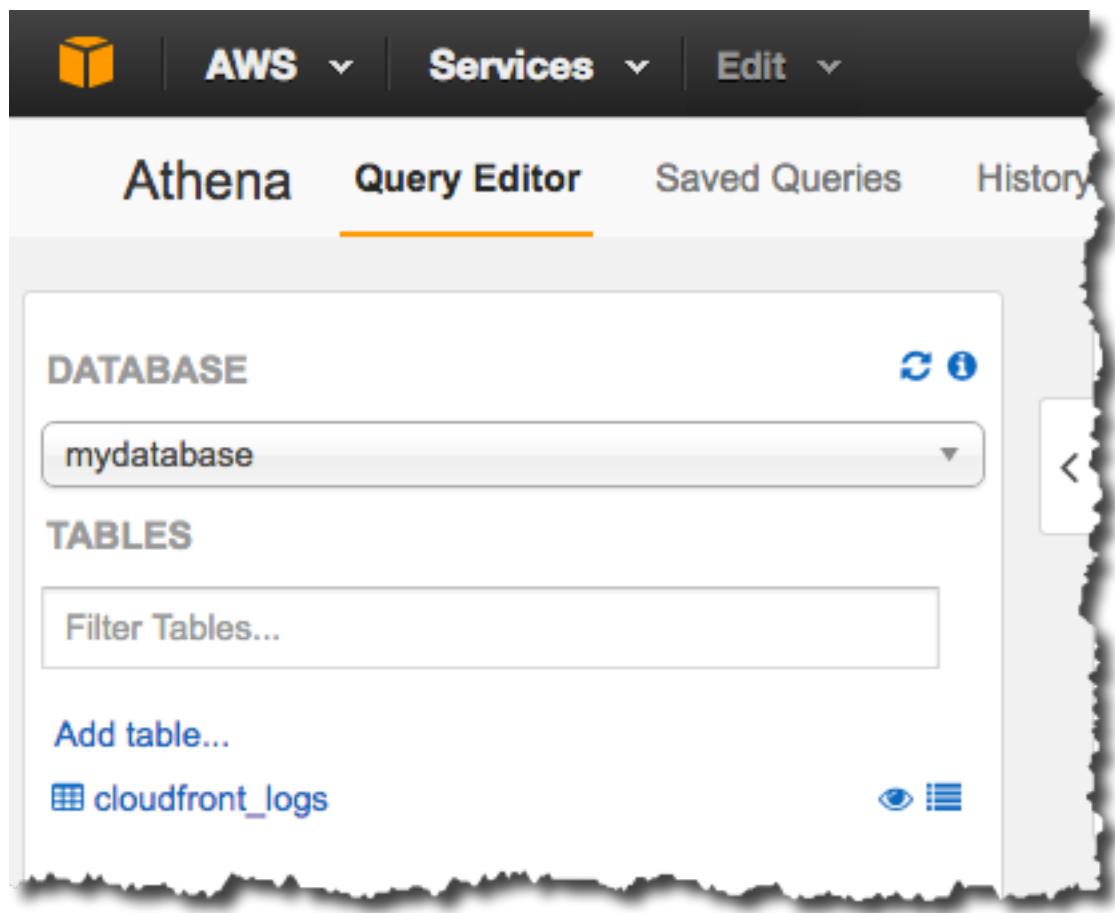
To create a table

1. Make sure that **mydatabase** is selected for **DATABASE** and then choose **New Query**.
 2. In the query pane, enter the following CREATE TABLE statement, and then choose **Run Query**:

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace *myregion* in `s3://athena-examples-myregion/path/to/data/` with the region identifier where you run Athena, for example, `s3://athena-examples-us-east-1/path/to/data/`.

The table `cloudfront_logs` is created and appears in the **Catalog** dashboard for your database.



Step 3: Query Data

Now that you have the `cloudfront_logs` table created in Athena based on the data in Amazon S3, you can run queries on the table and see the results in Athena.

To run a query

1. Choose **New Query**, enter the following statement anywhere in the query pane, and then choose **Run Query**:

```
SELECT os, COUNT(*) count
FROM cloudfront_logs
WHERE date BETWEEN date '2014-07-05' AND date '2014-08-05'
GROUP BY os;
```

Results are returned that look like the following:

	os	count
1	iOS	794
2	MacOS	852
3	OSX	799
4	Windows	883
5	Linux	813
6	Android	855

2. Optionally, you can save the results of a query to CSV by choosing the file icon on the **Results** pane.

The screenshot shows the 'Results' pane of the Amazon Athena console. At the top, there are buttons for 'Run query', 'Save as' (which is highlighted with a red box), 'Create', and status information '(Run time: 4.89 seconds, Data scanned: 992.88 KB)'. Below this is a search bar with the placeholder 'Use Ctrl + Enter to run query, Ctrl + Space to autocomplete'. To the right are 'Format query' and 'Clear' buttons. The main area is titled 'Results' and contains a table with columns: date, time, location, bytes, requestip, method, host. A single row of data is shown: 1 2014-07-05 15:00:00 LHR3 4260 10.0.0.15 GET eabcd12345678.cloudfla...

You can also view the results of previous queries or queries that may take some time to complete. Choose **History** then either search for your query or choose **View** or **Download** to view or download the results of previous completed queries. This also displays the status of queries that are currently running. Query history is retained for 45 days. For information, see [Viewing Query History \(p. 112\)](#).

The screenshot shows the 'History' pane of the Amazon Athena console. The top navigation bar includes 'AWS', 'Services', 'Edit', 'Athena', 'Query Editor', 'Saved Queries', 'History' (which is selected and highlighted with a red box), and 'Catalog Manager'. Below this is a search bar labeled 'Search for name, query, etc.'. The main area is titled 'History' and lists completed queries. The first query is shown with columns: Time, Name, and Query. The time is 2016/10/06 16:28:48 UTC-7, the name is 'Unsaved', and the query is: 'SELECT os, COUNT(*) count FROM cloudFront_logs WHERE date BETWEEN date '2014-07-05' AND date '2014-0...'. A red box highlights the download icon (a file icon with a downward arrow) next to this query entry.

Query results are also stored in Amazon S3 in a bucket called `aws-athena-query-results-ACCOUNTID-REGION`. You can change the default location in the console and encryption options by choosing **Settings** in the upper right pane. For more information, see [Query Results \(p. 107\)](#).

Accessing Amazon Athena

You can access Amazon Athena using the AWS Management Console, the Amazon Athena API, or the AWS CLI.

Using the Console

You can use the AWS Management Console for Amazon Athena to do the following:

- Create or select a database.
- Create, view, and delete tables.
- Filter tables by starting to type their names.
- Preview tables and generate CREATE TABLE DDL for them.
- Show table properties.
- Run queries on tables, save and format queries, and view query history.
- Create up to ten queries using different query tabs in the query editor. To open a new tab, click the plus sign.
- Display query results, save, and export them.
- Access the AWS Glue Data Catalog.
- View and change settings, such as view the query result location, configure auto-complete, and encrypt query results.

In the right pane, the Query Editor displays an introductory screen that prompts you to create your first table. You can view your tables under **Tables** in the left pane.

Here's a high-level overview of the actions available for each table:

- **Preview tables** – View the query syntax in the Query Editor on the right.
- **Show properties** – Show a table's name, its location in Amazon S3, input and output formats, the serialization (SerDe) library used, and whether the table has encrypted data.
- **Delete table** – Delete a table.
- **Generate CREATE TABLE DDL** – Generate the query behind a table and view it in the query editor.

Using the API

Amazon Athena enables application programming for Athena. For more information, see [Amazon Athena API Reference](#). The latest AWS SDKs include support for the Athena API.

For examples of using the AWS SDK for Java with Athena, see [Code Samples \(p. 326\)](#).

For more information about AWS SDK for Java documentation and downloads, see the *SDKs* section in [Tools for Amazon Web Services](#).

Using the CLI

You can access Amazon Athena using the AWS CLI. For more information, see the [AWS CLI Reference for Athena](#).

Creating Tables and Databases

Amazon Athena supports a subset of data definition language (DDL) statements and ANSI SQL functions and operators to define and query external tables where data resides in Amazon Simple Storage Service.

When you create a database and table in Athena, you describe the schema and the location of the data, making the data in the table ready for real-time querying.

To improve query performance and reduce costs, we recommend that you partition your data and use open source columnar formats for storage in Amazon S3, such as [Apache Parquet](#) or [ORC](#).

Topics

- [Tables and Databases Creation Process in Athena \(p. 28\)](#)
- [Names for Tables, Databases, and Columns \(p. 32\)](#)
- [Reserved Keywords \(p. 33\)](#)
- [Table Location in Amazon S3 \(p. 34\)](#)
- [Partitioning Data \(p. 36\)](#)
- [Columnar Storage Formats \(p. 39\)](#)
- [Converting to Columnar Formats \(p. 40\)](#)

Tables and Databases Creation Process in Athena

You can run DDL statements in the Athena console, using a JDBC or an ODBC driver, or using the Athena [Create Table](#) wizard.

When you create a new table schema in Athena, Athena stores the schema in a data catalog and uses it when you run queries.

Athena uses an approach known as *schema-on-read*, which means a schema is projected on to your data at the time you execute a query. This eliminates the need for data loading or transformation.

Athena does not modify your data in Amazon S3.

Athena uses Apache Hive to define tables and create databases, which are essentially a logical namespace of tables.

When you create a database and table in Athena, you are simply describing the schema and the location where the table data are located in Amazon S3 for read-time querying. Database and table, therefore, have a slightly different meaning than they do for traditional relational database systems because the data isn't stored along with the schema definition for the database and table.

When you query, you query the table using standard SQL and the data is read at that time. You can find guidance for how to create databases and tables using [Apache Hive documentation](#), but the following provides guidance specifically for Athena.

The maximum query string length is 256 KB.

Hive supports multiple data formats through the use of serializer-deserializer (SerDe) libraries. You can also define complex schemas using regular expressions. For a list of supported SerDe libraries, see [Supported Data Formats, SerDes, and Compression Formats \(p. 274\)](#).

Requirements for Tables in Athena and Data in Amazon S3

When you create a table, you specify an Amazon S3 bucket location for the underlying data using the `LOCATION` clause. Consider the following:

- Athena can only query the latest version of data on a versioned Amazon S3 bucket, and cannot query previous versions of the data.
- You must have the appropriate permissions to work with data in the Amazon S3 location. For more information, see [Access to Amazon S3 \(p. 207\)](#).
- If the data is not encrypted in Amazon S3, it can be stored in a different Region from the primary region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges.
- If the data is encrypted in Amazon S3, it must be stored in the same Region, and the user or principal who creates the table in Athena must have the appropriate permissions to decrypt the data. For more information, see [Configuring Encryption Options \(p. 197\)](#).
- Athena supports querying objects that are stored with multiple storage classes in the same bucket specified by the `LOCATION` clause. For example, you can query data in objects that are stored in different Storage classes (Standard, Standard-IA and Intelligent-Tiering) in Amazon S3.
- Athena supports [Requester Pays Buckets](#). For information how to enable Requester Pays for buckets with source data you intend to query in Athena, see [Creating a Workgroup \(p. 249\)](#).
- Athena does not support querying the data in the `GLACIER` storage class. It ignores objects transitioned to the `GLACIER` storage class based on an Amazon S3 lifecycle policy.

For more information, see [Storage Classes, Changing the Storage Class of an Object in Amazon S3](#), [Transitioning to the GLACIER Storage Class \(Object Archival\)](#), and [Requester Pays Buckets](#) in the [Amazon Simple Storage Service Developer Guide](#).

- If you issue queries against Amazon S3 buckets with a large number of objects and the data is not partitioned, such queries may affect the Get request rate limits in Amazon S3 and lead to Amazon S3 exceptions. To prevent errors, partition your data. Additionally, consider tuning your Amazon S3 request rates. For more information, see [Request Rate and Performance Considerations](#).

Functions Supported

The functions supported in Athena queries are those found within Presto. For more information, see [Presto 0.172 Functions and Operators](#) in the Presto documentation.

Transactional Data Transformations Are Not Supported

Athena does not support transaction-based operations (such as the ones found in Hive or Presto) on table data. For a full list of keywords not supported, see [Unsupported DDL \(p. 307\)](#).

Operations That Change Table States Are ACID

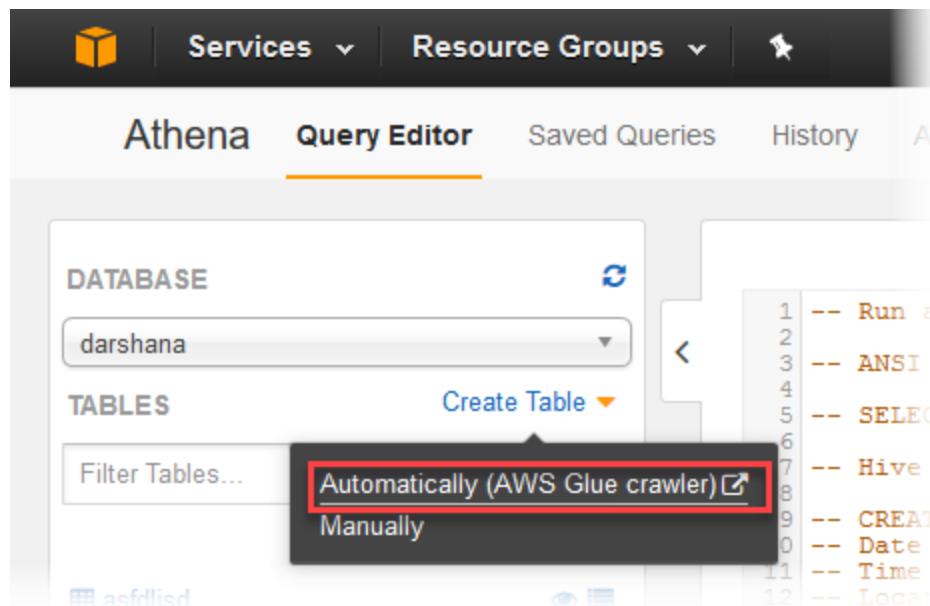
When you create, update, or delete tables, those operations are guaranteed ACID-compliant. For example, if multiple users or clients attempt to create or alter an existing table at the same time, only one will be successful.

All Tables Are EXTERNAL

If you use `CREATE TABLE` without the `EXTERNAL` keyword, Athena issues an error; only tables with the `EXTERNAL` keyword can be created. We recommend that you always use the `EXTERNAL` keyword. When you drop a table in Athena, only the table metadata is removed; the data remains in Amazon S3.

To create a table using the AWS Glue Data Catalog

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **AWS Glue Data Catalog**. You can now create a table with the AWS Glue crawler. For more information, see [Using AWS Glue Crawlers \(p. 49\)](#).



To create a table using the wizard

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Under the database display in the Query Editor, choose **Add table**, which displays a wizard.
3. Follow the steps for creating your table.

To create a database using Hive DDL

A database in Athena is a logical grouping for tables you create in it.

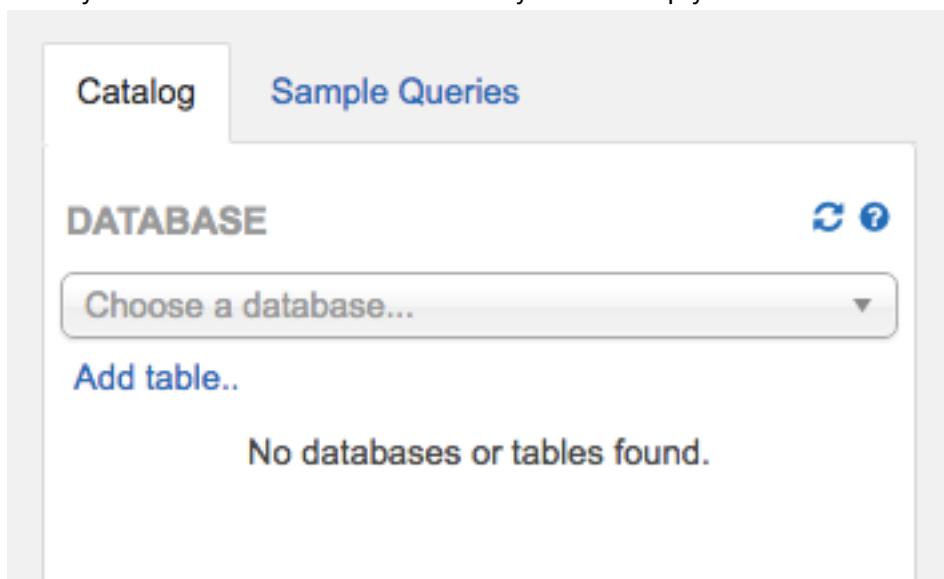
1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Query Editor**.
3. Enter `CREATE DATABASE myDataBase` and choose **Run Query**.

The screenshot shows the Amazon Athena Query Editor interface. In the query editor window, there is a code block containing the following Hive DDL statement:

```
1 CREATE DATABASE myDataBase
2
```

Below the code block are several buttons: "Run Query" (highlighted in blue), "Save As", "or create a", "New Query", and "...". Underneath the buttons, there are two tabs: "Recent Queries" (selected) and "Results". The results section displays the message: "The operation has no results."

4. Select your database from the menu. It is likely to be an empty database.



To create a table using Hive DDL

The Athena Query Editor displays the current database. If you create a table and don't specify a database, the table is created in the database chosen in the **Databases** section on the **Catalog** tab.

1. In the database that you created, create a table by entering the following statement and choosing **Run Query**:

```
CREATE EXTERNAL TABLE IF NOT EXISTS cloudfront_logs (
    `Date` Date,
    Time STRING,
    Location STRING,
    Bytes INT,
    RequestIP STRING,
```

2. If the table was successfully created, you can then run queries against your data.

Names for Tables, Databases, and Columns

Use these tips for naming items in Athena.

Table names and table column names in Athena must be lowercase

If you are interacting with Apache Spark, then your table names and table column names must be lowercase. Athena is case-insensitive and turns table names and column names to lower case, but Spark requires lowercase table and column names.

Queries with mixedCase column names, such as `profileURI`, or upper case column names do not work.

Athena table, view, database, and column names allow only underscore special characters

Athena table, view, database, and column names cannot contain special characters, other than underscore (_).

Names that begin with an underscore

Use backticks to enclose table, view, or column names that begin with an underscore. For example:

```
CREATE TABLE `myunderscoretable` (
  `_id` string,
  `_index` string,
  ...
)
```

Table or view names that include numbers

Enclose table names that include numbers in quotation marks. For example:

```
CREATE TABLE "table123"  
`_id` string,  
`index` string,
```

...

Reserved Keywords

When you run queries in Athena that include reserved keywords, you must escape them by enclosing them in special characters. Use the lists in this topic to check which keywords are reserved in Athena.

To escape reserved keywords in DDL statements, enclose them in backticks (`). To escape reserved keywords in SQL SELECT statements and in queries on [Working with Views \(p. 113\)](#), enclose them in double quotes ("").

- [List of Reserved Keywords in DDL Statements \(p. 33\)](#)
- [List of Reserved Keywords in SQL SELECT Statements \(p. 33\)](#)
- [Examples of Queries with Reserved Keywords \(p. 34\)](#)

List of Reserved Keywords in DDL Statements

Athena uses the following list of reserved keywords in its DDL statements. If you use them without escaping them, Athena issues an error. To escape them, enclose them in backticks (`).

You cannot use DDL reserved keywords as identifier names in DDL statements without enclosing them in backticks (`).

```
ALL, ALTER, AND, ARRAY, AS, AUTHORIZATION, BETWEEN, BIGINT, BINARY, BOOLEAN, BOTH,  
BY, CASE, CASHE, CAST, CHAR, COLUMN, CONF, CONSTRAINT, COMMIT, CREATE, CROSS, CUBE,  
CURRENT, CURRENT_DATE, CURRENT_TIMESTAMP, CURSOR, DATABASE, DATE, DAYOFWEEK, DECIMAL,  
DELETE, DESCRIBE, DISTINCT, DOUBLE, DROP, ELSE, END, EXCHANGE, EXISTS, EXTENDED,  
EXTERNAL, EXTRACT, FALSE, FETCH, FLOAT, FLOOR, FOLLOWING, FOR, FOREIGN, FROM, FULL,  
FUNCTION, GRANT, GROUP, GROUPING, HAVING, IF, IMPORT, IN, INNER, INSERT, INT, INTEGER,  
INTERSECT, INTERVAL, INTO, IS, JOIN, LATERAL, LEFT, LESS, LIKE, LOCAL, MACRO, MAP, MORE,  
NONE, NOT, NULL, NUMERIC, OF, ON, ONLY, OR, ORDER, OUT, OUTER, OVER, PARTIALSCAN,  
PARTITION,  
PERCENT, PRECEDING, PRECISION, PRESERVE, PRIMARY, PROCEDURE, RANGE, READS, REDUCE, REGEXP,  
REFERENCES, REVOKE, RIGHT, RLIKE, ROLLBACK, ROLLUP, ROW, ROWS, SELECT, SET, SMALLINT,  
START, TABLE,  
TABLESAMPLE, THEN, TIME, TIMESTAMP, TO, TRANSFORM, TRIGGER, TRUE, TRUNCATE,  
UNBOUNDED, UNION,  
UNIQUEJOIN, UPDATE, USER, USING, UTC_TIMESTAMP, VALUES, VARCHAR, VIEWS, WHEN, WHERE,  
WINDOW, WITH
```

List of Reserved Keywords in SQL SELECT Statements

Athena uses the following list of reserved keywords in SQL SELECT statements and in queries on views.

If you use these keywords as identifiers, you must enclose them in double quotes ("") in your query statements.

```
ALTER, AND, AS, BETWEEN, BY, CASE, CAST,  
CONSTRAINT, CREATE, CROSS, CUBE, CURRENT_DATE, CURRENT_PATH,  
CURRENT_TIME, CURRENT_TIMESTAMP, CURRENT_USER, DEALLOCATE,  
DELETE, DESCRIBE, DISTINCT, DROP, ELSE, END, ESCAPE, EXCEPT,  
EXECUTE, EXISTS, EXTRACT, FALSE, FIRST, FOR, FROM, FULL, GROUP,  
GROUPING, HAVING, IN, INNER, INSERT, INTERSECT, INTO,  
IS, JOIN, LAST, LEFT, LIKE, LOCALTIME, LOCALTIMESTAMP, NATURAL,  
NORMALIZE, NOT, NULL, ON, OR, ORDER, OUTER, PREPARE,
```

```
RECURSIVE, RIGHT, ROLLUP, SELECT, TABLE, THEN, TRUE,  
UNESCAPE, UNION, UNNEST, USING, VALUES, WHEN, WHERE, WITH
```

Examples of Queries with Reserved Words

The query in the following example uses backticks (`) to escape the DDL-related reserved keywords *partition* and *date* that are used for a table name and one of the column names:

```
CREATE EXTERNAL TABLE `partition` (  
`date` INT,  
col2 STRING  
)  
PARTITIONED BY (year STRING)  
STORED AS TEXTFILE  
LOCATION 's3://test_bucket/test_examples/';
```

The following example queries include a column name containing the DDL-related reserved keywords in `ALTER TABLE ADD PARTITION` and `ALTER TABLE DROP PARTITION` statements. The DDL reserved keywords are enclosed in backticks (`):

```
ALTER TABLE test_table  
ADD PARTITION (`date` = '2018-05-14')
```

```
ALTER TABLE test_table  
DROP PARTITION (`partition` = 'test_partition_value')
```

The following example query includes a reserved keyword (end) as an identifier in a `SELECT` statement. The keyword is escaped in double quotes:

```
SELECT *  
FROM TestTable  
WHERE "end" != nil;
```

The following example query includes a reserved keyword (first) in a `SELECT` statement. The keyword is escaped in double quotes:

```
SELECT "itemId"."first"  
FROM testTable  
LIMIT 10;
```

Table Location in Amazon S3

When you run a `CREATE TABLE` query in Athena, you register your table with the AWS Glue Data Catalog. If you are using Athena own catalog, we highly recommend that you [upgrade \(p. 56\)](#) to the AWS Glue Data Catalog. You specify the path to your data in the `LOCATION` property, as shown in the following abbreviated example:

```
CREATE EXTERNAL TABLE `test_table`(  
...  
)  
ROW FORMAT ...  
STORED AS INPUTFORMAT ...  
OUTPUTFORMAT ...
```

```
LOCATION s3://bucketname/prefix/
```

This location in Amazon S3 comprises *all* of the files representing your table. For more information, see [Using Folders in the Amazon Simple Storage Service Console User Guide](#).

Important

Athena reads *all* data stored under the '*s3://bucketname/prefix/*'. If you have data that you do *not* want Athena to read, do not store that data in the same Amazon S3 prefix as the data you want Athena to read. If you are leveraging partitioning, to ensure Athena scans data within a partition, your WHERE filter must include the partition. For more information, see [Table Location and Partitions \(p. 35\)](#).

Use these tips and examples when you specify the Amazon S3 location of your data in the Athena CREATE TABLE statement:

- In the LOCATION clause, use a trailing slash.

Use:

```
s3://bucketname/prefix/
```

- Do not use any of the following items for specifying the location for your data.
 - Do not use filenames, underscores, wildcards, or glob patterns for specifying file locations.
 - Do not add the full HTTP notation, such as `s3.amazonaws.com` to the Amazon S3 bucket path.
 - Do not use empty prefixes (with the extra /) in the path, as follows: `s3://bucketname/prefix//prefix/`. While this is a valid Amazon S3 path, Athena does not allow it and changes it to `s3://bucketname/prefix/prefix/`, removing the extra /.

Do not use:

```
s3://path_to_bucket
s3://path_to_bucket/*
s3://path_to_bucket/mySpecialFile.dat
s3://bucketname/prefix/filename.csv
s3://test-bucket.s3.amazonaws.com
S3://bucket/prefix//prefix/
arn:aws:s3:::bucketname/prefix
```

Table Location and Partitions

Your source data may be grouped into Amazon S3 prefixes, also known as partitions, based on a set of columns. For example, these columns may represent the year, month, and day the particular record was created.

When creating a table, you can choose to make it partitioned. When Athena executes an SQL query against a non-partitioned table, it uses the LOCATION property from the table definition as the base path to list and then scan all available files. Before a partitioned table can be queried, you must first update the AWS Glue Data Catalog with partition information. This information represents the schema of files within the particular partition and the LOCATION of files in Amazon S3 for the partition. To learn how the AWS Glue crawler adds partitions, see [How Does a Crawler Determine When to Create Partitions?](#) in the *AWS Glue Developer Guide*. To learn how to configure the crawler so that it creates tables for data in existing partitions, see [Using Multiple Data Sources with Crawlers \(p. 49\)](#). You can also create partitions in a table directly in Athena. For more information, see [Partitioning Data \(p. 36\)](#).

When Athena executes a query on a partitioned table, it first checks to see if any partitioned columns were used in the WHERE clause of the query. If partitioned columns were used, Athena requests the AWS

Glue Data Catalog to return the partition specification matching the specified partition columns. The partition specification includes the `LOCATION` property which tells Athena which Amazon S3 prefix it needs to use when reading data. In this case, *only* data stored in this prefix is scanned. If you do not use partitioned columns in the `WHERE` clause, Athena scans all of the files starting at the base Amazon S3 path specified by the `LOCATION` property in the main table definition.

For examples of using partitioning with Athena to improve query performance and reduce query costs, see [Top Performance Tuning Tips for Amazon Athena](#).

Partitioning Data

By partitioning your data, you can restrict the amount of data scanned by each query, thus improving performance and reducing cost. Athena leverages Hive for [partitioning](#) data. You can partition your data by any key. A common practice is to partition the data based on time, often leading to a multi-level partitioning scheme. For example, a customer who has data coming in every hour might decide to partition by year, month, date, and hour. Another customer, who has data coming from many different sources but loaded one time per day, may partition by a data source identifier and date.

If you issue queries against Amazon S3 buckets with a large number of objects and the data is not partitioned, such queries may affect the Get request rate limits in Amazon S3 and lead to Amazon S3 exceptions. To prevent errors, partition your data. Additionally, consider tuning your Amazon S3 request rates. For more information, see [Request Rate and Performance Considerations](#).

Note

If you query a partitioned table and specify the partition in the `WHERE` clause, Athena scans the data only from that partition. For more information, see [Table Location and Partitions \(p. 35\)](#).

To create a table with partitions, you must define it during the `CREATE TABLE` statement. Use `PARTITIONED BY` to define the keys by which to partition data. There are two scenarios discussed in the following sections:

1. Data is already partitioned, stored on Amazon S3, and you need to access the data on Athena.
2. Data is not partitioned.

Scenario 1: Data already partitioned and stored on S3 in hive format

Storing Partitioned Data

Partitions are stored in separate folders in Amazon S3. For example, here is the partial listing for sample ad impressions:

```
aws s3 ls s3://elasticmapreduce/samples/hive-ads/tables/impressions/  
  
PRE dt=2009-04-12-13-00/  
PRE dt=2009-04-12-13-05/  
PRE dt=2009-04-12-13-10/  
PRE dt=2009-04-12-13-15/  
PRE dt=2009-04-12-13-20/  
PRE dt=2009-04-12-14-00/  
PRE dt=2009-04-12-14-05/  
PRE dt=2009-04-12-14-10/  
PRE dt=2009-04-12-14-15/  
PRE dt=2009-04-12-14-20/
```

```
PRE dt=2009-04-12-15-00/  
PRE dt=2009-04-12-15-05/
```

Here, logs are stored with the column name (dt) set equal to date, hour, and minute increments. When you give a DDL with the location of the parent folder, the schema, and the name of the partitioned column, Athena can query data in those subfolders.

Creating a Table

To make a table out of this data, create a partition along 'dt' as in the following Athena DDL statement:

```
CREATE EXTERNAL TABLE impressions (  
    requestBeginTime string,  
    adId string,  
    impressionId string,  
    referrer string,  
    userAgent string,  
    userCookie string,  
    ip string,  
    number string,  
    processId string,  
    browserCookie string,  
    requestEndTime string,  
    timers struct<modelLookup:string, requestTime:string>,  
    threadId string,  
    hostname string,  
    sessionId string)  
PARTITIONED BY (dt string)  
ROW FORMAT serde 'org.apache.hive.hcatalog.data.JsonSerDe'  
    with serdeproperties ( 'paths'='requestBeginTime, adId, impressionId, referrer,  
    userAgent, userCookie, ip' )  
LOCATION 's3://elasticmapreduce/samples/hive-ads/tables/impressions/' ;
```

This table uses Hive's native JSON serializer-deserializer to read JSON data stored in Amazon S3. For more information about the formats supported, see [Supported Data Formats, SerDes, and Compression Formats \(p. 274\)](#).

After you execute this statement in Athena, choose **New Query** and execute:

```
MSCK REPAIR TABLE impressions
```

Athena loads the data in the partitions.

Query the Data

Now, query the data from the impressions table using the partition column. Here's an example:

```
SELECT dt,impressionid FROM impressions WHERE dt<'2009-04-12-14-00' and  
dt>='2009-04-12-13-00' ORDER BY dt DESC LIMIT 100
```

This query should show you data similar to the following:

2009-04-12-13-20	ap3HcVKAWfXtgIPu6WpuUfAfL0DQEe
2009-04-12-13-20	17uchtodoS9kdeQP1x0XThKl5IuRsV
2009-04-12-13-20	JOUfISCTrwviGw8sVcghqE5h0nkgtp
2009-04-12-13-20	NQ2XP0J0dvVbCXJ0pb4XvqJ5A49xxH
2009-04-12-13-20	fFAItiBMsgqro9kRdIwbeX60SROaxr
2009-04-12-13-20	V4og4R9W6G3QjHHwF7gI1cSqig5D1G

2009-04-12-13-20	hPEPtBwk45msmwWTxPVVo1kVu4v11b
2009-04-12-13-20	v0SkfkegheD90gp31UCr6FplnKpx6i
2009-04-12-13-20	1iD9odVgOIi4QWkhMcOhmwTkWDKfj
2009-04-12-13-20	b31tJiIA25CK8eDHQrHnbcknfSndUk

Scenario 2: Data is not partitioned

A layout like the following does not, however, work for automatically adding partition data with MSCK REPAIR TABLE:

```
aws s3 ls s3://athena-examples/elb/plain/text/ --recursive

2016-11-23 17:54:46  11789573 elb/plain/text/2015/01/01/part-r-00000-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46  8776899 elb/plain/text/2015/01/01/part-r-00001-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46  9309800 elb/plain/text/2015/01/01/part-r-00002-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47  9412570 elb/plain/text/2015/01/01/part-r-00003-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47  10725938 elb/plain/text/2015/01/01/part-r-00004-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46  9439710 elb/plain/text/2015/01/01/part-r-00005-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47  0 elb/plain/text/2015/01/01_$folder$*
2016-11-23 17:54:47  9012723 elb/plain/text/2015/01/02/part-r-00006-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47  7571816 elb/plain/text/2015/01/02/part-r-00007-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47  9673393 elb/plain/text/2015/01/02/part-r-00008-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  11979218 elb/plain/text/2015/01/02/part-r-00009-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  9546833 elb/plain/text/2015/01/02/part-r-00010-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  10960865 elb/plain/text/2015/01/02/part-r-00011-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  0 elb/plain/text/2015/01/02_$folder$*
2016-11-23 17:54:48  11360522 elb/plain/text/2015/01/03/part-r-00012-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  11211291 elb/plain/text/2015/01/03/part-r-00013-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48  8633768 elb/plain/text/2015/01/03/part-r-00014-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49  11891626 elb/plain/text/2015/01/03/part-r-00015-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49  9173813 elb/plain/text/2015/01/03/part-r-00016-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49  11899582 elb/plain/text/2015/01/03/part-r-00017-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49  0 elb/plain/text/2015/01/03_$folder$*
2016-11-23 17:54:50  8612843 elb/plain/text/2015/01/04/part-r-00018-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50  10731284 elb/plain/text/2015/01/04/part-r-00019-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50  9984735 elb/plain/text/2015/01/04/part-r-00020-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50  9290089 elb/plain/text/2015/01/04/part-r-00021-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50  7896339 elb/plain/text/2015/01/04/part-r-00022-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:51  8321364 elb/plain/text/2015/01/04/part-r-00023-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
```

```

2016-11-23 17:54:51      0 elb/plaintext/2015/01/04_$folder$  

2016-11-23 17:54:51      7641062 elb/plaintext/2015/01/05/part-r-00024-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      10253377 elb/plaintext/2015/01/05/part-r-00025-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      8502765 elb/plaintext/2015/01/05/part-r-00026-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      11518464 elb/plaintext/2015/01/05/part-r-00027-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      7945189 elb/plaintext/2015/01/05/part-r-00028-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      7864475 elb/plaintext/2015/01/05/part-r-00029-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      0 elb/plaintext/2015/01/05_$folder$  

2016-11-23 17:54:51      11342140 elb/plaintext/2015/01/06/part-r-00030-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:51      8063755 elb/plaintext/2015/01/06/part-r-00031-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      9387508 elb/plaintext/2015/01/06/part-r-00032-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      9732343 elb/plaintext/2015/01/06/part-r-00033-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      11510326 elb/plaintext/2015/01/06/part-r-00034-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      9148117 elb/plaintext/2015/01/06/part-r-00035-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      0 elb/plaintext/2015/01/06_$folder$  

2016-11-23 17:54:52      8402024 elb/plaintext/2015/01/07/part-r-00036-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      8282860 elb/plaintext/2015/01/07/part-r-00037-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:52      11575283 elb/plaintext/2015/01/07/part-r-00038-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:53      8149059 elb/plaintext/2015/01/07/part-r-00039-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:53      10037269 elb/plaintext/2015/01/07/part-r-00040-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:53      10019678 elb/plaintext/2015/01/07/part-r-00041-ce65fca5-d6c6-40e6-  

b1f9-190cc4f93814.txt  

2016-11-23 17:54:53      0 elb/plaintext/2015/01/07_$folder$  

2016-11-23 17:54:53      0 elb/plaintext/2015/01_$folder$  

2016-11-23 17:54:53      0 elb/plaintext/2015_$folder$
```

In this case, you would have to use `ALTER TABLE ADD PARTITION` to add each partition manually.

For example, to load the data in `s3://athena-examples/elb/plaintext/2015/01/01/`, you can run the following:

```
ALTER TABLE elb_logs_raw_native_part ADD PARTITION (year='2015',month='01',day='01')
location 's3://athena-examples/elb/plaintext/2015/01/01/'
```

You can also automate adding partitions by using the [JDBC driver \(p. 71\)](#).

Columnar Storage Formats

[Apache Parquet](#) and [ORC](#) are columnar storage formats that are optimized for fast retrieval of data and used in AWS analytical applications.

Columnar storage formats have the following characteristics that make them suitable for using with Athena:

- *Compression by column, with compression algorithm selected for the column data type* to save storage space in Amazon S3 and reduce disk space and I/O during query processing.
- *Predicate pushdown* in Parquet and ORC enables Athena queries to fetch only the blocks it needs, improving query performance. When an Athena query obtains specific column values from your data, it uses statistics from data block predicates, such as max/min values, to determine whether to read or skip the block.
- *Splitting of data* in Parquet and ORC allows Athena to split the reading of data to multiple readers and increase parallelism during its query processing.

To convert your existing raw data from other storage formats to Parquet or ORC, you can run [CREATE TABLE AS SELECT \(CTAS\) \(p. 118\)](#) queries in Athena and specify a data storage format as Parquet or ORC, or use the AWS Glue Crawler.

Converting to Columnar Formats

Your Amazon Athena query performance improves if you convert your data into open source columnar formats, such as [Apache Parquet](#) or [ORC](#).

Note

Use the [CREATE TABLE AS \(CTAS\) \(p. 124\)](#) queries to perform the conversion to columnar formats, such as Parquet and ORC, in one step.

You can do this to existing Amazon S3 data sources by creating a cluster in Amazon EMR and converting it using Hive. The following example using the AWS CLI shows you how to do this with a script and data stored in Amazon S3.

Overview

The process for converting to columnar formats using an EMR cluster is as follows:

1. Create an EMR cluster with Hive installed.
2. In the step section of the cluster create statement, specify a script stored in Amazon S3, which points to your input data and creates output data in the columnar format in an Amazon S3 location. In this example, the cluster auto-terminates.

Note

The script is based on Amazon EMR version 4.7 and needs to be updated to the current version. For information about versions, see [Amazon EMR Release Guide](#).

The full script is located on Amazon S3 at:

```
s3://athena-examples/conversion/write-parquet-to-s3.q
```

Here's an example script beginning with the CREATE TABLE snippet:

```
ADD JAR /usr/lib/hive-hcatalog/share/hcatalog/hive-hcatalog-core-1.0.0-amzn-5.jar;
CREATE EXTERNAL TABLE impressions (
    requestBeginTime string,
    adId string,
    impressionId string,
    referrer string,
    userAgent string,
    userCookie string,
    ip string,
    number string,
```

```

processId string,
browserCookie string,
requestEndTime string,
timers struct<modelLookup:string, requestTime:string>,
threadId string,
hostname string,
sessionId string)
PARTITIONED BY (dt string)
ROW FORMAT serde 'org.apache.hive.hcatalog.data.JsonSerDe'
with serdeproperties ( 'paths'='requestBeginTime, adId, impressionId, referrer,
userAgent, userCookie, ip' )
LOCATION 's3://${REGION}.elasticmapreduce/samples/hive-ads/tables/impressions/' ;

```

Note

Replace REGION in the LOCATION clause with the region where you are running queries. For example, if your console is in us-east-1, REGION is s3://us-east-1.elasticmapreduce/samples/hive-ads/tables/.

This creates the table in Hive on the cluster which uses samples located in the Amazon EMR samples bucket.

3. On Amazon EMR release 4.7.0, include the ADD JAR line to find the appropriate JsonSerDe. The prettified sample data looks like the following:

```
{
    "number": "977680",
    "referrer": "fastcompany.com",
    "processId": "1823",
    "adId": "TRktxshQXAHWo261jAHubijAoNlAqA",
    "browserCookie": "mvlrdrwmef",
    "userCookie": "emFlrLGrm5fA2xLFT5npwbPuG7kf6X",
    "requestEndTime": "1239714001000",
    "impressionId": "1I5G20RmOuG2rt7fFGFgsaWk9Xpkfb",
    "userAgent": "Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 6.0; SLCC1; .NET CLR 2.0.50727; Media Center PC 5.0; .NET CLR 3.0.0.04506; InfoPa",
    "timers": {
        "modelLookup": "0.3292",
        "requestTime": "0.6398"
    },
    "threadId": "99",
    "ip": "67.189.155.225",
    "modelId": "bxxiuxduad",
    "hostname": "ec2-0-51-75-39.amazon.com",
    "sessionId": "J9NOccA3dDMFlixCuSot19QBbj6aS",
    "requestBeginTime": "1239714000000"
}
```

4. In Hive, load the data from the partitions, so the script runs the following:

```
MSCK REPAIR TABLE impressions;
```

The script then creates a table that stores your data in a Parquet-formatted file on Amazon S3:

```

CREATE EXTERNAL TABLE parquet_hive (
    requestBeginTime string,
    adId string,
    impressionId string,
    referrer string,
    userAgent string,
    userCookie string,
    ip string
) STORED AS PARQUET

```

```
LOCATION 's3://myBucket/myParquet/';
```

The data are inserted from the *impressions* table into *parquet_hive*:

```
INSERT OVERWRITE TABLE parquet_hive
SELECT
requestbegintime,
adid,
impressionid,
referrer,
useragent,
usercookie,
ip FROM impressions WHERE dt='2009-04-14-04-05';
```

The script stores the above *impressions* table columns from the date, 2009-04-14-04-05, into s3://myBucket/myParquet/ in a Parquet-formatted file.

5. After your EMR cluster is terminated, create your table in Athena, which uses the data in the format produced by the cluster.

Before you begin

- You need to create EMR clusters. For more information about Amazon EMR, see the [Amazon EMR Management Guide](#).
- Follow the instructions found in [Setting Up \(p. 21\)](#).

Example: Converting data to Parquet using an EMR cluster

1. Use the AWS CLI to create a cluster. If you need to install the AWS CLI, see [Installing the AWS Command Line Interface](#) in the AWS Command Line Interface User Guide.
2. You need roles to use Amazon EMR, so if you haven't used Amazon EMR before, create the default roles using the following command:

```
aws emr create-default-roles
```

3. Create an Amazon EMR cluster using the emr-4.7.0 release to convert the data using the following AWS CLI **emr create-cluster** command:

```
export REGION=us-east-1
export SAMPLEURI=s3://${REGION}.elasticmapreduce/samples/hive-ads/tables/impressions/
export S3BUCKET=myBucketName

aws emr create-cluster
--applications Name=Hadoop Name=Hive Name=HCatalog \
--ec2-attributes KeyName=myKey,InstanceProfile=EMR_EC2_DefaultRole,SubnetId=subnet-
mySubnetId \
--service-role EMR_DefaultRole
--release-label emr-4.7.0
--instance-type m4.large
--instance-count 1
--steps Type=HIVE,Name="Convert to Parquet",\
ActionOnFailure=CONTINUE,
ActionOnFailure=TERMINATE_CLUSTER,
Args=[-f,
```

```
\s3://athena-examples/conversion/write-parquet-to-s3.q,-hiveconf,
INPUT=${SAMPLEURI},-hiveconf,
OUTPUT=s3://${S3BUCKET}/myParquet,-hiveconf,
REGION=${REGION}
] \
--region ${REGION}
--auto-terminate
```

For more information, see [Create and Use IAM Roles for Amazon EMR](#) in the Amazon EMR Management Guide.

A successful request gives you a cluster ID.

4. Monitor the progress of your cluster using the AWS Management Console, or using the cluster ID with the *list-steps* subcommand in the AWS CLI:

```
aws emr list-steps --cluster-id myClusterID
```

Look for the script step status. If it is COMPLETED, then the conversion is done and you are ready to query the data.

5. Create the same table that you created on the EMR cluster.

You can use the same statement as above. Log into Athena and enter the statement in the **Query Editor** window:

```
CREATE EXTERNAL TABLE parquet_hive (
    requestBeginTime string,
    adId string,
    impressionId string,
    referrer string,
    userAgent string,
    userCookie string,
    ip string
) STORED AS PARQUET
LOCATION 's3://myBucket/myParquet/' ;
```

Choose **Run Query**.

6. Run the following query to show that you can query this data:

```
SELECT * FROM parquet_hive LIMIT 10;
```

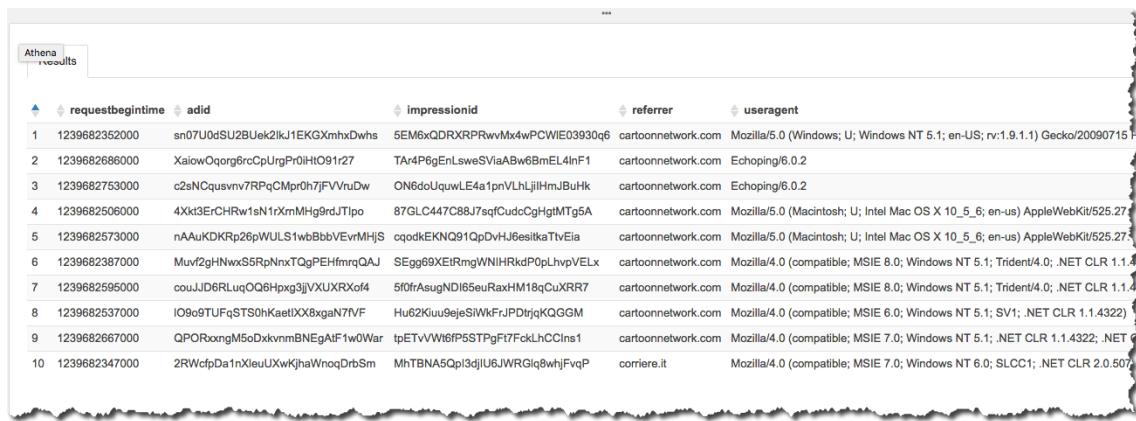
Alternatively, you can select the view (eye) icon next to the table's name in **Catalog**:



The results should show output similar to this:

Amazon Athena User Guide

Example: Converting data to Parquet using an EMR cluster



	requestbegintime	adid	impressionid	referrer	useragent
1	1239682352000	sn07U0dSU2BUEk2IkU1EKG3XnhxDwhs	5EM6xQDRXRPRvMxdwPCWIE03930q6	cartoonnetwork.com	Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.9.1.1) Gecko/20090715
2	1239682686000	XalowOqorg6rcCpUrgFr0lHO91z7	TAr4P6gEnLsweSViaABw6BmEl4InF1	cartoonnetwork.com	Echoping/6.0.2
3	1239682753000	c2sNCqusvnv7RPqCMpr0h7fVvruDw	ON6doUquwLE4a1pnVLhLjilHmJBuHk	cartoonnetwork.com	Echoping/6.0.2
4	1239682506000	4Xk3ErCHRw1sN1rXmMiHg9rdJTpo	87GLC447C88J7sqfCudcCgHigtMTg5A	cartoonnetwork.com	Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10_5_6; en-us) AppleWebKit/525.27
5	1239682573000	nAAuKDKRp26pWULSwbb/EvrMHJS	c9odkEKNQ91QpDvHJ6esikaTlvEia	cartoonnetwork.com	Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10_5_6; en-us) AppleWebKit/525.27
6	1239682387000	Muvf2gHNwxS5RpNnxTQgPEHfmrqQAJ	SEgg69XEIRmgWNiHRkdP0pLhpVELx	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 5.1; Trident/4.0; .NET CLR 1.1.4
7	1239682595000	couJD6RLuqOQ6Hpxg3jlVXUXRxof4	5f0frAsugND65euRaxHM18qCuXRR7	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 5.1; Trident/4.0; .NET CLR 1.1.4
8	1239682537000	IO9o9TUFeSTS0hKaetIXBxgan7IVF	Hu62Kiuu9ejeSiIWkFrJPDtjqkQQGM	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 1.1.4322)
9	1239682667000	QPORxongMs0DxkvnmBNNEgAfIw0Wa	tpETvVW6fp5STPgF7FckLhCCIns1	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1; .NET CLR 1.1.4322; .NET
10	1239682347000	2RWcfpDa1nXieuUXwkJhaWnoqDrbSm	MhTBNA5Qp13dJU6JWRGIq8whjFvqP	corriere.it	Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 6.0; SLCC1; .NET CLR 2.0.507

Connecting to Data Sources

You can use Amazon Athena to query data stored in different locations and formats in a *dataset*. This dataset might be in CSV, JSON, Avro, Parquet, or some other format.

The tables and databases that you work with in Athena to run queries are based on *metadata*. Metadata is data about the underlying data in your dataset. How that metadata describes your dataset is called the *schema*. For example, a table name, the column names in the table, and the data type of each column are schema, saved as metadata, that describe an underlying dataset. In Athena, we call a system for organizing metadata a *data catalog* or a *metastore*. The combination of a dataset and the data catalog that describes it is called a *data source*.

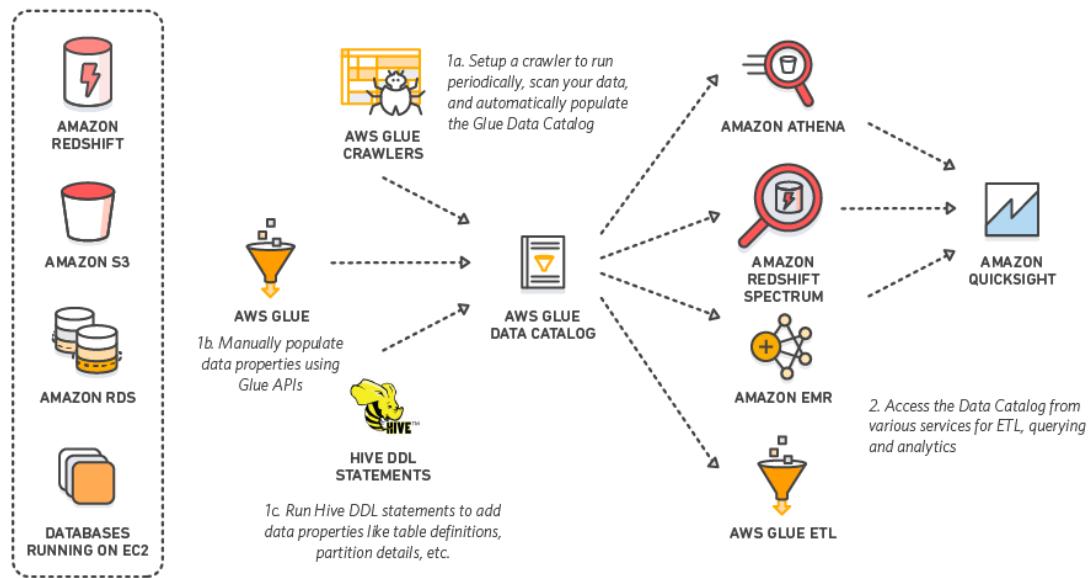
The relationship of metadata to an underlying dataset depends on the type of data source that you work with. Relational data sources like MySQL, PostgreSQL, and SQL Server tightly integrate the metadata with the dataset. In these systems, the metadata is most often written when the data is written. Other data sources, like those built using [Hive](#), allow you to define metadata on-the-fly when you read the dataset. The dataset can be in a variety of formats—for example, CSV, JSON, Parquet, or Avro.

Athena natively supports the AWS Glue Data Catalog. The AWS Glue Data Catalog is a data catalog built on top of other datasets and data sources such as Amazon S3, Amazon Redshift, and Amazon DynamoDB. You can also connect Athena to other data sources by using a variety of connectors.

Integration with AWS Glue

[AWS Glue](#) is a fully managed ETL (extract, transform, and load) service that can categorize your data, clean it, enrich it, and move it reliably between various data stores. AWS Glue crawlers automatically infer database and table schema from your dataset, storing the associated metadata in the AWS Glue Data Catalog.

Athena natively supports querying datasets and data sources that are registered with the AWS Glue Data Catalog. When you run Data Manipulation Language (DML) queries in Athena with the Data Catalog as your source, you are using the Data Catalog schema to derive insight from the underlying dataset. When you run Data Definition Language (DDL) queries, the schema you define are defined in the AWS Glue Data Catalog. From within Athena, you can also run a AWS Glue crawler on a data source to create schema in the AWS Glue Data Catalog.



In regions where AWS Glue is supported, Athena uses the AWS Glue Data Catalog as a central location to store and retrieve table metadata throughout an AWS account. The Athena execution engine requires table metadata that instructs it where to read data, how to read it, and other information necessary to process the data. The AWS Glue Data Catalog provides a unified metadata repository across a variety of data sources and data formats, integrating not only with Athena, but with Amazon S3, Amazon RDS, Amazon Redshift, Amazon Redshift Spectrum, Amazon EMR, and any application compatible with the Apache Hive metastore.

For more information about the AWS Glue Data Catalog, see [Populating the AWS Glue Data Catalog in the AWS Glue Developer Guide](#). For a list of regions where AWS Glue is available, see [Regions and Endpoints in the AWS General Reference](#).

Separate charges apply to AWS Glue. For more information, see [AWS Glue Pricing](#) and [Are there separate charges for AWS Glue? \(p. 59\)](#) For more information about the benefits of using AWS Glue with Athena, see [Why should I upgrade to the AWS Glue Data Catalog? \(p. 58\)](#)

Topics

- [Using AWS Glue to Connect to Data Sources in Amazon S3 \(p. 46\)](#)
- [Best Practices When Using Athena with AWS Glue \(p. 48\)](#)
- [Upgrading to the AWS Glue Data Catalog Step-by-Step \(p. 56\)](#)
- [FAQ: Upgrading to the AWS Glue Data Catalog \(p. 58\)](#)

Using AWS Glue to Connect to Data Sources in Amazon S3

Athena can connect to your data stored in Amazon S3 using the AWS Glue Data Catalog to store metadata such as table and column names. After the connection is made, your databases, tables, and views appear in Athena's query editor.

To define schema information for AWS Glue to use, you can set up an AWS Glue crawler to retrieve the information, or you can manually add a table and enter the schema information.

Setting up a Crawler

You set up a crawler by starting in the Athena console and then using the AWS Glue console in an integrated way. When you create a crawler, you can choose data stores to crawl or point the crawler to existing catalog tables.

To set up a crawler in AWS Glue to retrieve schema information automatically

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **AWS Glue Data Catalog**.
4. Click **Next**.
5. On the **Connection details** page, choose **Set up crawler in AWS Glue to retrieve schema information automatically**.
6. Click **Connect to AWS AWS Glue**.
7. On the **AWS Glue** console **Add crawler** page, follow the steps to create a crawler. For more information, see [Populating the AWS Glue Data Catalog](#).

Adding a Schema Table Manually

The following procedure shows you how to use the Athena console to add a table manually.

To add a table and enter schema information manually

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **AWS Glue Data Catalog**.
4. Click **Next**.
5. On the **Connection details** page, choose **Add a table and enter schema information manually**.
6. Click **Continue to add table**.
7. On the **Add table** page of the Athena console, for **Database**, choose an existing database or create a new one.
8. Enter or choose a table name.
9. For **Location of Input Data Set**, specify the path in Amazon S3 to the folder that contains the dataset that you want to process.
10. Click **Next**.
11. For **Data Format**, choose a data format (**Apache Web Logs**, **CSV**, **TSV**, **Text File with Custom Delimiters**, **JSON**, **Parquet**, or **ORC**).
 - For the **Apache Web Logs** option, you must also enter a regex expression in the **Regex** box.
 - For the **Text File with Custom Delimiters** option, specify a **Field terminator** (that is, a column delimiter). Optionally, you can specify a **Collection terminator** for array types or a **Map key terminator**.
12. For **Columns**, specify a column name and the column data type.
 - To add more columns one at a time, choose **Add a column**.
 - To quickly add more columns, choose **Bulk add columns**. In the text box, enter a comma separated list of columns in the format `column_name data_type, column_name data_type[...]`, and then choose **Add**.
13. Choose **Next**.
14. (Optional) For **Partitions**, click **Add a partition** to add column names and data types.

15. Choose **Create table**. The DDL for the table that you specified appears in the **Query Editor**. The following example shows the DDL generated for a two-column table in CSV format:

```
CREATE EXTERNAL TABLE IF NOT EXISTS MyManualDB.MyManualTable (
    `cola` string,
    `colb` string
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe'
WITH SERDEPROPERTIES (
    'serialization.format' = ',',
    'field.delim' = ','
) LOCATION 's3://bucket_name/'
TBLPROPERTIES ('has_encrypted_data='false');
```

16. Choose **Run query** to create the table.

Best Practices When Using Athena with AWS Glue

When using Athena with the AWS Glue Data Catalog, you can use AWS Glue to create databases and tables (schema) to be queried in Athena, or you can use Athena to create schema and then use them in AWS Glue and related services. This topic provides considerations and best practices when using either method.

Under the hood, Athena uses Presto to execute DML statements and Hive to execute the DDL statements that create and modify schema. With these technologies, there are a couple of conventions to follow so that Athena and AWS Glue work well together.

In this topic

- [Database, Table, and Column Names \(p. 48\)](#)
- [Using AWS Glue Crawlers \(p. 49\)](#)
 - [Scheduling a Crawler to Keep the AWS Glue Data Catalog and Amazon S3 in Sync \(p. 49\)](#)
 - [Using Multiple Data Sources with Crawlers \(p. 49\)](#)
 - [Syncing Partition Schema to Avoid "HIVE_PARTITION_SCHEMA_MISMATCH" \(p. 51\)](#)
 - [Updating Table Metadata \(p. 52\)](#)
- [Working with CSV Files \(p. 52\)](#)
 - [CSV Data Enclosed in Quotes \(p. 52\)](#)
 - [CSV Files with Headers \(p. 54\)](#)
- [Working with Geospatial Data \(p. 54\)](#)
- [Using AWS Glue Jobs for ETL with Athena \(p. 54\)](#)
 - [Creating Tables Using Athena for AWS Glue ETL Jobs \(p. 54\)](#)
 - [Using ETL Jobs to Optimize Query Performance \(p. 55\)](#)
 - [Converting SMALLINT and TINYINT Datatypes to INT When Converting to ORC \(p. 56\)](#)
 - [Automating AWS Glue Jobs for ETL \(p. 56\)](#)

Database, Table, and Column Names

When you create schema in AWS Glue to query in Athena, consider the following:

- A database name cannot be longer than 252 characters.
- A table name cannot be longer than 255 characters.
- A column name cannot be longer than 128 characters.

- The only acceptable characters for database names, table names, and column names are lowercase letters, numbers, and the underscore character.

You can use the AWS Glue Catalog Manager to rename columns, but at this time table names and database names cannot be changed using the AWS Glue console. To correct database names, you need to create a new database and copy tables to it (in other words, copy the metadata to a new entity). You can follow a similar process for tables. You can use the AWS Glue SDK or AWS CLI to do this.

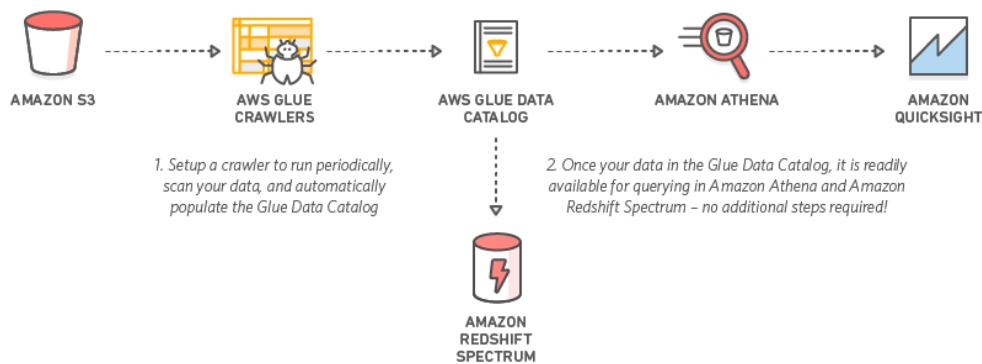
Using AWS Glue Crawlers

AWS Glue crawlers help discover and register the schema for datasets in the AWS Glue Data Catalog. The crawlers go through your data, and inspect portions of it to determine the schema. In addition, the crawler can detect and register partitions. For more information, see [Cataloging Data with a Crawler](#) in the *AWS Glue Developer Guide*.

Scheduling a Crawler to Keep the AWS Glue Data Catalog and Amazon S3 in Sync

AWS Glue crawlers can be set up to run on a schedule or on demand. For more information, see [Time-Based Schedules for Jobs and Crawlers](#) in the *AWS Glue Developer Guide*.

If you have data that arrives for a partitioned table at a fixed time, you can set up an AWS Glue Crawler to run on schedule to detect and update table partitions. This can eliminate the need to run a potentially long and expensive MSCK REPAIR command or manually execute an ALTER TABLE ADD PARTITION command. For more information, see [Table Partitions](#) in the *AWS Glue Developer Guide*.



Using Multiple Data Sources with Crawlers

When an AWS Glue Crawler scans Amazon S3 and detects multiple directories, it uses a heuristic to determine where the root for a table is in the directory structure, and which directories are partitions for the table. In some cases, where the schema detected in two or more directories is similar, the crawler may treat them as partitions instead of separate tables. One way to help the crawler discover individual tables is to add each table's root directory as a data store for the crawler.

The following partitions in Amazon S3 are an example:

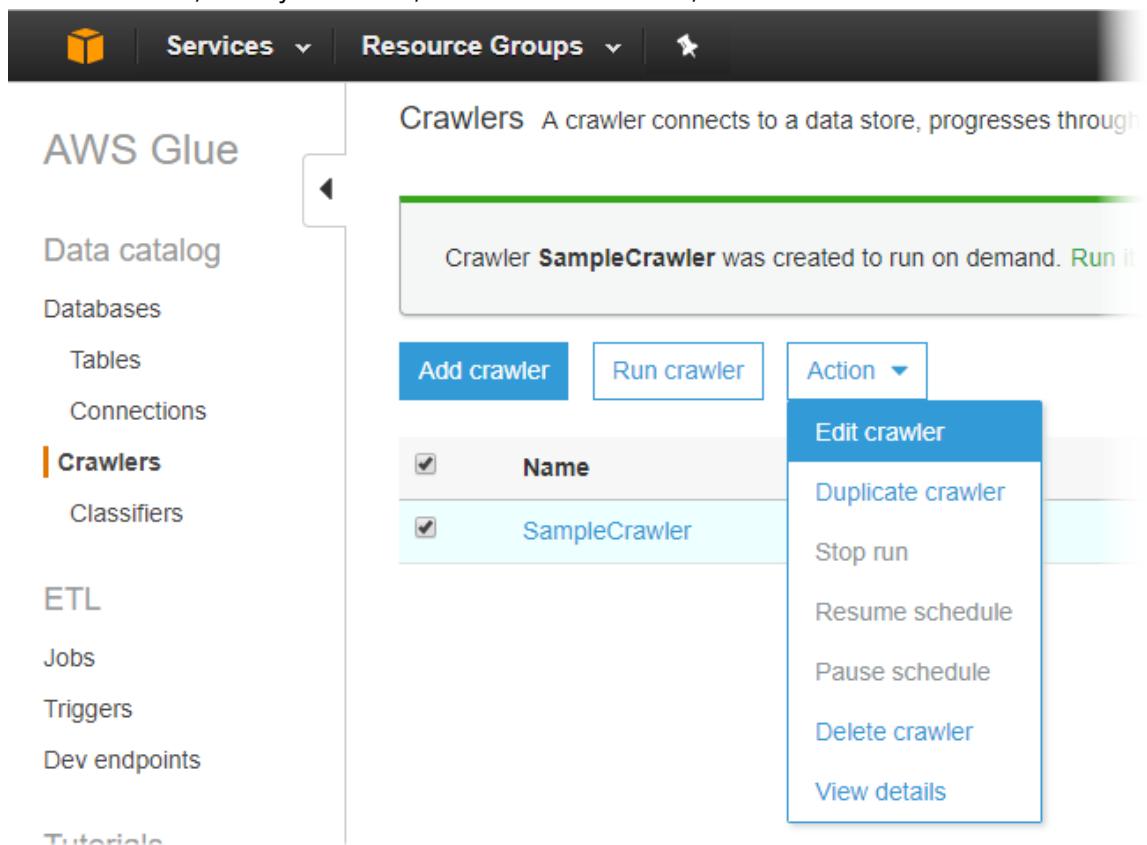
```
s3://bucket01/folder1/table1/partition1/file.txt
s3://bucket01/folder1/table1/partition2/file.txt
s3://bucket01/folder1/table1/partition3/file.txt
s3://bucket01/folder1/table2/partition4/file.txt
s3://bucket01/folder1/table2/partition5/file.txt
```

If the schema for `table1` and `table2` are similar, and a single data source is set to `s3://bucket01/folder1/` in AWS Glue, the crawler may create a single table with two partition columns: one partition column that contains `table1` and `table2`, and a second partition column that contains `partition1` through `partition5`.

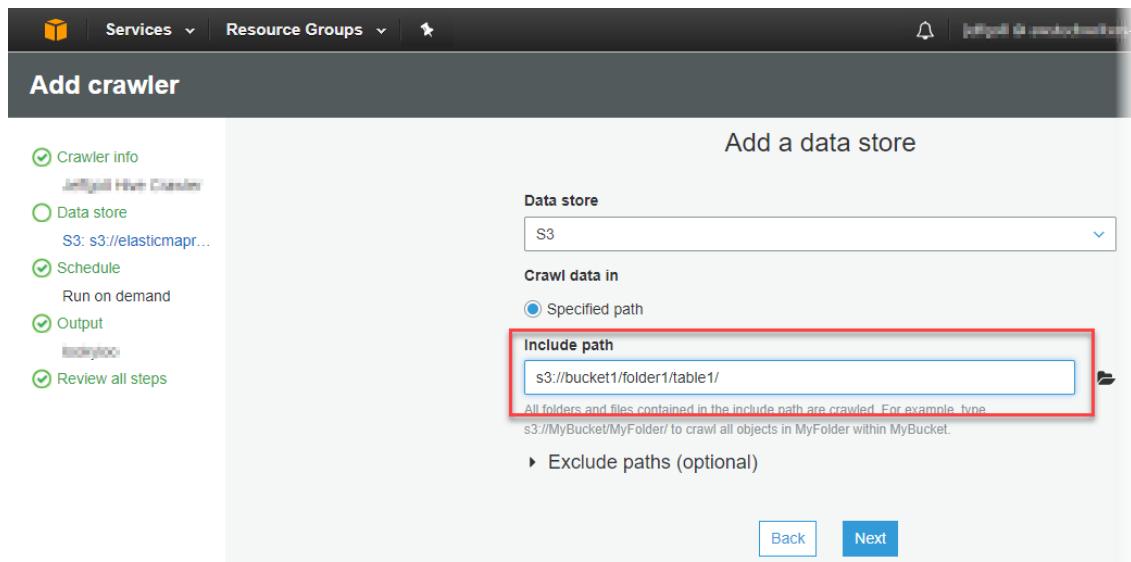
To have the AWS Glue crawler create two separate tables, set the crawler to have two data sources, `s3://bucket01/folder1/table1/` and `s3://bucket01/folder1/table2`, as shown in the following procedure.

To add another data store to an existing crawler in AWS Glue

1. Sign in to the AWS Management Console and open the AWS Glue console at <https://console.aws.amazon.com/glue/>.
2. Choose **Crawlers**, select your crawler, and then choose **Action, Edit crawler**.



3. Under **Add information about your crawler**, choose additional settings as appropriate, and then choose **Next**.
4. Under **Add a data store**, change **Include path** to the table-level directory. For instance, given the example above, you would change it from `s3://bucket01/folder1/` to `s3://bucket01/folder1/table1/`. Choose **Next**.



5. For **Add another data store**, choose **Yes, Next**.
6. For **Include path**, enter your other table-level directory (for example, `s3://bucket01/folder1/table2/`) and choose **Next**.
 - a. Repeat steps 3-5 for any additional table-level directories, and finish the crawler configuration.

The new values for **Include locations** appear under data stores as follows:

Crawler info	
Name	SampleCrawler
Service role	AWSGlueServiceRole

Data stores	
Data store	S3
Include path	s3://bucket1/folder1/table1/
Exclude paths	
Data store	S3
Include path	s3://bucket1/folder1/table2/
Exclude paths	

Syncing Partition Schema to Avoid "HIVE_PARTITION_SCHEMA_MISMATCH"

For each table within the AWS Glue Data Catalog that has partition columns, the schema is stored at the table level and for each individual partition within the table. The schema for partitions are populated by an AWS Glue crawler based on the sample of data that it reads within the partition. For more information, see [Using Multiple Data Sources with Crawlers \(p. 49\)](#).

When Athena runs a query, it validates the schema of the table and the schema of any partitions necessary for the query. The validation compares the column data types in order and makes sure that they match for the columns that overlap. This prevents unexpected operations such as adding or removing columns from the middle of a table. If Athena detects that the schema of a partition

differs from the schema of the table, Athena may not be able to process the query and fails with `HIVE_PARTITION_SCHEMA_MISMATCH`.

There are a few ways to fix this issue. First, if the data was accidentally added, you can remove the data files that cause the difference in schema, drop the partition, and re-crawl the data. Second, you can drop the individual partition and then run `MSCK REPAIR` within Athena to re-create the partition using the table's schema. This second option works only if you are confident that the schema applied will continue to read the data correctly.

Updating Table Metadata

After a crawl, the AWS Glue crawler automatically assigns certain table metadata to help make it compatible with other external technologies like Apache Hive, Presto, and Spark. Occasionally, the crawler may incorrectly assign metadata properties. Manually correct the properties in AWS Glue before querying the table using Athena. For more information, see [Viewing and Editing Table Details](#) in the [AWS Glue Developer Guide](#).

AWS Glue may mis-assign metadata when a CSV file has quotes around each data field, getting the `serializationLib` property wrong. For more information, see [CSV Data Enclosed in quotes \(p. 52\)](#).

Working with CSV Files

CSV files occasionally have quotes around the data values intended for each column, and there may be header values included in CSV files, which aren't part of the data to be analyzed. When you use AWS Glue to create schema from these files, follow the guidance in this section.

CSV Data Enclosed in Quotes

If you run a query in Athena against a table created from a CSV file with quoted data values, update the table definition in AWS Glue so that it specifies the right SerDe and SerDe properties. This allows the table definition to use the OpenCSVSerDe. For more information about the OpenCSV SerDe, see [OpenCSVSerDe for Processing CSV \(p. 280\)](#).

In this case, make the following changes:

- Change the `serializationLib` property under `field` in the `SerDeInfo` field in the table to `org.apache.hadoop.hive.serde2.OpenCSVSerde`.
- Enter appropriate values for `separatorChar`, `quoteChar`, and `escapeChar`. The `separatorChar` value is a comma, the `quoteChar` value is double quotes (` `), and the `escapeChar` value is the backslash (\).

For example, for a CSV file with records such as the following:

```
"John", "Doe", "123-555-1231", "John said \"hello\""  
"Jane", "Doe", "123-555-9876", "Jane said \"hello\""
```

You can use the AWS Glue console to edit table details as shown in this example:

Edit table details

Table name
sample_csv_table

Input format
org.apache.hadoop.mapred.TextInputFormat

Output format
org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat

Serde name

Serde serialization lib
org.apache.hadoop.hive.serde2.OpenCSVSerde

Serde parameters

Key	Value
escapeChar	\
quoteChar	"
separatorChar	,
Type key...	Type value...

Description

Apply

Alternatively, you can update the table definition in AWS Glue to have a SerDeInfo block such as the following:

```
"SerDeInfo": {
```

```
        "name": "",  
        "serializationLib": "org.apache.hadoop.hive.serde2.OpenCSVSerde",  
        "parameters": {  
            "separatorChar": ", "  
            "quoteChar": "" "  
            "escapeChar": "\\\""  
        }  
    },
```

For more information, see [Viewing and Editing Table Details](#) in the *AWS Glue Developer Guide*.

CSV Files with Headers

If you are writing CSV files from AWS Glue to query using Athena, you must remove the CSV headers so that the header information is not included in Athena query results. One way to achieve this is to use AWS Glue jobs, which perform extract, transform, and load (ETL) work. You can write scripts in AWS Glue using a language that is an extension of the PySpark Python dialect. For more information, see [Authoring Jobs in Glue](#) in the *AWS Glue Developer Guide*.

The following example shows a function in an AWS Glue script that writes out a dynamic frame using `from_options`, and sets the `writeHeader` format option to false, which removes the header information:

```
glueContext.write_dynamic_frame.from_options(frame = applymapping1, connection_type  
= "s3", connection_options = {"path": "s3://MYBUCKET/MYTABLEDATA/"}, format = "csv",  
format_options = {"writeHeader": False}, transformation_ctx = "datasink2")
```

Working with Geospatial Data

AWS Glue does not natively support Well-known Text (WKT), Well-Known Binary (WKB), or other PostGIS data types. The AWS Glue classifier parses geospatial data and classifies them using supported data types for the format, such as `varchar` for CSV. As with other AWS Glue tables, you may need to update the properties of tables created from geospatial data to allow Athena to parse these data types as-is. For more information, see [Using AWS Glue Crawlers \(p. 49\)](#) and [Working with CSV Files \(p. 52\)](#). Athena may not be able to parse some geospatial data types in AWS Glue tables as-is. For more information about working with geospatial data in Athena, see [Querying Geospatial Data \(p. 157\)](#).

Using AWS Glue Jobs for ETL with Athena

AWS Glue jobs perform ETL operations. An AWS Glue job runs a script that extracts data from sources, transforms the data, and loads it into targets. For more information, see [Authoring Jobs in Glue](#) in the *AWS Glue Developer Guide*.

Creating Tables Using Athena for AWS Glue ETL Jobs

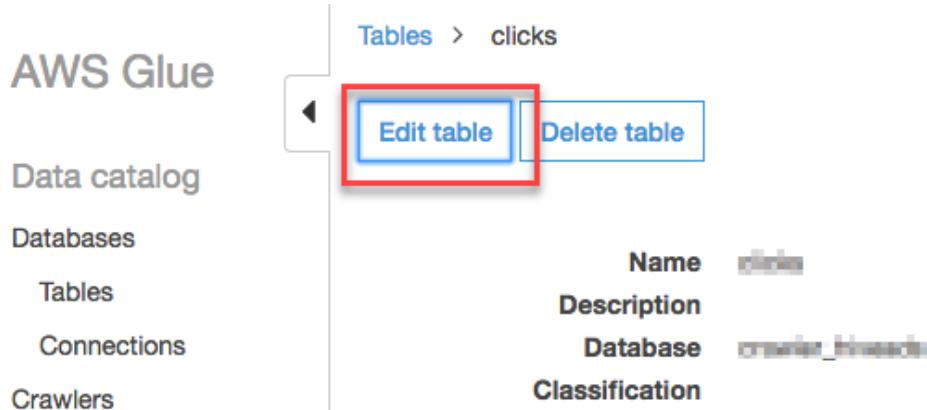
Tables that you create in Athena must have a `table` property added to them called a `classification`, which identifies the format of the data. This allows AWS Glue to use the tables for ETL jobs. The `classification` values can be `csv`, `parquet`, `orc`, `avro`, or `json`. An example `CREATE TABLE` statement in Athena follows:

```
CREATE EXTERNAL TABLE sampleTable (  
    column1 INT,  
    column2 INT  
) STORED AS PARQUET  
TBLPROPERTIES ('  
classification'='parquet')
```

If the table property was not added when the table was created, you can add it using the AWS Glue console.

To change the classification property using the console

1. Choose Edit Table.



2. For Classification, select the file type and choose Apply.

The screenshot shows the 'Edit table details' dialog box. It has two columns of input fields. The first column contains 'compressionType' (set to 'none') and 'classification' (set to 'json'). The second column contains 'typeOfData' (set to 'file'). A large red oval surrounds the 'classification' row. At the bottom is a blue 'Apply' button.

For more information, see [Working with Tables](#) in the *AWS Glue Developer Guide*.

Using ETL Jobs to Optimize Query Performance

AWS Glue jobs can help you transform data to a format that optimizes query performance in Athena. Data formats have a large impact on query performance and query costs in Athena.

We recommend to use Parquet and ORC data formats. AWS Glue supports writing to both of these data formats, which can make it easier and faster for you to transform data to an optimal format for Athena. For more information about these formats and other ways to improve performance, see [Top Performance Tuning Tips for Amazon Athena](#).

Converting SMALLINT and TINYINT Data Types to INT When Converting to ORC

To reduce the likelihood that Athena is unable to read the `SMALLINT` and `TINYINT` data types produced by an AWS Glue ETL job, convert `SMALLINT` and `TINYINT` to `INT` when using the wizard or writing a script for an ETL job.

Automating AWS Glue Jobs for ETL

You can configure AWS Glue ETL jobs to run automatically based on triggers. This feature is ideal when data from outside AWS is being pushed to an Amazon S3 bucket in a suboptimal format for querying in Athena. For more information, see [Triggering AWS Glue Jobs](#) in the *AWS Glue Developer Guide*.

Upgrading to the AWS Glue Data Catalog Step-by-Step

Amazon Athena manages its own data catalog until the time that AWS Glue releases in the Athena region. At that time, if you previously created databases and tables using Athena or Amazon Redshift Spectrum, you can choose to upgrade Athena to the AWS Glue Data Catalog. If you are new to Athena, you don't need to make any changes; databases and tables are available to Athena using the AWS Glue Data Catalog and vice versa. For more information about the benefits of using the AWS Glue Data Catalog, see [FAQ: Upgrading to the AWS Glue Data Catalog \(p. 58\)](#). For a list of regions where AWS Glue is available, see [Regions and Endpoints](#) in the *AWS General Reference*.

Until you upgrade, the Athena-managed data catalog continues to store your table and database metadata, and you see the option to upgrade at the top of the console. The metadata in the Athena-managed catalog isn't available in the AWS Glue Data Catalog or vice versa. While the catalogs exist side-by-side, you aren't able to create tables or databases with the same names, and the creation process in either AWS Glue or Athena fails in this case.

We created a wizard in the Athena console to walk you through the steps of upgrading to the AWS Glue console. The upgrade takes just a few minutes, and you can pick up where you left off. For more information about each upgrade step, see the topics in this section. For more information about working with data and tables in the AWS Glue Data Catalog, see the guidelines in [Best Practices When Using Athena with AWS Glue \(p. 48\)](#).

Step 1 - Allow a User to Perform the Upgrade

By default, the action that allows a user to perform the upgrade is not allowed in any policy, including any managed policies. Because the AWS Glue Data Catalog is shared throughout an account, this extra failsafe prevents someone from accidentally migrating the catalog.

Before the upgrade can be performed, you need to attach a customer-managed IAM policy, with a policy statement that allows the upgrade action, to the user who performs the migration.

The following is an example policy statement.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "glue:ImportCatalogToGlue"  
            ],  
            "Resource": [ "*" ]  
        }  
    ]  
}
```

```
        ]  
    }  
}
```

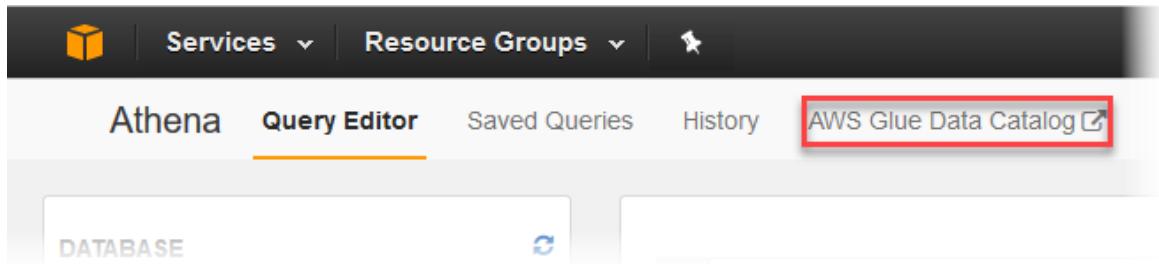
Step 2 - Update Customer-Managed/Inline Policies Associated with Athena Users

If you have customer-managed or inline IAM policies associated with Athena users, you need to update the policy or policies to allow actions that AWS Glue requires. If you use the managed policy, they are automatically updated. The AWS Glue policy actions to allow are listed in the example policy below. For the full policy statement, see [IAM Policies for User Access \(p. 203\)](#).

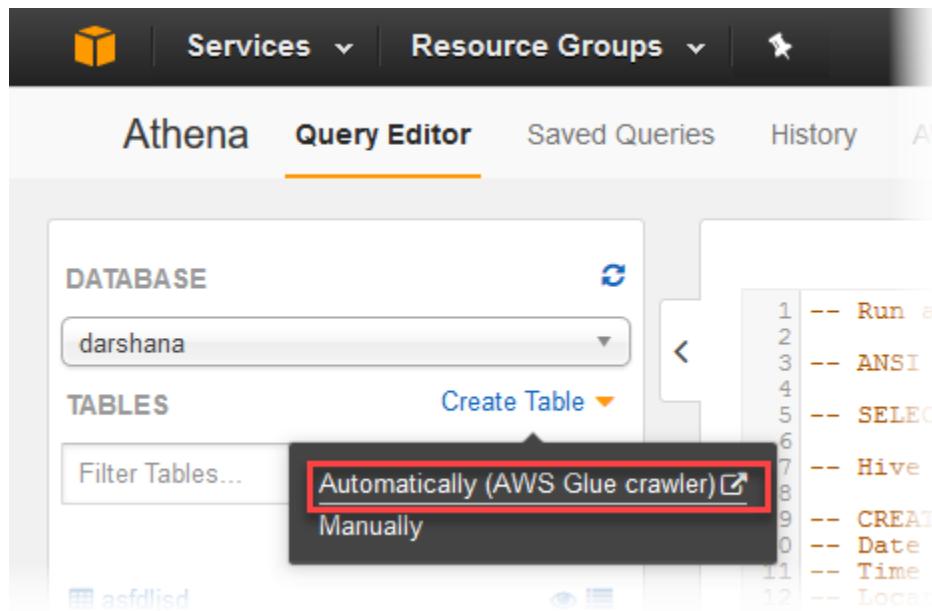
```
{  
    "Effect": "Allow",  
    "Action": [  
        "glue>CreateDatabase",  
        "glue>DeleteDatabase",  
        "glue>GetDatabase",  
        "glue>GetDatabases",  
        "glue>UpdateDatabase",  
        "glue>CreateTable",  
        "glue>DeleteTable",  
        "glue>BatchDeleteTable",  
        "glue>UpdateTable",  
        "glue>GetTable",  
        "glue>GetTables",  
        "glue>BatchCreatePartition",  
        "glue>CreatePartition",  
        "glue>DeletePartition",  
        "glue>BatchDeletePartition",  
        "glue>UpdatePartition",  
        "glue>GetPartition",  
        "glue>GetPartitions",  
        "glue>BatchGetPartition"  
    ],  
    "Resource": [  
        "*"  
    ]  
}
```

Step 3 - Choose Upgrade in the Athena Console

After you make the required IAM policy updates, choose **Upgrade** in the Athena console. Athena moves your metadata to the AWS Glue Data Catalog. The upgrade takes only a few minutes. After you upgrade, the Athena console has a link to open the AWS Glue Catalog Manager from within Athena.



When you create a table using the console, you now have the option to create a table using an AWS Glue crawler. For more information, see [Using AWS Glue Crawlers \(p. 49\)](#).



FAQ: Upgrading to the AWS Glue Data Catalog

If you created databases and tables using Athena in a region before AWS Glue was available in that region, metadata is stored in an Athena-managed data catalog, which only Athena and Amazon Redshift Spectrum can access. To use AWS Glue features together with Athena and Redshift Spectrum, you must upgrade to the AWS Glue Data Catalog. Athena can only be used together with the AWS Glue Data Catalog in regions where AWS Glue is available. For a list of regions, see [Regions and Endpoints](#) in the [AWS General Reference](#).

Why should I upgrade to the AWS Glue Data Catalog?

AWS Glue is a completely-managed extract, transform, and load (ETL) service. It has three main components:

- **An AWS Glue crawler** can automatically scan your data sources, identify data formats, and infer schema.
- **A fully managed ETL service** allows you to transform and move data to various destinations.
- **The AWS Glue Data Catalog** stores metadata information about databases and tables, pointing to a data store in Amazon S3 or a JDBC-compliant data store.

For more information, see [AWS Glue Concepts](#).

Upgrading to the AWS Glue Data Catalog has the following benefits.

Unified metadata repository

The AWS Glue Data Catalog provides a unified metadata repository across a variety of data sources and data formats. It provides out-of-the-box integration with [Amazon Simple Storage Service \(Amazon S3\)](#), [Amazon Relational Database Service \(Amazon RDS\)](#), [Amazon Redshift](#), [Amazon Redshift Spectrum](#), Athena, [Amazon EMR](#), and any application compatible with the Apache Hive metastore. You can create your table definitions one time and query across engines.

For more information, see [Populating the AWS Glue Data Catalog](#).

Automatic schema and partition recognition

AWS Glue crawlers automatically crawl your data sources, identify data formats, and suggest schema and transformations. Crawlers can help automate table creation and automatic loading of partitions that you can query using Athena, Amazon EMR, and Redshift Spectrum. You can also create tables and partitions directly using the AWS Glue API, SDKs, and the AWS CLI.

For more information, see [Cataloging Tables with a Crawler](#).

Easy-to-build pipelines

The AWS Glue ETL engine generates Python code that is entirely customizable, reusable, and portable. You can edit the code using your favorite IDE or notebook and share it with others using GitHub. After your ETL job is ready, you can schedule it to run on the fully managed, scale-out Spark infrastructure of AWS Glue. AWS Glue handles provisioning, configuration, and scaling of the resources required to run your ETL jobs, allowing you to tightly integrate ETL with your workflow.

For more information, see [Authoring AWS Glue Jobs in the AWS Glue Developer Guide](#).

Are there separate charges for AWS Glue?

Yes. With AWS Glue, you pay a monthly rate for storing and accessing the metadata stored in the AWS Glue Data Catalog, an hourly rate billed per second for AWS Glue ETL jobs and crawler runtime, and an hourly rate billed per second for each provisioned development endpoint. The AWS Glue Data Catalog allows you to store up to a million objects at no charge. If you store more than a million objects, you are charged USD\$1 for each 100,000 objects over a million. An object in the AWS Glue Data Catalog is a table, a partition, or a database. For more information, see [AWS Glue Pricing](#).

Upgrade process FAQ

- [Who can perform the upgrade? \(p. 59\)](#)
- [My users use a managed policy with Athena and Redshift Spectrum. What steps do I need to take to upgrade? \(p. 59\)](#)
- [What happens if I don't upgrade? \(p. 60\)](#)
- [Why do I need to add AWS Glue policies to Athena users? \(p. 60\)](#)
- [What happens if I don't allow AWS Glue policies for Athena users? \(p. 60\)](#)
- [Is there risk of data loss during the upgrade? \(p. 60\)](#)
- [Is my data also moved during this upgrade? \(p. 60\)](#)

Who can perform the upgrade?

You need to attach a customer-managed IAM policy with a policy statement that allows the upgrade action to the user who will perform the migration. This extra check prevents someone from accidentally migrating the catalog for the entire account. For more information, see [Step 1 - Allow a User to Perform the Upgrade \(p. 56\)](#).

My users use a managed policy with Athena and Redshift Spectrum. What steps do I need to take to upgrade?

The Athena managed policy has been automatically updated with new policy actions that allow Athena users to access AWS Glue. However, you still must explicitly allow the upgrade action for the user who performs the upgrade. To prevent accidental upgrade, the managed policy does not allow this action.

What happens if I don't upgrade?

If you don't upgrade, you are not able to use AWS Glue features together with the databases and tables you create in Athena or vice versa. You can use these services independently. During this time, Athena and AWS Glue both prevent you from creating databases and tables that have the same names in the other data catalog. This prevents name collisions when you do upgrade.

Why do I need to add AWS Glue policies to Athena users?

Before you upgrade, Athena manages the data catalog, so Athena actions must be allowed for your users to perform queries. After you upgrade to the AWS Glue Data Catalog, Athena actions no longer apply to accessing the AWS Glue Data Catalog, so AWS Glue actions must be allowed for your users. Remember, the managed policy for Athena has already been updated to allow the required AWS Glue actions, so no action is required if you use the managed policy.

What happens if I don't allow AWS Glue policies for Athena users?

If you upgrade to the AWS Glue Data Catalog and don't update a user's customer-managed or inline IAM policies, Athena queries fail because the user won't be allowed to perform actions in AWS Glue. For the specific actions to allow, see [Step 2 - Update Customer-Managed/Inline Policies Associated with Athena Users \(p. 57\)](#).

Is there risk of data loss during the upgrade?

No.

Is my data also moved during this upgrade?

No. The migration only affects metadata.

Using Athena Data Connector for External Hive Metastore (Preview)

You can use the Athena Data Connector for External Hive Metastore (Preview) to query data sets in Amazon S3 that use an Apache Hive metastore. No migration of metadata to the AWS Glue Data Catalog is necessary. In the Athena management console, you configure a Lambda function to communicate with the Hive metastore in your private VPC and then connect it. For the Lambda function code, you can use Athena's default implementation – the Athena data source connector for external Hive metastore – or provide your own.

Considerations and Limitations

Prebuilt and custom data connectors might require access to the following resources to function correctly. Check the information for the connector that you use to ensure that you have configured your VPC correctly. For information about required IAM permissions to run queries and create a data source connector in Athena, see [Allow Access to an Athena Data Connector for External Hive Metastore \(Preview\) \(p. 215\)](#).

- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named AmazonAthenaPreviewFunctionality and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).
- **Amazon S3** – In addition to writing query results to the Athena query results location in Amazon S3, data connectors also write to a spill bucket in Amazon S3. Connectivity and permissions to this Amazon S3 location are required.

- **Athena** – For checking query status and preventing overscan.
- **AWS Secrets Manager**
- **AWS Glue** if your connector uses AWS Glue for supplemental or primary metadata.
- **AWS Key Management Service**
- **Policies** – Hive metastore, Athena Query Federation, and UDFs require policies in addition to the [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#). For more information, see [Identity and Access Management in Athena \(p. 203\)](#).

Connecting Athena to an Apache Hive Metastore

To connect Athena to an Apache Hive Metastore, you must create and configure a Lambda function. For a basic implementation, you can perform all required steps from the Athena management console.

To connect Athena to a Hive metastore

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, for **Choose a metadata catalog**, choose **Apache Hive metastore**.
4. Choose **Next**.
5. On the **Connection details** page, for **Lambda function**, click **Create Lambda function**.
6. In the **Create Lambda function** dialog box, enter the following information for the Lambda function. To use the default implementation, accept the defaults for the function code location in Amazon S3 and the Lambda handler.
 - **Lambda function name** – Provide a name for the function. For example, **myHiveMetastore**.
 - **Lambda execution role** – Choose an IAM role or click **Create a new role** to create one.
 - **Function code** – The location in Amazon S3 for the Lambda function JAR file. Use the default or enter the location of your custom JAR file.
 - **Lambda handler** – The method in the JAR file that implements the Hive connector. Use the default, or replace it with the handler in your custom code.
 - **Hive metastore (HMS) URI** – Enter the name of your Hive metastore host that uses the Thrift protocol at port 9083 with the syntax `thrift://<host_name>:9083`.
 - **Spill location in S3** – Specify an Amazon S3 location in this account to hold spillover metadata if the Lambda function response size exceeds 4MB.
 - **Virtual Private (VPC)** – Choose the VPC that contains your Hive metastore.
 - **Subnets** – Choose the VPC subnets for Lambda to use to set up your VPC configuration.
 - **Security Groups** – Choose the VPC security groups for Lambda to use to set up your VPC configuration.
 - **Memory** – Specify a value from 128MB to 3008MB. The Lambda function is allocated CPU cycles proportional to the amount of memory that you configure.
 - **Timeout** – Specify a value from 1 second to 15 minutes 59 seconds. The default is 3 seconds.
7. Click **Create**. The **Connection details** page informs you that the function is being created. When the operation completes, your function name is available in the **Choose a function name** box, and your Lambda function ARN is displayed.
8. For **Catalog name**, enter a unique name to use for the data source in your SQL queries. The name can be up to 127 characters and must be unique within your account. It cannot be changed after creation. Valid characters are a-z, A-z, 0-9, _(underscore), @(ampersand) and -(hyphen).
9. Click **Connect** to connect Athena to your data source.

The **Data sources** page shows your connector in the list of catalog names. You can now use the **Catalog name** that you specified to reference the Hive metastore in your SQL queries. Use the

syntax in the following example, where `MyHiveMetastore` is the catalog name that you specified earlier.

```
SELECT * FROM MyHiveMetastore.CustomerData.customers;
```

Using Amazon Athena Federated Query (Preview)

If you have data in sources other than Amazon S3, you can use Athena Federated Query (Preview) to query the data in place or build pipelines that extract data from multiple data sources and store them in Amazon S3. With Athena Federated Query (Preview), you can run SQL queries across data stored in relational, non-relational, object, and custom data sources.

Athena uses *data source connectors* that run on AWS Lambda to execute federated queries. A data source connector is a piece of code that can translate between your target data source and Athena. You can think of a connector as an extension of Athena's query engine. Prebuilt Athena data source connectors exist for data sources like Amazon CloudWatch Logs, Amazon DynamoDB, Amazon DocumentDB, and Amazon RDS, and JDBC-compliant relational data sources such MySQL, and PostgreSQL under the Apache 2.0 license. You can also use the Athena Query Federation SDK to write custom connectors. To choose, configure, and deploy a data source connector to your account, you can use the Athena and Lambda consoles or the AWS Serverless Application Repository. After you deploy data source connectors, the connector is associated with a catalog that you can specify in SQL queries. You can combine SQL statements from multiple catalogs and span multiple data sources with a single query.

When a query is submitted against a data source, Athena invokes the corresponding connector to identify parts of the tables that need to be read, manages parallelism, and pushes down filter predicates. Based on the user submitting the query, connectors can provide or restrict access to specific data elements. Connectors use Apache Arrow as the format for returning data requested in a query, which enables connectors to be implemented in languages such as C, C++, Java, Python, and Rust. Since connectors are executed in Lambda, they can be used to access data from any data source on the cloud or on-premises that is accessible from Lambda.

To write your own data source connector, you can use the Athena Query Federation SDK to customize one of the prebuilt connectors that Amazon Athena provides and maintains. You can modify a copy of the source code from the [GitHub repository](#) and then use the [Connector Publish Tool](#) to create your own AWS Serverless Application Repository package.

For a list of available Athena data source connectors, see [Using Athena Data Source Connectors \(p. 65\)](#).

For information about writing your own data source connector, see [Example Athena Connector](#) on GitHub.

Considerations and Limitations

Data source connectors might require access to the following resources to function correctly. If you use a prebuilt connector, check the information for the connector to ensure that you have configured your VPC correctly. Also, ensure that IAM principals running queries and creating connectors have privileges to required actions. For more information, see [Example IAM Permissions Policies to Allow Athena Federated Query \(Preview\) \(p. 217\)](#).

- For the most up-to-date information about known issues and limitations, see [Limitations and Issues](#) in the aws-athena-query-federation GitHub repository.
- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

- **Amazon S3 – In addition to writing query results to the Athena query results location in Amazon S3, data connectors also write to a spill bucket in Amazon S3. Connectivity and permissions to this Amazon S3 location are required.**
- **Athena** – Data sources need connectivity to Athena and vice versa for checking query status and preventing overscan.
- **AWS Glue Data Catalog** – Connectivity and permissions are required if your connector uses Data Catalog for supplemental or primary metadata.

Deploying a Connector and Connecting to a Data Source

Preparing to create federated queries is a two-part process: deploying a Lambda function data source connector, and connecting the Lambda function to a data source. In the first part, you give the Lambda function a name that you can later choose in the Athena console. In the second part, you give the connector a name that you can reference in your SQL queries.

Part 1: Deploying a Data Source Connector

To choose, name, and deploy a data source connector, you use the Athena and Lambda consoles in an integrated process.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

To deploy a data source connector

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **Query a data source**.
4. For **Choose a data source**, choose the data source that you want to query with Athena, such as **Amazon CloudWatch Logs**.
5. Choose **Next**.
6. For **Lambda function**, choose **Configure new function**. The function page for the connector that you chose opens in the Lambda console. The page includes detailed information about the connector.
7. Under **Application settings**, enter the required information. At a minimum, this includes:
 - **AthenaCatalogName** – A name for the Lambda function that indicates the data source that it targets, such as `cloudwatchlogs`.
 - **SpillBucket** – An Amazon S3 bucket in your account to store data that exceeds Lambda function response size limits.
8. Select **I acknowledge that this app creates custom IAM roles**. For more information, choose the **Info** link.
9. Choose **Deploy**. The **Resources** section of the Lambda console shows the deployment status of the connector and informs you when the deployment is complete.

Part 2: Connecting to a Data Source

After you deploy the data source connector to your account, you can connect it to a data source.

To connect to a data source using a connector that you have deployed to your account

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. Choose **Query a data source**.
4. Choose the data source for the connector that you just deployed, such as **Amazon CloudWatch Logs**. If you used the Athena Query Federation SDK to create your own connector and have deployed it to your account, choose **All other data sources**.
5. Choose **Next**.
6. For **Choose Lambda function**, choose the function that you named. The Lambda function's ARN is displayed.
7. For **Catalog name**, enter a unique name to use for the data source in your SQL queries, such as `cloudwatchlogs`. The name can be up to 127 characters and must be unique within your account. It cannot be changed after creation. Valid characters are a-z, A-z, 0-9, _(underscore), @(ampersand) and -(hyphen).
8. Choose **Connect**. The **Data sources** page now shows your connector in the list of catalog names. You can now use the connector in your queries.

For information about writing queries with data connectors, see [Writing Federated Queries \(p. 67\)](#).

Using the AWS Serverless Application Repository to Deploy a Data Source Connector

You can also use the [AWS Serverless Application Repository](#) to deploy an Athena data source connector. You find the connector that you want to use, provide the parameters that the connector requires, and then deploy the connector to your account.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

To use the AWS Serverless Application Repository to deploy a data source connector to your account

1. Open the **Serverless App Repository** console.
2. Select the option **Show apps that create custom IAM roles or resource policies**.
3. In the search box, type the name of the connector, or search for applications published with the author name **Amazon Athena Federation**. This author name is reserved for applications that the Amazon Athena team has written, tested, and validated.
4. Choose the name of the connector. This opens the Lambda function's **Application details** page in the AWS Lambda console.
5. On the right side of the details page, for **SpillBucket**, specify an Amazon S3 bucket to receive data from large response payloads. For information about the remaining configurable options, see the corresponding [Available Connectors](#) topic on GitHub.
6. At the bottom right of the **Application details** page, choose **Deploy**.

Using Athena Data Source Connectors

This section lists prebuilt Athena data source connectors that you can use to query a variety of data sources external to Amazon S3. To use a connector in your Athena queries, configure it and deploy it to your account.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

See the following topics for more information:

- For information about deploying an Athena data source connector, see [Deploying a Connector and Connecting to a Data Source \(p. 63\)](#).
- For information about writing queries that use Athena data source connectors, see [Writing Federated Queries \(p. 67\)](#).
- For complete information about the Athena data source connectors, see [Available Connectors](#) on GitHub.

Topics

- [Athena AWS CMDB Connector \(p. 65\)](#)
- [Amazon Athena CloudWatch Connector \(p. 65\)](#)
- [Amazon Athena CloudWatch Metrics Connector \(p. 66\)](#)
- [Amazon Athena DocumentDB Connector \(p. 66\)](#)
- [Amazon Athena DynamoDB Connector \(p. 66\)](#)
- [Amazon Athena HBase Connector \(p. 66\)](#)
- [Amazon Athena Connector for JDBC-Compliant Data Sources \(p. 66\)](#)
- [Amazon Athena Redis Connector \(p. 66\)](#)
- [Amazon Athena TPC Benchmark DS \(TPC-DS\) Connector \(p. 66\)](#)

Athena AWS CMDB Connector

The Amazon Athena AWS CMDB connector enables Amazon Athena to communicate with various AWS services so that you can query them with SQL.

For information about supported services, parameters, permissions, deployment, performance, and licensing, see [Amazon Athena AWS CMDB Connector](#) on GitHub.

Amazon Athena CloudWatch Connector

The Amazon Athena CloudWatch connector enables Amazon Athena to communicate with CloudWatch so that you can query your log data with SQL.

The connector maps your LogGroups as schemas and each LogStream as a table. The connector also maps a special `all_log_streams` view that contains all LogStreams in the LogGroup. This view enables you to query all the logs in a LogGroup at once instead of searching through each LogStream individually.

For more information about configuration options, throttling control, table mapping schema, permissions, deployment, performance considerations, and licensing, see [Amazon Athena CloudWatch Connector](#) on GitHub.

Amazon Athena CloudWatch Metrics Connector

The Amazon Athena CloudWatch Metrics connector enables Amazon Athena to communicate with CloudWatch Metrics so that you can query your metrics data with SQL.

For information about configuration options, table mapping, permissions, deployment, performance considerations, and licensing, see [Amazon Athena Cloudwatch Metrics Connector](#) on GitHub.

Amazon Athena DocumentDB Connector

The Amazon Athena Amazon DocumentDB connector enables Amazon Athena to communicate with your Amazon DocumentDB instances so that you can query your Amazon DocumentDB data with SQL. The connector also works with any endpoint that is compatible with MongoDB.

For information about how the connector generates schemas, configuration options, permissions, deployment, and performance considerations, see [Amazon Athena DocumentDB Connector](#) on GitHub.

Amazon Athena DynamoDB Connector

The Amazon Athena DynamoDB connector enables Amazon Athena to communicate with DynamoDB so that you can query your tables with SQL.

For information about configuration options, permissions, deployment, and performance considerations, see [Amazon Athena DynamoDB Connector](#) on GitHub.

Amazon Athena HBase Connector

The Amazon Athena HBase Connector enables Amazon Athena to communicate with your HBase instances so that you can query your HBase data with SQL.

For information about configuration options, data types, permissions, deployment, performance, and licensing, see [Amazon Athena HBase Connector](#) on GitHub.

Amazon Athena Connector for JDBC-Compliant Data Sources

The Amazon Athena Lambda JDBC connector enables Amazon Athena to access your JDBC-compliant database. Currently supported databases include MySQL, PostgreSQL, and Amazon Redshift.

For information about supported databases, configuration parameters, supported data types, JDBC driver versions, limitations, and other information, see [Amazon Athena Lambda JDBC Connector](#) on GitHub.

Amazon Athena Redis Connector

The Amazon Athena Redis connector enables Amazon Athena to communicate with your Redis instances so that you can query your Redis data with SQL. You can use the AWS Glue Data Catalog to map your Redis key-value pairs into virtual tables.

For information about configuration options, setting up databases and tables, data types, permissions, deployment, performance, and licensing, see [Amazon Athena Redis Connector](#) on GitHub.

Amazon Athena TPC Benchmark DS (TPC-DS) Connector

The Amazon Athena TPC-DS connector enables Amazon Athena to communicate with a source of randomly generated TPC Benchmark DS data for use in benchmarking and functional testing. The Athena TPC-DS connector generates a TPC-DS compliant database at one of four scale factors.

For information about configuration options, databases and tables, permissions, deployment, performance, and licensing, see [Amazon Athena TPC-DS Connector](#) on GitHub.

Writing Federated Queries

After you have configured one or more data connectors and deployed them to your account, you can use them in your Athena queries.

Querying a Single Data Source

The examples in this section assume that you have configured and deployed the Athena CloudWatch connector to your account. Use the same approach to query when you use other connectors.

To create an Athena query that uses the CloudWatch connector

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. In the Athena Query Editor, create a SQL query that uses the following syntax in the `FROM` clause.

```
MyCloudwatchCatalog.database_name.table_name
```

Examples

The following example uses the Athena CloudWatch connector to connect to the `all_log_streams` view in the `/var/ecommerce-engine/order-processor` CloudWatch Logs [Log Group](#). The `all_log_streams` view is a view of all the log streams in the log group. The example query limits the number of rows returned to 100.

Example

```
SELECT * FROM "MyCloudwatchCatalog"." /var/ecommerce-engine/order-processor".all_log_streams
    limit 100;
```

The following example parses information from the same view as the previous example. The example extracts the order ID and log level and filters out any message that has the level `INFO`.

Example

```
SELECT log_stream as ec2_instance,
       Regexp_extract(message '.*orderId=(\d+) .*', 1) AS orderId,
       message AS
       order_processor_log,
       Regexp_extract(message, '(.*):.*', 1) AS log_level
  FROM
    "MyCloudwatchCatalog"." /var/ecommerce-engine/order-
processor".all_log_streams
 WHERE Regexp_extract(message, '(.*)', 1) != 'INFO'
```

The following image shows a sample result.

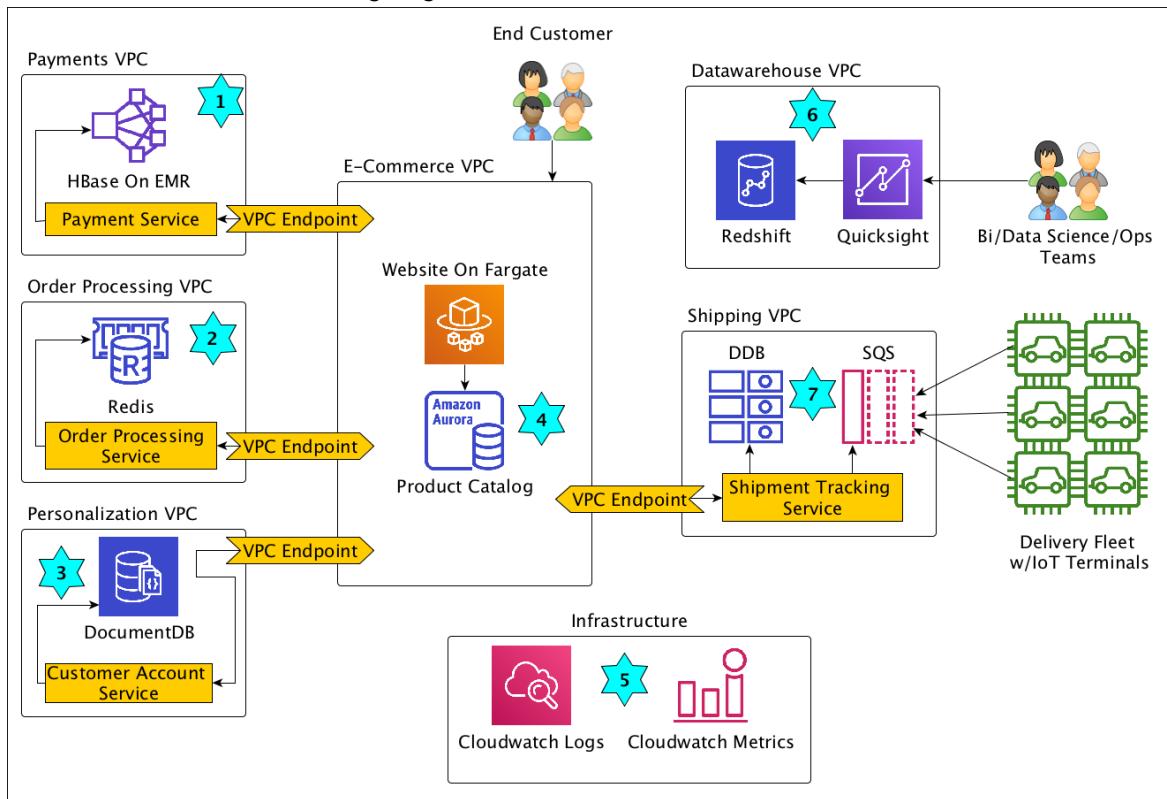
Note

This example shows a query where the data source has been registered as a catalog with Athena. You can also reference a data source connector Lambda function using the format `lambda:MyLambdaFunctionName`.

Results				
	ec2_instance	orderId	order_processor_log	log_level
1	i-0a94127ec09dd	0001235	ERROR: orderId=0001235 encountered a problem during shipping.	ERROR
2	i-0a94127ec09dd	0002234	WARN: orderId=0002234 encountered a problem during shipping.	WARN

Querying Multiple Data Sources

As a more complex example, imagine an ecommerce company that has an application infrastructure such as the one shown in the following diagram.



The following descriptions explain the numbered items in the diagram.

1. Payment processing in a secure VPC with transaction records stored in HBase on Amazon EMR
2. Redis to store active orders so that the processing engine can access them quickly
3. Amazon DocumentDB for customer account data such as email addresses and shipping addresses
4. A product catalog in Amazon Aurora for an ecommerce site that uses automatic scaling on Fargate
5. CloudWatch Logs to house the order processor's log events
6. A write-once-read-many data warehouse on Amazon RDS
7. DynamoDB to store shipment tracking data

Imagine that a data analyst for this ecommerce application discovers that the state of some orders is being reported erroneously. Some orders show as pending even though they were delivered, while others show as delivered but haven't shipped.

The analyst wants to know how many orders are being delayed and what the affected orders have in common across the ecommerce infrastructure. Instead of investigating the sources of information separately, the analyst federates the data sources and retrieves the necessary information in a single query. Extracting the data into a single location is not necessary.

The analyst's query uses the following Athena data connectors:

- **CloudWatch Logs** – Retrieves logs from the order processing service and uses regex matching and extraction to filter for orders with `WARN` or `ERROR` events.
 - **Redis** – Retrieves the active orders from the Redis instance.
 - **CMDB** – Retrieves the ID and state of the Amazon EC2 instance that ran the order processing service and logged the `WARN` or `ERROR` message.
 - **DocumentDB** – Retrieves the customer email and address from Amazon DocumentDB for the affected orders.
 - **DynamoDB** – Retrieves the shipping status and tracking details from the shipping table to identify possible discrepancies between reported and actual status.
 - **HBase** – Retrieves the payment status for the affected orders from the payment processing service.

Example

Note

This example shows a query where the data source has been registered as a catalog with Athena. You can also reference a data source connector Lambda function using the format `lambda:MyLambdaFunctionName`.

```

        "summary:status",
        "summary:cc_id",
        "details:network"
    FROM "hbase".hbase_payments.transactions)

SELECT _key_          AS redis_order_id,
       customer_id,
       customer.email   AS cust_email,
       "summary:cc_id"  AS credit_card,
       "details:network" AS CC_type,
       "summary:status" AS payment_status,
       status           AS redis_status,
       addresses.street AS street_address,
       shipments.shipment_time AS shipment_time,
       shipments.carrier AS shipment_carrier,
       publicipaddress  AS ec2_order_processor,
       NAME              AS ec2_state,
       log_level,
       order_processor_log
FROM active_orders
LEFT JOIN logs
      ON logs.orderid = active_orders._key_
LEFT JOIN order_processors
      ON logs.log_stream = order_processors.instanceid
LEFT JOIN customer
      ON customer.id = customer_id
LEFT JOIN addresses
      ON addresses.id = address_id
LEFT JOIN shipments
      ON shipments.order_id = active_orders._key_
LEFT JOIN payments
      ON payments."summary:order_id" = active_orders._key_

```

The following image shows sample results of the query.

Results									
	redis_order_id	customer_id	cust_email	credit_card	CC_type	payment_status	redis_status	street_address	shipment_time
1	0001236	12151	jdoe@email.com	5612	VISA	PENDING	pending_payment	456790 Rufus Lane	
2	0001234	11123	jdoe@email.com	4119	AMEX	FUNDED	preparing_to_ship	13456 Rufus Dr.	2013-06-17 19:14
3	0001235	11123	jdoe@email.com	4119	AMEX	FUNDED	shipping	13456 Rufus Dr.	2012-12-09 21:16
4	0002234	9820	cdoe@email.com	1189	VISA	PENDING	backordered	13890 Rufus Road	
5	0001237	92053	sdoe@email.com	9001	VISA	PENDING	backordered	96110 Rufus Ave.	
6	0001238	453	adoe@email.com	8827	MASTERCARD	FUNDED	preparing_to_ship	987 Rufus St.	1976-03-23 15:52

Writing a Data Source Connector Using the Athena Query Federation SDK

To write your own [data source connectors \(p. 62\)](#), you can use the [Athena Query Federation SDK](#). The Athena Query Federation SDK defines a set of interfaces and wire protocols that you can use to enable Athena to delegate portions of its query execution plan to code that you write and deploy. The SDK includes a connector suite and an example connector.

You can also customize Amazon Athena's [prebuilt connectors](#) for your own use. You can modify a copy of the source code from GitHub and then use the [Connector Publish Tool](#) to create your own AWS Serverless Application Repository package. After you deploy your connector in this way, you can use it in your Athena queries.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

For information about how to download the SDK and detailed instructions for writing your own connector, see [Example Athena Connector](#) on GitHub.

Managing Data Sources

You can use the **Data Sources** page of the Athena console to view, edit, or delete the data sources that you create, including Athena data source connector, AWS Glue Data Catalog, and Hive metastore catalog types.

To view a data source

- Choose the catalog name of the data source, or select the button next to it and choose **View details**. The details page includes options to **Edit** or **Delete** the data source.

To edit a data source

- Choose the catalog name of the data source, or select the button next to the catalog name.
- Choose **Edit**.
- On the **Edit** page for the metastore, you can choose a different Lambda function for the data source or change the description of the existing function. When you edit an AWS Glue catalog, the AWS Glue console opens the corresponding catalog for editing.
- Choose **Save**.

To delete a data source

- Select the button next to the data source or the name of the data source, and then choose **Delete**. You are warned that when you delete a metastore data source, its corresponding Data Catalog, tables, and views are removed from the query editor. Saved queries that used the metastore no longer run in Athena.
- Choose **Delete**.

Connecting to Amazon Athena with ODBC and JDBC Drivers

To explore and visualize your data with business intelligence tools, download, install, and configure an ODBC (Open Database Connectivity) or JDBC (Java Database Connectivity) driver.

Topics

- [Using Athena with the JDBC Driver \(p. 71\)](#)
- [Connecting to Amazon Athena with ODBC \(p. 73\)](#)

Using Athena with the JDBC Driver

You can use a JDBC connection to connect Athena to business intelligence tools and other applications, such as [SQL Workbench](#). To do this, download, install, and configure the Athena JDBC driver, using the following links on Amazon S3.

Links for Downloading the JDBC Driver

The JDBC driver version 2.0.9 complies with the JDBC API 4.1 and 4.2 data standards. Before downloading the driver, check which version of Java Runtime Environment (JRE) you use. The JRE version depends on the version of the JDBC API you are using with the driver. If you are not sure, download the latest version of the driver.

Download the driver that matches your version of the JDK and the JDBC data standards:

- The [AthenaJDBC41-2.0.9.jar](#) is compatible with JDBC 4.1 and requires JDK 7.0 or later.
- The [AthenaJDBC42-2.0.9.jar](#) is compatible with JDBC 4.2 and requires JDK 8.0 or later.

JDBC Driver Release Notes, License Agreement, and Notices

After you download the version you need, read the release notes, and review the License Agreement and Notices.

- [Release Notes](#)
- [License Agreement](#)
- [Notices](#)
- [Third-Party Licenses](#)

JDBC Driver Documentation

Download the following documentation for the driver:

- [JDBC Driver Installation and Configuration Guide](#). Use this guide to install and configure the driver.
- [JDBC Driver Migration Guide](#). Use this guide to migrate from previous versions to the current version.

Links for Downloading the JDBC Driver for Preview Features

These drivers support Athena preview features. Download the driver that matches your version of the JDK and the JDBC data standards:

- The [AthenaJDBC41_preview.jar](#) is compatible with JDBC 4.1 and requires JDK 7.0 or later.
- The [AthenaJDBC42_preview.jar](#) is compatible with JDBC 4.2 and requires JDK 8.0 or later.

JDBC Driver Release Notes, License Agreement, and Notices for Preview Driver

After you download the version you need, read the release notes, and review the License Agreement and Notices.

- [Release Notes](#)
- [License Agreement](#)
- [Notices](#)
- [Third-Party Licenses](#)

JDBC Driver Documentation for Preview Driver

Download the following documentation for the driver:

- [JDBC Driver Installation and Configuration Guide](#). Use this guide to install and configure the driver.
- [JDBC Driver Migration Guide](#). Use this guide to migrate from previous versions to the current version.

Migration from Previous Version of the JDBC Driver

The current JDBC driver version 2.0.9 is a drop-in replacement of the previous version of the JDBC driver version 2.0.8, and is backwards compatible with the JDBC driver version 2.0.8, with the following step that you must perform to ensure the driver runs.

Important

To use JDBC driver version 2.0.5 or later, attach a permissions policy to IAM principals using the JDBC driver that allows the `athena:GetQueryResultsStream` policy action. This policy action is not exposed directly with the API. It is only used with the JDBC driver as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#). Additionally, ensure that port 444 is open to outbound traffic. For more information about upgrading to versions 2.0.5 or later from version 2.0.2, see the [JDBC Driver Migration Guide](#).

For more information about the previous versions of the JDBC driver, see [Using the Previous Version of the JDBC Driver \(p. 334\)](#).

If you are migrating from a 1.x driver to a 2.x driver, you must migrate your existing configurations to the new configuration. We highly recommend that you migrate to driver version 2.x. For information, see the [JDBC Driver Migration Guide](#).

Connecting to Amazon Athena with ODBC

Download the ODBC driver, the Amazon Athena ODBC driver License Agreement, and the documentation for the driver using the following links.

Amazon Athena ODBC Driver License Agreement

[License Agreement](#)

Windows

Driver Version	Download Link
ODBC 1.0.5 for Windows 32-bit	Windows 32 bit ODBC Driver 1.0.5
ODBC 1.0.5 for Windows 64-bit	Windows 64 bit ODBC Driver 1.0.5

Linux

Driver Version	Download Link
ODBC 1.0.5 for Linux 32-bit	Linux 32 bit ODBC Driver 1.0.5
ODBC 1.0.5 for Linux 64-bit	Linux 64 bit ODBC Driver 1.0.5

OSX

Driver Version	Download Link
ODBC 1.0.5 for OSX	OSX ODBC Driver 1.0.5

ODBC Driver Documentation

Driver Version	Download Link
Documentation for ODBC 1.0.5	ODBC Driver Installation and Configuration Guide version 1.0.5
Release Notes for ODBC 1.0.5	ODBC Driver Release Notes version 1.0.5

Migration from the Previous Version of the ODBC Driver

The current ODBC driver version 1.0.5 is a drop-in replacement of the previous version of the ODBC driver version 1.0.4. It is also backward compatible with the ODBC driver version 1.0.3, if you use the following required steps to make sure that the driver runs.

Important

To use the ODBC driver versions 1.0.3 and greater, follow these requirements:

- Keep the port 444 open to outbound traffic.
- Add the `athena:GetQueryResultsStream` policy action to the list of policies for Athena. This policy action is not exposed directly with the API operation, and is used only with the ODBC and JDBC drivers, as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#).

Previous Versions of the ODBC Driver

Driver Version 1.0.4	Download Link
ODBC 1.0.4 for Windows 32-bit	Windows 32 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Windows 64-bit	Windows 64 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Linux 32-bit	Linux 32 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Linux 64-bit	Linux 64 bit ODBC Driver 1.0.4
ODBC 1.0.4 for OSX	OSX ODBC Driver 1.0.4
Documentation for ODBC 1.0.4	ODBC Driver Installation and Configuration Guide version 1.0.4

Driver Version 1.0.3	Download Link
ODBC 1.0.3 for Windows 32-bit	Windows 32-bit ODBC Driver 1.0.3

Driver Version 1.0.3	Download Link
ODBC 1.0.3 for Windows 64-bit	Windows 64-bit ODBC Driver 1.0.3
ODBC 1.0.3 for Linux 32-bit	Linux 32-bit ODBC Driver 1.0.3
ODBC 1.0.3 for Linux 64-bit	Linux 64-bit ODBC Driver 1.0.3
ODBC 1.0.3 for OSX	OSX ODBC Driver 1.0
Documentation for ODBC 1.0.3	ODBC Driver Installation and Configuration Guide version 1.0.3

Driver Version 1.0.2	Download Link
ODBC 1.0.2 for Windows 32-bit	Windows 32-bit ODBC Driver 1.0.2
ODBC 1.0.2 for Windows 64-bit	Windows 64-bit ODBC Driver 1.0.2
ODBC 1.0.2 for Linux 32-bit	Linux 32-bit ODBC Driver 1.0.2
ODBC 1.0.2 for Linux 64-bit	Linux 64-bit ODBC Driver 1.0.2
ODBC 1.0 for OSX	OSX ODBC Driver 1.0
Documentation for ODBC 1.0.2	ODBC Driver Installation and Configuration Guide version 1.0.2

Running SQL Queries Using Amazon Athena

You can run SQL queries using Amazon Athena on data sources that are registered with the AWS Glue Data Catalog and data sources that you connect to using Athena query federation (preview), such as Hive metastores and Amazon DocumentDB instances. For more information about working with data sources, see

You can use Amazon Athena to query data stored in different locations and formats in a *dataset*. This dataset might be in CSV, JSON, Avro, Parquet, or some other format.

The tables and databases that you work with in Athena to run queries are based on *metadata*. Metadata is data about the underlying data in your dataset. How that metadata describes your dataset is called the *schema*. For example, a table name, the column names in the table, and the data type of each column are schema, saved as metadata, that describe an underlying dataset. In Athena, we call a system for organizing metadata a *data catalog* or a *metastore*. The combination of a dataset and the data catalog that describes it is called a *data source*.

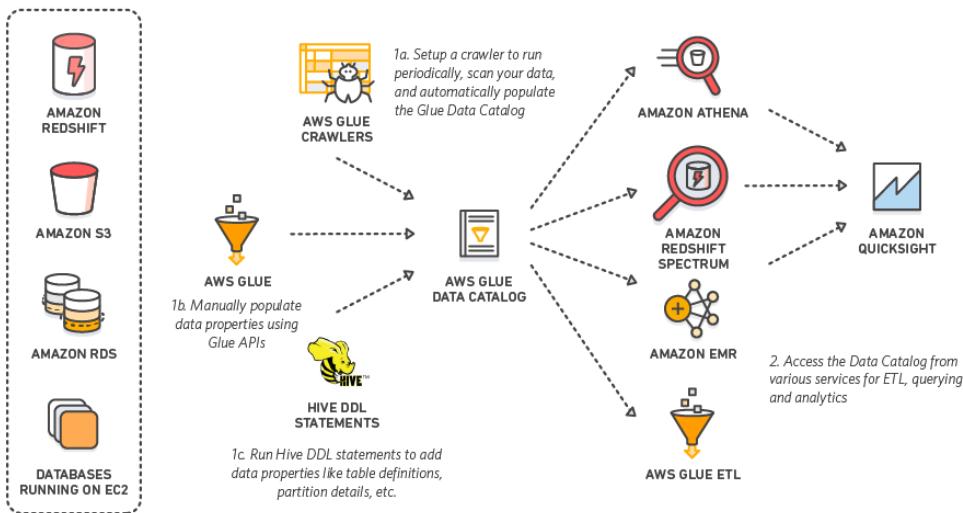
The relationship of metadata to an underlying dataset depends on the type of data source that you work with. Relational data sources like MySQL, PostgreSQL, and SQL Server tightly integrate the metadata with the dataset. In these systems, the metadata is most often written when the data is written. Other data sources, like those built using Hive, allow you to define metadata on-the-fly when you read the dataset. The dataset can be in a variety of formats—for example, CSV, JSON, Parquet, or Avro.

Athena natively supports the AWS Glue Data Catalog. The AWS Glue Data Catalog is a data catalog built on top of other datasets and data sources such as Amazon S3, Amazon Redshift, and Amazon DynamoDB. You can also connect Athena to other data sources by using a variety of connectors.

Integration with AWS Glue

AWS Glue is a fully managed ETL (extract, transform, and load) service that can categorize your data, clean it, enrich it, and move it reliably between various data stores. AWS Glue crawlers automatically infer database and table schema from your dataset, storing the associated metadata in the AWS Glue Data Catalog.

Athena natively supports querying datasets and data sources that are registered with the AWS Glue Data Catalog. When you run Data Manipulation Language (DML) queries in Athena with the Data Catalog as your source, you are using the Data Catalog schema to derive insight from the underlying dataset. When you run Data Definition Language (DDL) queries, the schema you define are defined in the AWS Glue Data Catalog. From within Athena, you can also run a AWS Glue crawler on a data source to create schema in the AWS Glue Data Catalog.



In regions where AWS Glue is supported, Athena uses the AWS Glue Data Catalog as a central location to store and retrieve table metadata throughout an AWS account. The Athena execution engine requires table metadata that instructs it where to read data, how to read it, and other information necessary to process the data. The AWS Glue Data Catalog provides a unified metadata repository across a variety of data sources and data formats, integrating not only with Athena, but with Amazon S3, Amazon RDS, Amazon Redshift, Amazon Redshift Spectrum, Amazon EMR, and any application compatible with the Apache Hive metastore.

For more information about the AWS Glue Data Catalog, see [Populating the AWS Glue Data Catalog in the AWS Glue Developer Guide](#). For a list of regions where AWS Glue is available, see [Regions and Endpoints in the AWS General Reference](#).

Separate charges apply to AWS Glue. For more information, see [AWS Glue Pricing](#) and [Are there separate charges for AWS Glue? \(p. 59\)](#) For more information about the benefits of using AWS Glue with Athena, see [Why should I upgrade to the AWS Glue Data Catalog? \(p. 58\)](#)

Topics

- [Using AWS Glue to Connect to Data Sources in Amazon S3 \(p. 46\)](#)
- [Best Practices When Using Athena with AWS Glue \(p. 48\)](#)
- [Upgrading to the AWS Glue Data Catalog Step-by-Step \(p. 56\)](#)
- [FAQ: Upgrading to the AWS Glue Data Catalog \(p. 58\)](#)

Using AWS Glue to Connect to Data Sources in Amazon S3

Athena can connect to your data stored in Amazon S3 using the AWS Glue Data Catalog to store metadata such as table and column names. After the connection is made, your databases, tables, and views appear in Athena's query editor.

To define schema information for AWS Glue to use, you can set up an AWS Glue crawler to retrieve the information, or you can manually add a table and enter the schema information.

Setting up a Crawler

You set up a crawler by starting in the Athena console and then using the AWS Glue console in an integrated way. When you create a crawler, you can choose data stores to crawl or point the crawler to existing catalog tables.

To set up a crawler in AWS Glue to retrieve schema information automatically

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **AWS Glue Data Catalog**.
4. Click **Next**.
5. On the **Connection details** page, choose **Set up crawler in AWS Glue to retrieve schema information automatically**.
6. Click **Connect to AWS AWS Glue**.
7. On the **AWS Glue** console **Add crawler** page, follow the steps to create a crawler. For more information, see [Populating the AWS Glue Data Catalog](#).

Adding a Schema Table Manually

The following procedure shows you how to use the Athena console to add a table manually.

To add a table and enter schema information manually

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **AWS Glue Data Catalog**.
4. Click **Next**.
5. On the **Connection details** page, choose **Add a table and enter schema information manually**.
6. Click **Continue to add table**.
7. On the **Add table** page of the Athena console, for **Database**, choose an existing database or create a new one.
8. Enter or choose a table name.
9. For **Location of Input Data Set**, specify the path in Amazon S3 to the folder that contains the dataset that you want to process.
10. Click **Next**.
11. For **Data Format**, choose a data format (**Apache Web Logs**, **CSV**, **TSV**, **Text File with Custom Delimiters**, **JSON**, **Parquet**, or **ORC**).
 - For the **Apache Web Logs** option, you must also enter a regex expression in the **Regex** box.
 - For the **Text File with Custom Delimiters** option, specify a **Field terminator** (that is, a column delimiter). Optionally, you can specify a **Collection terminator** for array types or a **Map key terminator**.
12. For **Columns**, specify a column name and the column data type.
 - To add more columns one at a time, choose **Add a column**.
 - To quickly add more columns, choose **Bulk add columns**. In the text box, enter a comma separated list of columns in the format `column_name data_type`, `column_name data_type`[, ...], and then choose **Add**.

13. Choose **Next**.

14. (Optional) For **Partitions**, click **Add a partition** to add column names and data types.
15. Choose **Create table**. The DDL for the table that you specified appears in the **Query Editor**. The following example shows the DDL generated for a two-column table in CSV format:

```
CREATE EXTERNAL TABLE IF NOT EXISTS MyManualDB.MyManualTable (
    `cola` string,
    `colb` string
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe'
WITH SERDEPROPERTIES (
    'serialization.format' = ',',
    'field.delim' = ','
) LOCATION 's3://bucket_name/'
TBLPROPERTIES ('has_encrypted_data'='false');
```

16. Choose **Run query** to create the table.

Best Practices When Using Athena with AWS Glue

When using Athena with the AWS Glue Data Catalog, you can use AWS Glue to create databases and tables (schema) to be queried in Athena, or you can use Athena to create schema and then use them in AWS Glue and related services. This topic provides considerations and best practices when using either method.

Under the hood, Athena uses Presto to execute DML statements and Hive to execute the DDL statements that create and modify schema. With these technologies, there are a couple of conventions to follow so that Athena and AWS Glue work well together.

In this topic

- [Database, Table, and Column Names \(p. 48\)](#)
- [Using AWS Glue Crawlers \(p. 49\)](#)
 - Scheduling a Crawler to Keep the AWS Glue Data Catalog and Amazon S3 in Sync (p. 49)
 - Using Multiple Data Sources with Crawlers (p. 49)
 - Syncing Partition Schema to Avoid "HIVE_PARTITION_SCHEMA_MISMATCH" (p. 51)
 - Updating Table Metadata (p. 52)
- [Working with CSV Files \(p. 52\)](#)
 - CSV Data Enclosed in Quotes (p. 52)
 - CSV Files with Headers (p. 54)
- [Working with Geospatial Data \(p. 54\)](#)
- [Using AWS Glue Jobs for ETL with Athena \(p. 54\)](#)
 - Creating Tables Using Athena for AWS Glue ETL Jobs (p. 54)
 - Using ETL Jobs to Optimize Query Performance (p. 55)
 - Converting SMALLINT and TINYINT Datatypes to INT When Converting to ORC (p. 56)
 - Automating AWS Glue Jobs for ETL (p. 56)

Database, Table, and Column Names

When you create schema in AWS Glue to query in Athena, consider the following:

- A database name cannot be longer than 252 characters.
- A table name cannot be longer than 255 characters.
- A column name cannot be longer than 128 characters.
- The only acceptable characters for database names, table names, and column names are lowercase letters, numbers, and the underscore character.

You can use the AWS Glue Catalog Manager to rename columns, but at this time table names and database names cannot be changed using the AWS Glue console. To correct database names, you need to create a new database and copy tables to it (in other words, copy the metadata to a new entity). You can follow a similar process for tables. You can use the AWS Glue SDK or AWS CLI to do this.

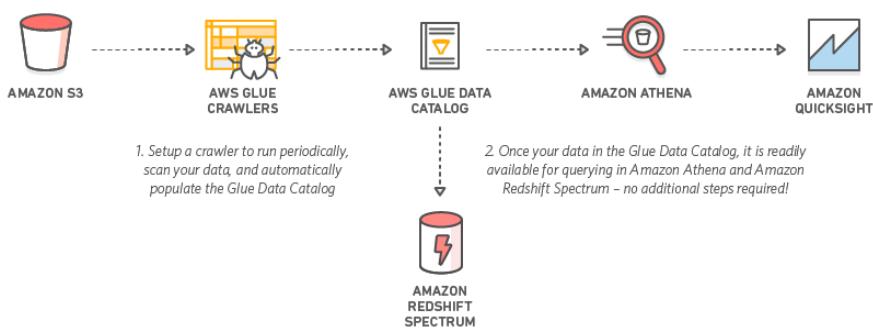
Using AWS Glue Crawlers

AWS Glue crawlers help discover and register the schema for datasets in the AWS Glue Data Catalog. The crawlers go through your data, and inspect portions of it to determine the schema. In addition, the crawler can detect and register partitions. For more information, see Cataloging Data with a Crawler in the *AWS Glue Developer Guide*.

Scheduling a Crawler to Keep the AWS Glue Data Catalog and Amazon S3 in Sync

AWS Glue crawlers can be set up to run on a schedule or on demand. For more information, see Time-Based Schedules for Jobs and Crawlers in the *AWS Glue Developer Guide*.

If you have data that arrives for a partitioned table at a fixed time, you can set up an AWS Glue Crawler to run on schedule to detect and update table partitions. This can eliminate the need to run a potentially long and expensive `MSCK REPAIR` command or manually execute an `ALTER TABLE ADD PARTITION` command. For more information, see Table Partitions in the *AWS Glue Developer Guide*.



Using Multiple Data Sources with Crawlers

When an AWS Glue Crawler scans Amazon S3 and detects multiple directories, it uses a heuristic to determine where the root for a table is in the directory structure, and which directories are partitions for the table. In some cases, where the schema detected in two or more directories is similar, the crawler may treat them as partitions instead of separate

tables. One way to help the crawler discover individual tables is to add each table's root directory as a data store for the crawler.

The following partitions in Amazon S3 are an example:

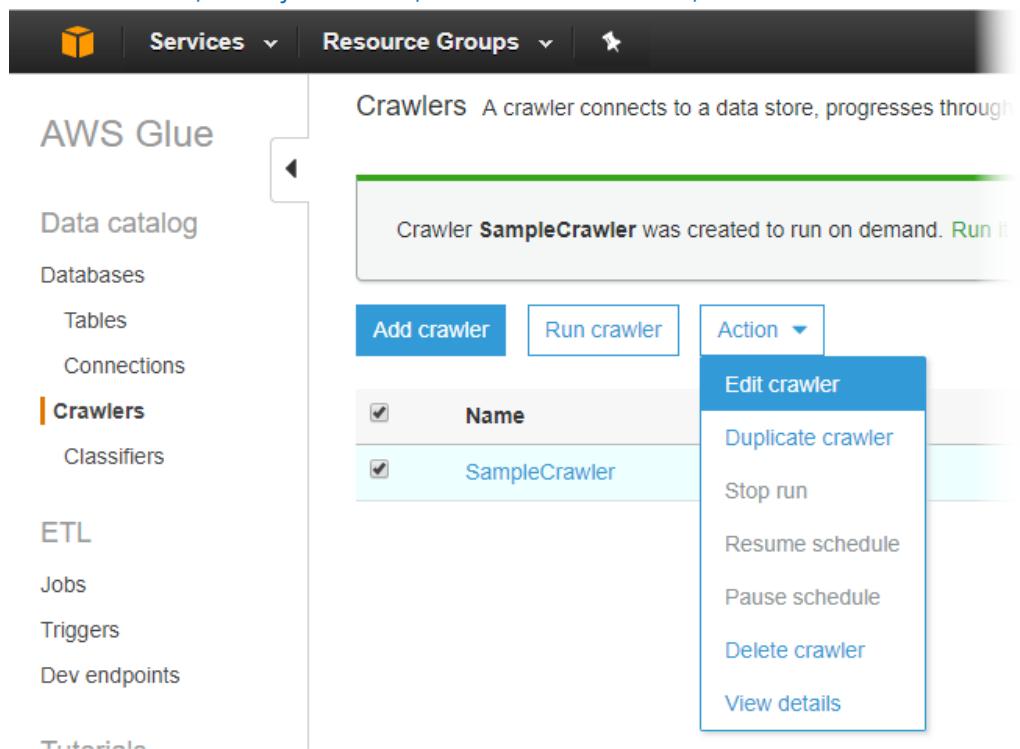
```
s3://bucket01/folder1/table1/partition1/file.txt  
s3://bucket01/folder1/table1/partition2/file.txt  
s3://bucket01/folder1/table1/partition3/file.txt  
s3://bucket01/folder1/table2/partition4/file.txt  
s3://bucket01/folder1/table2/partition5/file.txt
```

If the schema for `table1` and `table2` are similar, and a single data source is set to `s3://bucket01/folder1/` in AWS Glue, the crawler may create a single table with two partition columns: one partition column that contains `table1` and `table2`, and a second partition column that contains `partition1` through `partition5`.

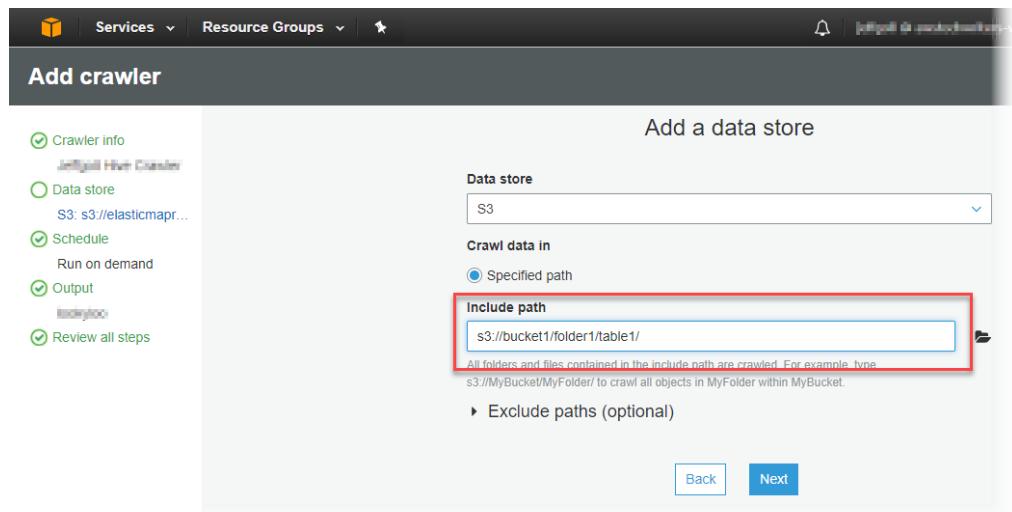
To have the AWS Glue crawler create two separate tables, set the crawler to have two data sources, `s3://bucket01/folder1/table1/` and `s3://bucket01/folder1/table2/`, as shown in the following procedure.

To add another data store to an existing crawler in AWS Glue

1. Sign in to the AWS Management Console and open the AWS Glue console at <https://console.aws.amazon.com/glue/>.
2. Choose **Crawlers**, select your crawler, and then choose **Action, Edit crawler**.



3. Under **Add information about your crawler**, choose additional settings as appropriate, and then choose **Next**.
4. Under **Add a data store**, change **Include path** to the table-level directory. For instance, given the example above, you would change it from `s3://bucket01/folder1` to `s3://bucket01/folder1/table1/`. Choose **Next**.



5. For **Add another data store**, choose **Yes, Next**.
6. For **Include path**, enter your other table-level directory (for example, `s3://bucket01/folder1/table2/`) and choose **Next**.
 - a. Repeat steps 3-5 for any additional table-level directories, and finish the crawler configuration.

The new values for **Include locations** appear under data stores as follows:

Crawler info	
Name	SampleCrawler
Service role	[REDACTED]

Data stores	
Data store	S3
Include path	<code>s3://bucket1/folder1/table1/</code>
Exclude paths	
Data store	S3
Include path	<code>s3://bucket1/folder1/table2/</code>
Exclude paths	

Syncing Partition Schema to Avoid "HIVE_PARTITION_SCHEMA_MISMATCH"

For each table within the AWS Glue Data Catalog that has partition columns, the schema is stored at the table level and for each individual partition within the table. The schema for partitions are populated by an AWS Glue crawler based on the sample of data that it reads within the partition. For more information, see [Using Multiple Data Sources with Crawlers](#) (p. 49).

When Athena runs a query, it validates the schema of the table and the schema of any partitions necessary for the query. The validation compares the column data types in order and makes sure that they match for the columns that overlap. This prevents unexpected operations such as adding or removing columns from the middle of a table. If Athena detects that the schema of a partition differs from the schema of the table, Athena may not be able to process the query and fails with `HIVE_PARTITION_SCHEMA_MISMATCH`.

There are a few ways to fix this issue. First, if the data was accidentally added, you can remove the data files that cause the difference in schema, drop the partition, and re-crawl the data. Second, you can drop the individual partition and then run `MSCK REPAIR` within Athena to re-create the partition using the table's schema. This second option works only if you are confident that the schema applied will continue to read the data correctly.

Updating Table Metadata

After a crawl, the AWS Glue crawler automatically assigns certain table metadata to help make it compatible with other external technologies like Apache Hive, Presto, and Spark. Occasionally, the crawler may incorrectly assign metadata properties. Manually correct the properties in AWS Glue before querying the table using Athena. For more information, see [Viewing and Editing Table Details in the AWS Glue Developer Guide](#).

AWS Glue may mis-assign metadata when a CSV file has quotes around each data field, getting the `serializationLib` property wrong. For more information, see [CSV Data Enclosed in quotes \(p. 52\)](#).

Working with CSV Files

CSV files occasionally have quotes around the data values intended for each column, and there may be header values included in CSV files, which aren't part of the data to be analyzed. When you use AWS Glue to create schema from these files, follow the guidance in this section.

CSV Data Enclosed in Quotes

If you run a query in Athena against a table created from a CSV file with quoted data values, update the table definition in AWS Glue so that it specifies the right SerDe and SerDe properties. This allows the table definition to use the OpenCSVSerDe. For more information about the OpenCSV SerDe, see [OpenCSVSerDe for Processing CSV \(p. 280\)](#).

In this case, make the following changes:

- Change the `serializationLib` property under `field` in the `SerdeInfo` field in the table to `org.apache.hadoop.hive.serde2.OpenCSVSerde`.
- Enter appropriate values for `separatorChar`, `quoteChar`, and `escapeChar`. The `separatorChar` value is a comma, the `quoteChar` value is double quotes (` `), and the `escapeChar` value is the backslash (\).

For example, for a CSV file with records such as the following:

```
"John", "Doe", "123-555-1231", "John said \"hello\""
```

```
"Jane", "Doe", "123-555-9876", "Jane said \"hello\""
```

You can use the AWS Glue console to edit table details as shown in this example:

Edit table details

Table name
sample_csv_table

Input format
org.apache.hadoop.mapred.TextInputFormat

Output format
org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat

Serde name

Serde serialization lib
org.apache.hadoop.hive.serde2.OpenCSVSerde

Serde parameters

Key	Value
escapeChar	\
quoteChar	"
separatorChar	,
Type key...	Type value...

Description

Apply

Alternatively, you can update the table definition in AWS Glue to have a SerDeInfo block such as the following:

```
"SerDeInfo": {  
    "name": "",  
    "serializationLib": "org.apache.hadoop.hive.serde2.OpenCSVSerde",  
    "parameters": {  
        "separatorChar": ", "  
        "quoteChar": "" "  
        "escapeChar": "\\" "
```

```
}
```

```
,
```

For more information, see [Viewing and Editing Table Details in the AWS Glue Developer Guide](#).

CSV Files with Headers

If you are writing CSV files from AWS Glue to query using Athena, you must remove the CSV headers so that the header information is not included in Athena query results. One way to achieve this is to use AWS Glue jobs, which perform extract, transform, and load (ETL) work. You can write scripts in AWS Glue using a language that is an extension of the PySpark Python dialect. For more information, see [Authoring Jobs in Glue](#) in the *AWS Glue Developer Guide*.

The following example shows a function in an AWS Glue script that writes out a dynamic frame using `from_options`, and sets the `writeHeader` format option to false, which removes the header information:

```
glueContext.write_dynamic_frame.from_options(frame = applymapping1,  
connection_type = "s3", connection_options = {"path": "s3://MYBUCKET/  
MYTABLEDATA/"}, format = "csv", format_options = {"writeHeader": False},  
transformation_ctx = "datasink2")
```

Working with Geospatial Data

AWS Glue does not natively support Well-known Text (WKT), Well-Known Binary (WKB), or other PostGIS data types. The AWS Glue classifier parses geospatial data and classifies them using supported data types for the format, such as `varchar` for CSV. As with other AWS Glue tables, you may need to update the properties of tables created from geospatial data to allow Athena to parse these data types as-is. For more information, see [Using AWS Glue Crawlers](#) (p. 49) and [Working with CSV Files](#) (p. 52). Athena may not be able to parse some geospatial data types in AWS Glue tables as-is. For more information about working with geospatial data in Athena, see [Querying Geospatial Data](#) (p. 157).

Using AWS Glue Jobs for ETL with Athena

AWS Glue jobs perform ETL operations. An AWS Glue job runs a script that extracts data from sources, transforms the data, and loads it into targets. For more information, see [Authoring Jobs in Glue](#) in the *AWS Glue Developer Guide*.

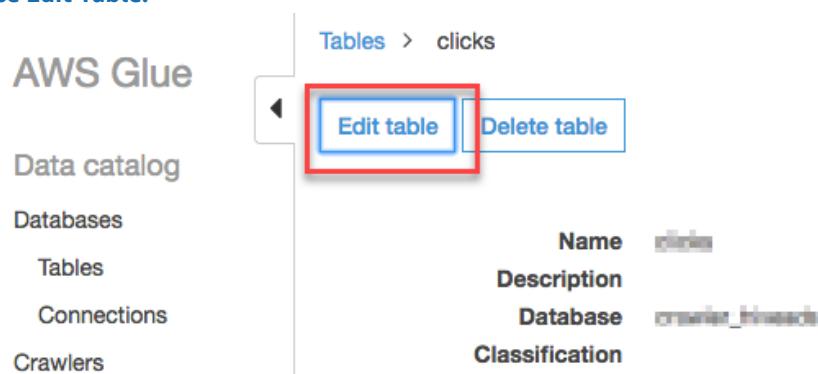
Creating Tables Using Athena for AWS Glue ETL Jobs

Tables that you create in Athena must have a table property added to them called a `classification`, which identifies the format of the data. This allows AWS Glue to use the tables for ETL jobs. The classification values can be `csv`, `parquet`, `orc`, `avro`, or `json`. An example `CREATE TABLE` statement in Athena follows:

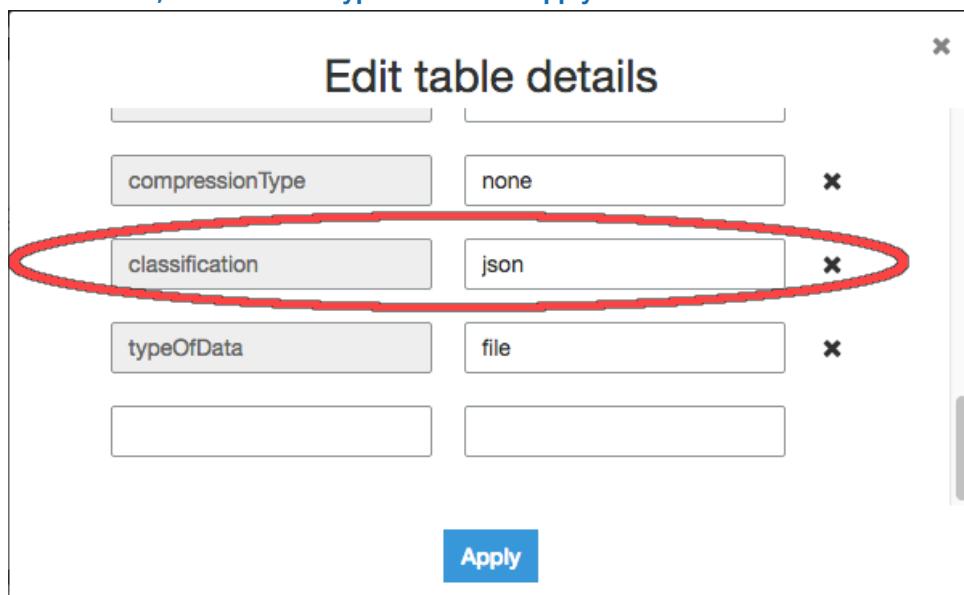
```
CREATE EXTERNAL TABLE sampleTable (  
    column1 INT,  
    column2 INT  
) STORED AS PARQUET  
TBLPROPERTIES ('classification'='parquet')
```

To change the classification property using the console

1. Choose Edit Table.



2. For Classification, select the file type and choose Apply.



For more information, see [Working with Tables in the AWS Glue Developer Guide](#).

Using ETL Jobs to Optimize Query Performance

AWS Glue jobs can help you transform data to a format that optimizes query performance in Athena. Data formats have a large impact on query performance and query costs in Athena.

We recommend to use Parquet and ORC data formats. AWS Glue supports writing to both of these data formats, which can make it easier and faster for you to transform data to an optimal format for Athena. For more information about these formats and other ways to improve performance, see [Top Performance Tuning Tips for Amazon Athena](#).

Converting SMALLINT and TINYINT Data Types to INT When Converting to ORC

To reduce the likelihood that Athena is unable to read the `SMALLINT` and `TINYINT` data types produced by an AWS Glue ETL job, convert `SMALLINT` and `TINYINT` to `INT` when using the wizard or writing a script for an ETL job.

Automating AWS Glue Jobs for ETL

You can configure AWS Glue ETL jobs to run automatically based on triggers. This feature is ideal when data from outside AWS is being pushed to an Amazon S3 bucket in a suboptimal format for querying in Athena. For more information, see [Triggering AWS Glue Jobs in the AWS Glue Developer Guide](#).

Upgrading to the AWS Glue Data Catalog Step-by-Step

Amazon Athena manages its own data catalog until the time that AWS Glue releases in the Athena region. At that time, if you previously created databases and tables using Athena or Amazon Redshift Spectrum, you can choose to upgrade Athena to the AWS Glue Data Catalog. If you are new to Athena, you don't need to make any changes; databases and tables are available to Athena using the AWS Glue Data Catalog and vice versa. For more information about the benefits of using the AWS Glue Data Catalog, see [FAQ: Upgrading to the AWS Glue Data Catalog](#) (p. 58). For a list of regions where AWS Glue is available, see [Regions and Endpoints in the AWS General Reference](#).

Until you upgrade, the Athena-managed data catalog continues to store your table and database metadata, and you see the option to upgrade at the top of the console. The metadata in the Athena-managed catalog isn't available in the AWS Glue Data Catalog or vice versa. While the catalogs exist side-by-side, you aren't able to create tables or databases with the same names, and the creation process in either AWS Glue or Athena fails in this case.

We created a wizard in the Athena console to walk you through the steps of upgrading to the AWS Glue console. The upgrade takes just a few minutes, and you can pick up where you left off. For more information about each upgrade step, see the topics in this section. For more information about working with data and tables in the AWS Glue Data Catalog, see the guidelines in [Best Practices When Using Athena with AWS Glue](#) (p. 48).

Step 1 - Allow a User to Perform the Upgrade

By default, the action that allows a user to perform the upgrade is not allowed in any policy, including any managed policies. Because the AWS Glue Data Catalog is shared throughout an account, this extra failsafe prevents someone from accidentally migrating the catalog.

Before the upgrade can be performed, you need to attach a customer-managed IAM policy, with a policy statement that allows the upgrade action, to the user who performs the migration.

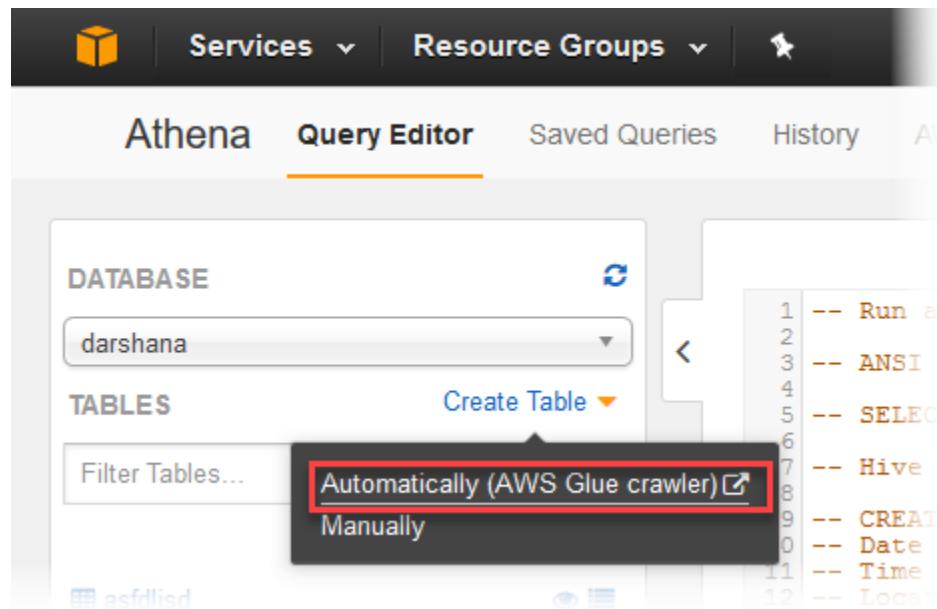
The following is an example policy statement.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "glue:ImportCatalogToGlue"  
            ],  
            "Resource": ["*"]  
        }  
    ]  
}
```

Step 2 - Update Customer-Managed/Inline Policies Associated with Athena Users

If you have customer-managed or inline IAM policies associated with Athena users, you need to update the policy or policies to allow actions that AWS Glue requires. If you use the managed policy, they are automatically updated. The AWS Glue policy actions to allow are listed in the example policy below. For the full policy statement, see [IAM Policies for User Access \(p. 203\)](#).

```
{  
    "Effect": "Allow",  
    "Action": [  
        "glue>CreateDatabase",  
        "glue>DeleteDatabase",  
        "glue>GetDatabase",  
        "glue>GetDatabases",  
        "glue>UpdateDatabase",  
        "glue>CreateTable",  
        "glue>DeleteTable",  
        "glue>BatchDeleteTable",  
        "glue>UpdateTable",  
        "glue>GetTable",  
        "glue>GetTables",  
        "glue>BatchCreatePartition",  
        "glue>CreatePartition",  
        "glue>DeletePartition",  
        "glue>BatchDeletePartition",  
        "glue>UpdatePartition",  
        "glue>GetPartition",  
        "glue>GetPartitions",  
        "glue>BatchGetPartition"  
    ],  
    "Resource": [  
        "*"  
    ]  
}
```



FAQ: Upgrading to the AWS Glue Data Catalog

If you created databases and tables using Athena in a region before AWS Glue was available in that region, metadata is stored in an Athena-managed data catalog, which only Athena and Amazon Redshift Spectrum can access. To use AWS Glue features together with Athena and Redshift Spectrum, you must upgrade to the AWS Glue Data Catalog. Athena can only be used together with the AWS Glue Data Catalog in regions where AWS Glue is available. For a list of regions, see [Regions and Endpoints in the AWS General Reference](#).

Why should I upgrade to the AWS Glue Data Catalog?

AWS Glue is a completely-managed extract, transform, and load (ETL) service. It has three main components:

- **An AWS Glue crawler** can automatically scan your data sources, identify data formats, and infer schema.
 - **A fully managed ETL service** allows you to transform and move data to various destinations.
 - **The AWS Glue Data Catalog** stores metadata information about databases and tables, pointing to a data store in Amazon S3 or a JDBC-compliant data store.
- For more information, see [AWS Glue Concepts](#).

Upgrading to the AWS Glue Data Catalog has the following benefits.

Unified metadata repository

The AWS Glue Data Catalog provides a unified metadata repository across a variety of data sources and data formats. It provides out-of-the-box integration with Amazon Simple Storage Service (Amazon S3), Amazon Relational Database Service (Amazon RDS), Amazon Redshift, Amazon Redshift Spectrum, Athena, Amazon EMR, and any application compatible with the Apache Hive metastore. You can create your table definitions one time and query across engines.

For more information, see [Populating the AWS Glue Data Catalog](#).

Automatic schema and partition recognition

AWS Glue crawlers automatically crawl your data sources, identify data formats, and suggest schema and transformations. Crawlers can help automate table creation and automatic loading of partitions that you can query using Athena, Amazon EMR, and Redshift Spectrum. You can also create tables and partitions directly using the AWS Glue API, SDKs, and the AWS CLI.

For more information, see [Cataloging Tables with a Crawler](#).

Easy-to-build pipelines

The AWS Glue ETL engine generates Python code that is entirely customizable, reusable, and portable. You can edit the code using your favorite IDE or notebook and share it with others using GitHub. After your ETL job is ready, you can schedule it to run on the fully managed, scale-out Spark infrastructure of AWS Glue. AWS Glue handles provisioning, configuration, and scaling of the resources required to run your ETL jobs, allowing you to tightly integrate ETL with your workflow.

For more information, see [Authoring AWS Glue Jobs in the AWS Glue Developer Guide](#).

Are there separate charges for AWS Glue?

Yes. With AWS Glue, you pay a monthly rate for storing and accessing the metadata stored in the AWS Glue Data Catalog, an hourly rate billed per second for AWS Glue ETL jobs and crawler runtime, and an hourly rate billed per second for each provisioned development endpoint. The AWS Glue Data Catalog allows you to store up to a million objects at no charge. If you store more than a million objects, you are charged USD\$1 for each 100,000 objects over a million. An object in the AWS Glue Data Catalog is a table, a partition, or a database. For more information, see [AWS Glue Pricing](#).

Upgrade process FAQ

- Who can perform the upgrade? (p. 59)
- My users use a managed policy with Athena and Redshift Spectrum. What steps do I need to take to upgrade? (p. 59)
- What happens if I don't upgrade? (p. 60)
- Why do I need to add AWS Glue policies to Athena users? (p. 60)
- What happens if I don't allow AWS Glue policies for Athena users? (p. 60)
- Is there risk of data loss during the upgrade? (p. 60)
- Is my data also moved during this upgrade? (p. 60)

Who can perform the upgrade?

You need to attach a customer-managed IAM policy with a policy statement that allows the upgrade action to the user who will perform the migration. This extra check prevents someone from accidentally migrating the catalog for the entire account. For more information, see [Step 1 - Allow a User to Perform the Upgrade](#) (p. 56).

My users use a managed policy with Athena and Redshift Spectrum. What steps do I need to take to upgrade?

The Athena managed policy has been automatically updated with new policy actions that allow Athena users to access AWS Glue. However, you still must explicitly allow the upgrade

action for the user who performs the upgrade. To prevent accidental upgrade, the managed policy does not allow this action.

What happens if I don't upgrade?

If you don't upgrade, you are not able to use AWS Glue features together with the databases and tables you create in Athena or vice versa. You can use these services independently. During this time, Athena and AWS Glue both prevent you from creating databases and tables that have the same names in the other data catalog. This prevents name collisions when you do upgrade.

Why do I need to add AWS Glue policies to Athena users?

Before you upgrade, Athena manages the data catalog, so Athena actions must be allowed for your users to perform queries. After you upgrade to the AWS Glue Data Catalog, Athena actions no longer apply to accessing the AWS Glue Data Catalog, so AWS Glue actions must be allowed for your users. Remember, the managed policy for Athena has already been updated to allow the required AWS Glue actions, so no action is required if you use the managed policy.

What happens if I don't allow AWS Glue policies for Athena users?

If you upgrade to the AWS Glue Data Catalog and don't update a user's customer-managed or inline IAM policies, Athena queries fail because the user won't be allowed to perform actions in AWS Glue. For the specific actions to allow, see Step 2 - Update Customer-Managed/Inline Policies Associated with Athena Users (p. 57).

Is there risk of data loss during the upgrade?

No.

Is my data also moved during this upgrade?

No. The migration only affects metadata.

Using Athena Data Connector for External Hive Metastore (Preview)

You can use the Athena Data Connector for External Hive Metastore (Preview) to query data sets in Amazon S3 that use an Apache Hive metastore. No migration of metadata to the AWS Glue Data Catalog is necessary. In the Athena management console, you configure a Lambda function to communicate with the Hive metastore in your private VPC and then connect it. For the Lambda function code, you can use Athena's default implementation – the Athena data source connector for external Hive metastore – or provide your own.

Considerations and Limitations

Prebuilt and custom data connectors might require access to the following resources to function correctly. Check the information for the connector that you use to ensure that you have configured your VPC correctly. For information about required IAM permissions to run queries and create a data source connector in Athena, see Allow Access to an Athena Data Connector for External Hive Metastore (Preview) (p. 215).

- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see Managing Workgroups (p. 248).

- **Amazon S3** – In addition to writing query results to the Athena query results location in Amazon S3, data connectors also write to a spill bucket in Amazon S3. Connectivity and permissions to this Amazon S3 location are required.
- **Athena** – For checking query status and preventing overscan.
- **AWS Secrets Manager**
- **AWS Glue** if your connector uses AWS Glue for supplemental or primary metadata.
- **AWS Key Management Service**
- **Policies** – Hive metastore, Athena Query Federation, and UDFs require policies in addition to the AmazonAthenaFullAccess Managed Policy (p. 204). For more information, see Identity and Access Management in Athena (p. 203).

Connecting Athena to an Apache Hive Metastore

To connect Athena to an Apache Hive Metastore, you must create and configure a Lambda function. For a basic implementation, you can perform all required steps from the Athena management console.

To connect Athena to a Hive metastore

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, for **Choose a metadata catalog**, choose **Apache Hive metastore**.
4. Choose **Next**.
5. On the **Connection details** page, for **Lambda function**, click **Create Lambda function**.
6. In the **Create Lambda function** dialog box, enter the following information for the Lambda function. To use the default implementation, accept the defaults for the function code location in Amazon S3 and the Lambda handler.
 - **Lambda function name** – Provide a name for the function. For example, `myHiveMetastore`.
 - **Lambda execution role** – Choose an IAM role or click **Create a new role** to create one.
 - **Function code** – The location in Amazon S3 for the Lambda function JAR file. Use the default or enter the location of your custom JAR file.
 - **Lambda handler** – The method in the JAR file that implements the Hive connector. Use the default, or replace it with the handler in your custom code.
 - **Hive metastore (HMS) URI** – Enter the name of your Hive metastore host that uses the Thrift protocol at port 9083 with the syntax `thrift://<host_name>:9083`.
 - **Spill location in S3** – Specify an Amazon S3 location in this account to hold spillover metadata if the Lambda function response size exceeds 4MB.
 - **Virtual Private (VPC)** – Choose the VPC that contains your Hive metastore.
 - **Subnets** – Choose the VPC subnets for Lambda to use to set up your VPC configuration.
 - **Security Groups** – Choose the VPC security groups for Lambda to use to set up your VPC configuration.
 - **Memory** – Specify a value from 128MB to 3008MB. The Lambda function is allocated CPU cycles proportional to the amount of memory that you configure.
 - **Timeout** – Specify a value from 1 second to 15 minutes 59 seconds. The default is 3 seconds.

7. Click **Create**. The **Connection details** page informs you that the function is being created. When the operation completes, your function name is available in the **Choose a function name** box, and your Lambda function ARN is displayed.
8. For **Catalog name**, enter a unique name to use for the data source in your SQL queries. The name can be up to 127 characters and must be unique within your account. It cannot be changed after creation. Valid characters are a-z, A-z, 0-9, _(underscore), @(ampersand) and -(hyphen).
9. Click **Connect** to connect Athena to your data source. The **Data sources** page shows your connector in the list of catalog names. You can now use the **Catalog name** that you specified to reference the Hive metastore in your SQL queries. Use the syntax in the following example, where **MyHiveMetastore** is the catalog name that you specified earlier.

```
SELECT * FROM MyHiveMetastore.CustomerData.customers;
```

Using Amazon Athena Federated Query (Preview)

If you have data in sources other than Amazon S3, you can use Athena Federated Query (Preview) to query the data in place or build pipelines that extract data from multiple data sources and store them in Amazon S3. With Athena Federated Query (Preview), you can run SQL queries across data stored in relational, non-relational, object, and custom data sources.

Athena uses *data source connectors* that run on AWS Lambda to execute federated queries. A data source connector is a piece of code that can translate between your target data source and Athena. You can think of a connector as an extension of Athena's query engine. Prebuilt Athena data source connectors exist for data sources like Amazon CloudWatch Logs, Amazon DynamoDB, Amazon DocumentDB, and Amazon RDS, and JDBC-compliant relational data sources such as MySQL, and PostgreSQL under the Apache 2.0 license. You can also use the Athena Query Federation SDK to write custom connectors. To choose, configure, and deploy a data source connector to your account, you can use the Athena and Lambda consoles or the AWS Serverless Application Repository. After you deploy data source connectors, the connector is associated with a catalog that you can specify in SQL queries. You can combine SQL statements from multiple catalogs and span multiple data sources with a single query.

When a query is submitted against a data source, Athena invokes the corresponding connector to identify parts of the tables that need to be read, manages parallelism, and pushes down filter predicates. Based on the user submitting the query, connectors can provide or restrict access to specific data elements. Connectors use Apache Arrow as the format for returning data requested in a query, which enables connectors to be implemented in languages such as C, C++, Java, Python, and Rust. Since connectors are executed in Lambda, they can be used to access data from any data source on the cloud or on-premises that is accessible from Lambda.

To write your own data source connector, you can use the Athena Query Federation SDK to customize one of the prebuilt connectors that Amazon Athena provides and maintains. You can modify a copy of the source code from the GitHub repository and then use the Connector Publish Tool to create your own AWS Serverless Application Repository package.

For a list of available Athena data source connectors, see [Using Athena Data Source Connectors \(p. 65\)](#).

For information about writing your own data source connector, see [Example Athena Connector on GitHub](#).

Considerations and Limitations

Data source connectors might require access to the following resources to function correctly. If you use a prebuilt connector, check the information for the connector to ensure that you have configured your VPC correctly. Also, ensure that IAM principals running queries and creating connectors have privileges to required actions. For more information, see Example IAM Permissions Policies to Allow Athena Federated Query (Preview) (p. 217).

- For the most up-to-date information about known issues and limitations, see Limitations and Issues in the [aws-athena-query-federation GitHub repository](#).
- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see Managing Workgroups (p. 248).
- **Amazon S3 – In addition to writing query results to the Athena query results location in Amazon S3, data connectors also write to a spill bucket in Amazon S3. Connectivity and permissions to this Amazon S3 location are required.**
- **Athena** – Data sources need connectivity to Athena and vice versa for checking query status and preventing overscan.
- **AWS Glue Data Catalog** – Connectivity and permissions are required if your connector uses Data Catalog for supplemental or primary metadata.

Deploying a Connector and Connecting to a Data Source

Preparing to create federated queries is a two-part process: deploying a Lambda function data source connector, and connecting the Lambda function to a data source. In the first part, you give the Lambda function a name that you can later choose in the Athena console. In the second part, you give the connector a name that you can reference in your SQL queries.

Part 1: Deploying a Data Source Connector

To choose, name, and deploy a data source connector, you use the Athena and Lambda consoles in an integrated process.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see Managing Workgroups (p. 248).

To deploy a data source connector

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. On the **Connect data source** page, choose **Query a data source**.
4. For **Choose a data source**, choose the data source that you want to query with Athena, such as **Amazon CloudWatch Logs**.
5. Choose **Next**.
6. For **Lambda function**, choose **Configure new function**. The function page for the connector that you chose opens in the Lambda console. The page includes detailed information about the connector.
7. Under **Application settings**, enter the required information. At a minimum, this includes:

- **AthenaCatalogName** – A name for the Lambda function that indicates the data source that it targets, such as `cloudwatchlogs`.
 - **SpillBucket** – An Amazon S3 bucket in your account to store data that exceeds Lambda function response size limits.
8. Select **I acknowledge that this app creates custom IAM roles**. For more information, choose the **Info** link.
 9. Choose **Deploy**. The **Resources** section of the Lambda console shows the deployment status of the connector and informs you when the deployment is complete.

Part 2: Connecting to a Data Source

After you deploy the data source connector to your account, you can connect it to a data source.

To connect to a data source using a connector that you have deployed to your account

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose **Connect data source**.
3. Choose **Query a data source**.
4. Choose the data source for the connector that you just deployed, such as **Amazon CloudWatch Logs**. If you used the Athena Query Federation SDK to create your own connector and have deployed it to your account, choose **All other data sources**.
5. Choose **Next**.
6. For **Choose Lambda function**, choose the function that you named. The Lambda function's ARN is displayed.
7. For **Catalog name**, enter a unique name to use for the data source in your SQL queries, such as `cloudwatchlogs`. The name can be up to 127 characters and must be unique within your account. It cannot be changed after creation. Valid characters are a-z, A-z, 0-9, _(underscore), @(ampersand) and -(hyphen).
8. Choose **Connect**. The **Data sources** page now shows your connector in the list of catalog names. You can now use the connector in your queries.
For information about writing queries with data connectors, see Writing Federated Queries (p. 67).

Using the AWS Serverless Application Repository to Deploy a Data Source Connector

You can also use the AWS Serverless Application Repository to deploy an Athena data source connector. You find the connector that you want to use, provide the parameters that the connector requires, and then deploy the connector to your account.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see Managing Workgroups (p. 248).

To use the AWS Serverless Application Repository to deploy a data source connector to your account

1. Open the **Serverless App Repository** console.

2. Select the option **Show apps that create custom IAM roles or resource policies**.
3. In the search box, type the name of the connector, or search for applications published with the author name **Amazon Athena Federation**. This author name is reserved for applications that the Amazon Athena team has written, tested, and validated.
4. Choose the name of the connector. This opens the Lambda function's **Application details** page in the AWS Lambda console.
5. On the right side of the details page, for **SpillBucket**, specify an Amazon S3 bucket to receive data from large response payloads. For information about the remaining configurable options, see the corresponding Available Connectors topic on GitHub.
6. At the bottom right of the **Application details** page, choose **Deploy**.

Using Athena Data Source Connectors

This section lists prebuilt Athena data source connectors that you can use to query a variety of data sources external to Amazon S3. To use a connector in your Athena queries, configure it and deploy it to your account.

Note

To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).

See the following topics for more information:

- For information about deploying an Athena data source connector, see [Deploying a Connector and Connecting to a Data Source \(p. 63\)](#).
- For information about writing queries that use Athena data source connectors, see [Writing Federated Queries \(p. 67\)](#).
- For complete information about the Athena data source connectors, see [Available Connectors on GitHub](#).

Topics

- [Athena AWS CMDB Connector \(p. 65\)](#)
- [Amazon Athena CloudWatch Connector \(p. 65\)](#)
- [Amazon Athena CloudWatch Metrics Connector \(p. 66\)](#)
- [Amazon Athena DocumentDB Connector \(p. 66\)](#)
- [Amazon Athena DynamoDB Connector \(p. 66\)](#)
- [Amazon Athena HBase Connector \(p. 66\)](#)
- [Amazon Athena Connector for JDBC-Compliant Data Sources \(p. 66\)](#)
- [Amazon Athena Redis Connector \(p. 66\)](#)
- [Amazon Athena TPC Benchmark DS \(TPC-DS\) Connector \(p. 66\)](#)

Athena AWS CMDB Connector

The Amazon Athena AWS CMDB connector enables Amazon Athena to communicate with various AWS services so that you can query them with SQL.

For information about supported services, parameters, permissions, deployment, performance, and licensing, see [Amazon Athena AWS CMDB Connector on GitHub](#).

Amazon Athena CloudWatch Connector

The Amazon Athena CloudWatch connector enables Amazon Athena to communicate with CloudWatch so that you can query your log data with SQL.

The connector maps your LogGroups as schemas and each LogStream as a table. The connector also maps a special `all_log_streams` view that contains all LogStreams in the LogGroup. This view enables you to query all the logs in a LogGroup at once instead of searching through each LogStream individually.

For more information about configuration options, throttling control, table mapping schema, permissions, deployment, performance considerations, and licensing, see [Amazon Athena CloudWatch Connector on GitHub](#).

Amazon Athena CloudWatch Metrics Connector

The Amazon Athena CloudWatch Metrics connector enables Amazon Athena to communicate with CloudWatch Metrics so that you can query your metrics data with SQL.

For information about configuration options, table mapping, permissions, deployment, performance considerations, and licensing, see [Amazon Athena Cloudwatch Metrics Connector on GitHub](#).

Amazon Athena DocumentDB Connector

The Amazon Athena Amazon DocumentDB connector enables Amazon Athena to communicate with your Amazon DocumentDB instances so that you can query your Amazon DocumentDB data with SQL. The connector also works with any endpoint that is compatible with MongoDB.

For information about how the connector generates schemas, configuration options, permissions, deployment, and performance considerations, see [Amazon Athena DocumentDB Connector on GitHub](#).

Amazon Athena DynamoDB Connector

The Amazon Athena DynamoDB connector enables Amazon Athena to communicate with DynamoDB so that you can query your tables with SQL.

For information about configuration options, permissions, deployment, and performance considerations, see [Amazon Athena DynamoDB Connector on GitHub](#).

Amazon Athena HBase Connector

The Amazon Athena HBase Connector enables Amazon Athena to communicate with your HBase instances so that you can query your HBase data with SQL.

For information about configuration options, data types, permissions, deployment, performance, and licensing, see [Amazon Athena HBase Connector on GitHub](#).

Amazon Athena Connector for JDBC-Compliant Data Sources

The Amazon Athena Lambda JDBC connector enables Amazon Athena to access your JDBC-compliant database. Currently supported databases include MySQL, PostgreSQL, and Amazon Redshift.

For information about supported databases, configuration parameters, supported data types, JDBC driver versions, limitations, and other information, see Amazon Athena Lambda JDBC Connector on GitHub.

Amazon Athena Redis Connector

The Amazon Athena Redis connector enables Amazon Athena to communicate with your Redis instances so that you can query your Redis data with SQL. You can use the AWS Glue Data Catalog to map your Redis key-value pairs into virtual tables.

For information about configuration options, setting up databases and tables, data types, permissions, deployment, performance, and licensing, see Amazon Athena Redis Connector on GitHub.

Amazon Athena TPC Benchmark DS (TPC-DS) Connector

The Amazon Athena TPC-DS connector enables Amazon Athena to communicate with a source of randomly generated TPC Benchmark DS data for use in benchmarking and functional testing. The Athena TPC-DS connector generates a TPC-DS compliant database at one of four scale factors.

For information about configuration options, databases and tables, permissions, deployment, performance, and licensing, see Amazon Athena TPC-DS Connector on GitHub.

Writing Federated Queries

After you have configured one or more data connectors and deployed them to your account, you can use them in your Athena queries.

Querying a Single Data Source

The examples in this section assume that you have configured and deployed the Athena CloudWatch connector to your account. Use the same approach to query when you use other connectors.

To create an Athena query that uses the CloudWatch connector

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. In the Athena Query Editor, create a SQL query that uses the following syntax in the `FROM` clause.

`MyCloudwatchCatalog.database_name.table_name`

Examples

The following example uses the Athena CloudWatch connector to connect to the `all_log_streams` view in the `/var/ecommerce-engine/order-processor` CloudWatch Logs Log Group. The `all_log_streams` view is a view of all the log streams in the log group. The example query limits the number of rows returned to 100.

Example

```
SELECT * FROM "MyCloudwatchCatalog"." /var/ecommerce-engine/order-
processor".all_log_streams limit 100;
```

The following example parses information from the same view as the previous example. The example extracts the order ID and log level and filters out any message that has the level INFO.

Example

```
SELECT log_stream as ec2_instance,
       Regexp_extract(message '.*orderId=(\d+) .*', 1) AS
       orderId,
       message AS
       order_processor_log,
       Regexp_extract(message, '(.*):.*', 1) AS
       log_level
FROM
    "MyCloudwatchCatalog"."var/ecommerce-engine/order-
processor".all_log_streams
WHERE Regexp_extract(message, '(.*):.*', 1) != 'INFO'
```

The following image shows a sample result.

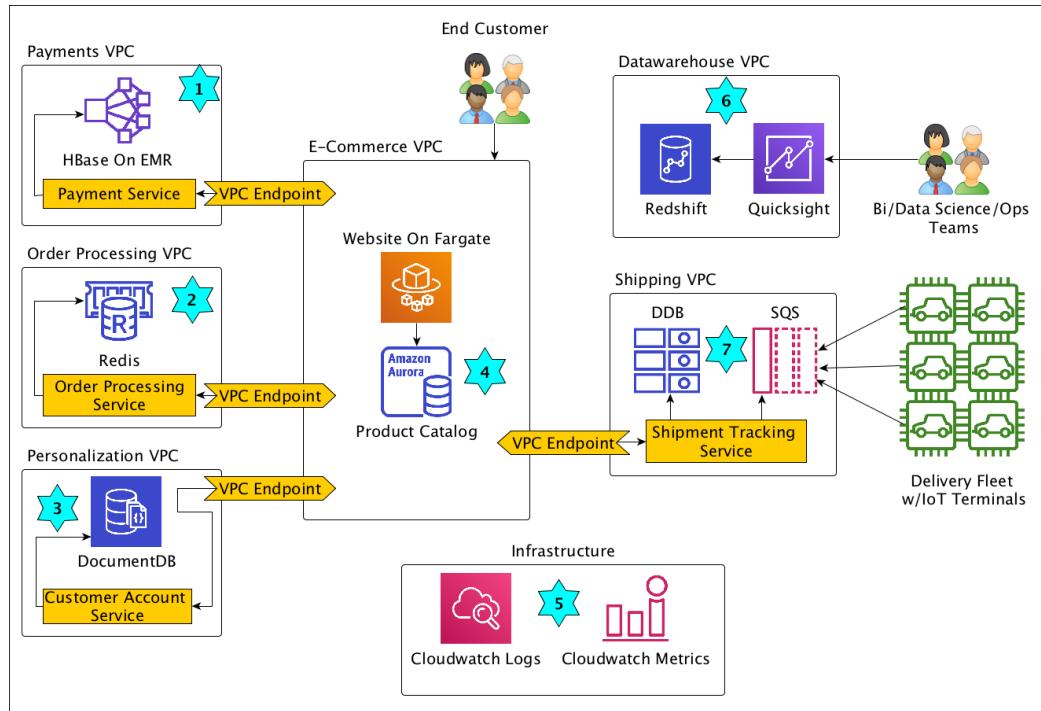
Note

This example shows a query where the data source has been registered as a catalog with Athena. You can also reference a data source connector Lambda function using the format `lambda:MyLambdaFunctionName`.

Results				
	ec2_instance	orderId	order_processor_log	log_level
1	i-0a94127ec09dd	0001235	ERROR: orderId=0001235 encountered a problem during shipping.	ERROR
2	i-0a94127ec09dd	0002234	WARN: orderId=0002234 encountered a problem during shipping.	WARN

Querying Multiple Data Sources

As a more complex example, imagine an ecommerce company that has an application infrastructure such as the one shown in the following diagram.



The following descriptions explain the numbered items in the diagram.

1. Payment processing in a secure VPC with transaction records stored in HBase on Amazon EMR
2. Redis to store active orders so that the processing engine can access them quickly
3. Amazon DocumentDB for customer account data such as email addresses and shipping addresses
4. A product catalog in Amazon Aurora for an ecommerce site that uses automatic scaling on Fargate
5. CloudWatch Logs to house the order processor's log events
6. A write-once-read-many data warehouse on Amazon RDS
7. DynamoDB to store shipment tracking data

Imagine that a data analyst for this ecommerce application discovers that the state of some orders is being reported erroneously. Some orders show as pending even though they were delivered, while others show as delivered but haven't shipped.

The analyst wants to know how many orders are being delayed and what the affected orders have in common across the ecommerce infrastructure. Instead of investigating the sources of information separately, the analyst federates the data sources and retrieves the necessary information in a single query. Extracting the data into a single location is not necessary.

The analyst's query uses the following Athena data connectors:

- CloudWatch Logs – Retrieves logs from the order processing service and uses regex matching and extraction to filter for orders with `WARN` or `ERROR` events.
- Redis – Retrieves the active orders from the Redis instance.
- CMDB – Retrieves the ID and state of the Amazon EC2 instance that ran the order processing service and logged the `WARN` or `ERROR` message.

- DocumentDB – Retrieves the customer email and address from Amazon DocumentDB for the affected orders.
- DynamoDB – Retrieves the shipping status and tracking details from the shipping table to identify possible discrepancies between reported and actual status.
- HBase – Retrieves the payment status for the affected orders from the payment processing service.

Example

Note

This example shows a query where the data source has been registered as a catalog with Athena. You can also reference a data source connector Lambda function using the format `lambda:MyLambdaFunctionName`.

```
--Sample query using multiple Athena data connectors.

WITH logs

    AS (SELECT log_stream,
               message
                  AS
               order_processor_log,
               Regexp_extract(message, '.*orderId=(\d+) .*', 1) AS orderId,
               Regexp_extract(message, '(.*):.*', 1)           AS log_level
        FROM
            "MyCloudwatchCatalog"." /var/ecommerce-engine/order-
processor".all_log_streams
        WHERE  Regexp_extract(message, '(.*):.*', 1) != 'INFO'),
active_orders
    AS (SELECT *
        FROM    redis.redis_db.redis_customer_orders,
               order_processors
    AS (SELECT instanceid,
               publicipaddress,
               state.NAME
        FROM    awscmdb.ec2.ec2_instances),
customer
    AS (SELECT id,
               email
        FROM    docdb.customer_info),
addresses
    AS (SELECT id,
```

```

    addresses.street AS street_address,
    shipments.shipment_time as shipment_time,
    shipments.carrier as shipment_carrier,
    publicipaddress AS ec2_order_processor,
    NAME AS ec2_state,
    log_level,
    order_processor_log
  FROM active_orders
    LEFT JOIN logs
      ON logs.orderid = active_orders._key_
    LEFT JOIN order_processors
      ON logs.log_stream = order_processors.instanceid
    LEFT JOIN customer
      ON customer.id = customer_id
    LEFT JOIN addresses
      ON addresses.id = address_id
    LEFT JOIN shipments
      ON shipments.order_id = active_orders._key_
    LEFT JOIN payments
      ON payments."summary:order_id" = active_orders._key_

```

The following image shows sample results of the query.

Results									
	redis_order_id	customer_id	cust_email	credit_card	CC_type	payment_status	redis_status	street_address	shipment_time
1	0001236	12151	jadee@email.com	5612	VISA	PENDING	pending_payment	456790 Rufus Lane	
2	0001234	11123	jdoe@email.com	4119	AMEX	FUNDED	preparing_to_ship	13456 Rufus Dr.	2013-06-17 19:14
3	0001235	11123	jdoe@email.com	4119	AMEX	FUNDED	shipping	13456 Rufus Dr.	2012-12-09 21:16
4	0002234	9820	cdoe@email.com	1189	VISA	PENDING	backordered	13890 Rufus Road	
5	0001237	92053	sdoe@email.com	9001	VISA	PENDING	backordered	96110 Rufus Ave.	
6	0001238	453	adoe@email.com	8827	MASTERCARD	FUNDED	preparing_to_ship	987 Rufus St.	1976-03-23 15:52

Writing a Data Source Connector Using the Athena Query Federation SDK

To write your own data source connectors (p. 62), you can use the Athena Query Federation SDK. The Athena Query Federation SDK defines a set of interfaces and wire protocols that you can use to enable Athena to delegate portions of its query execution plan to code that you write and deploy. The SDK includes a connector suite and an example connector.

You can also customize Amazon Athena's prebuilt connectors for your own use. You can modify a copy of the source code from GitHub and then use the Connector Publish Tool to create your own AWS Serverless Application Repository package. After you deploy your

To view a data source

- Choose the catalog name of the data source, or select the button next to it and choose **View details**. The details page includes options to **Edit** or **Delete** the data source.

To edit a data source

1. Choose the catalog name of the data source, or select the button next to the catalog name.
2. Choose **Edit**.
3. On the **Edit** page for the metastore, you can choose a different Lambda function for the data source or change the description of the existing function. When you edit an AWS Glue catalog, the AWS Glue console opens the corresponding catalog for editing.
4. Choose **Save**.

To delete a data source

1. Select the button next to the data source or the name of the data source, and then choose **Delete**. You are warned that when you delete a metastore data source, its corresponding Data Catalog, tables, and views are removed from the query editor. Saved queries that used the metastore no longer run in Athena.
2. Choose **Delete**.

Connecting to Amazon Athena with ODBC and JDBC Drivers

To explore and visualize your data with business intelligence tools, download, install, and configure an ODBC (Open Database Connectivity) or JDBC (Java Database Connectivity) driver.

Topics

- Using Athena with the JDBC Driver (p. 71)
- Connecting to Amazon Athena with ODBC (p. 73)

Using Athena with the JDBC Driver

You can use a JDBC connection to connect Athena to business intelligence tools and other applications, such as SQL Workbench. To do this, download, install, and configure the Athena JDBC driver, using the following links on Amazon S3.

Links for Downloading the JDBC Driver

The JDBC driver version 2.0.9 complies with the JDBC API 4.1 and 4.2 data standards. Before downloading the driver, check which version of Java Runtime Environment (JRE) you use. The JRE version depends on the version of the JDBC API you are using with the driver. If you are not sure, download the latest version of the driver.

Download the driver that matches your version of the JDK and the JDBC data standards:

- The AthenaJDBC41-2.0.9.jar is compatible with JDBC 4.1 and requires JDK 7.0 or later.

- The AthenaJDBC42-2.0.9.jar is compatible with JDBC 4.2 and requires JDK 8.0 or later.

JDBC Driver Release Notes, License Agreement, and Notices

After you download the version you need, read the release notes, and review the License Agreement and Notices.

- [Release Notes](#)

- [License Agreement](#)
- [Notices](#)
- [Third-Party Licenses](#)

JDBC Driver Documentation

Download the following documentation for the driver:

- JDBC Driver Installation and Configuration Guide. Use this guide to install and configure the driver.
- JDBC Driver Migration Guide. Use this guide to migrate from previous versions to the current version.

Links for Downloading the JDBC Driver for Preview Features

These drivers support Athena preview features. Download the driver that matches your version of the JDK and the JDBC data standards:

- The AthenaJDBC41_preview.jar is compatible with JDBC 4.1 and requires JDK 7.0 or later.
- The AthenaJDBC42_preview.jar is compatible with JDBC 4.2 and requires JDK 8.0 or later.

JDBC Driver Release Notes, License Agreement, and Notices for Preview Driver

After you download the version you need, read the release notes, and review the License Agreement and Notices.

- [Release Notes](#)

- [License Agreement](#)

- [Notices](#)

- [Third-Party Licenses](#)

JDBC Driver Documentation for Preview Driver

Download the following documentation for the driver:

- JDBC Driver Installation and Configuration Guide. Use this guide to install and configure the driver.
- JDBC Driver Migration Guide. Use this guide to migrate from previous versions to the current version.

Migration from Previous Version of the JDBC Driver

The current JDBC driver version 2.0.9 is a drop-in replacement of the previous version of the JDBC driver version 2.0.8, and is backwards compatible with the JDBC driver version 2.0.8, with the following step that you must perform to ensure the driver runs.

Important

To use JDBC driver version 2.0.5 or later, attach a permissions policy to IAM principals using the JDBC driver that allows the `athena:GetQueryResultsStream` policy action. This policy action is not exposed directly with the API. It is only used with the JDBC driver as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#). Additionally, ensure that port 444 is open to outbound traffic. For more information about upgrading to versions 2.0.5 or later from version 2.0.2, see the [JDBC Driver Migration Guide](#).

For more information about the previous versions of the JDBC driver, see [Using the Previous Version of the JDBC Driver \(p. 334\)](#).

If you are migrating from a 1.x driver to a 2.x driver, you must migrate your existing configurations to the new configuration. We highly recommend that you migrate to driver version 2.x. For information, see the [JDBC Driver Migration Guide](#).

Connecting to Amazon Athena with ODBC

Download the ODBC driver, the Amazon Athena ODBC driver License Agreement, and the documentation for the driver using the following links.

Amazon Athena ODBC Driver License Agreement

[License Agreement](#)

Windows

ODBC 1.0.5 for Windows 32-bit	Windows 32 bit ODBC Driver 1.0.5
---	--

ODBC 1.0.5 for Windows 64-bit	Windows 64 bit ODBC Driver 1.0.5
Driver Version	Download Link

Linux

ODBC 1.0.5 for Linux 32-bit	Linux 32 bit ODBC Driver 1.0.5
---	--

ODBC 1.0.5 for Linux 64-bit	Linux 64 bit ODBC Driver 1.0.5
Driver Version	Download Link

OSX

ODBC 1.0.5 for OSX	OSX ODBC Driver 1.0.5
Driver Version	Download Link

ODBC Driver Documentation

Documentation for ODBC 1.0.5	ODBC Driver Installation and Configuration Guide version 1.0.5
------------------------------	--

Release Notes for ODBC 1.0.5	ODBC Driver Release Notes version 1.0.5
Driver Version	Download Link

Migration from the Previous Version of the ODBC Driver

The current ODBC driver version 1.0.5 is a drop-in replacement of the previous version of the ODBC driver version 1.0.4. It is also backward compatible with the ODBC driver version 1.0.3, if you use the following required steps to make sure that the driver runs.

Important

To use the ODBC driver versions 1.0.3 and greater, follow these requirements:

- Keep the port 444 open to outbound traffic.
- Add the `athena:GetQueryResultsStream` policy action to the list of policies for Athena. This policy action is not exposed directly with the API operation, and is used only with the ODBC and JDBC drivers, as part of streaming results support. For an example policy, see [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#).

Previous Versions of the ODBC Driver

ODBC 1.0.4 for Windows 32-bit	Windows 32 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Windows 64-bit	Windows 64 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Linux 32-bit	Linux 32 bit ODBC Driver 1.0.4
ODBC 1.0.4 for Linux 64-bit	Linux 64 bit ODBC Driver 1.0.4
ODBC 1.0.4 for OSX	OSX ODBC Driver 1.0.4
Documentation for ODBC 1.0.4	ODBC Driver Installation and Configuration Guide version 1.0.4
Driver Version 1.0.4	Download Link
ODBC 1.0.3 for Windows 32-bit	Windows 32-bit ODBC Driver 1.0.3
ODBC 1.0.3 for Windows 64-bit	Windows 64-bit ODBC Driver 1.0.3
ODBC 1.0.3 for Linux 32-bit	Linux 32-bit ODBC Driver 1.0.3
ODBC 1.0.3 for Linux 64-bit	Linux 64-bit ODBC Driver 1.0.3
ODBC 1.0.3 for OSX	OSX ODBC Driver 1.0

Documentation for ODBC 1.0.3	ODBC Driver Installation and Configuration Guide version 1.0.3
--	--

Driver Version 1.0.3	Download Link
ODBC 1.0.2 for Windows 32-bit	Windows 32-bit ODBC Driver 1.0.2

ODBC 1.0.2 for Windows 64-bit	Windows 64-bit ODBC Driver 1.0.2
ODBC 1.0.2 for Linux 32-bit	Linux 32-bit ODBC Driver 1.0.2
ODBC 1.0.2 for Linux 64-bit	Linux 64-bit ODBC Driver 1.0.2
ODBC 1.0 for OSX	OSX ODBC Driver 1.0
Documentation for ODBC 1.0.2	ODBC Driver Installation and Configuration Guide version 1.0.2
Driver Version 1.0.2	Download Link

(p. 45). When you run a Data Definition Language (DDL) query that modifies schema, Athena writes the metadata to the metastore associated with the data source. In addition, some queries, such as `CREATE TABLE AS` and `INSERT INTO` can write records to the dataset—for example, adding a CSV record to an Amazon S3 location. When you run a query, Athena saves the results of a query in a query result location that you specify. This allows you to view query history and to download and view query results sets.

This section provides guidance for running Athena queries on common data sources and data types using a variety of SQL statements. General guidance is provided for working with common structures and operators—for example, working with arrays, concatenating, filtering, flattening, and sorting. Other examples include queries for data in tables with nested structures and maps, tables based on JSON-encoded datasets, and datasets associated with AWS services such as AWS CloudTrail logs and Amazon EMR logs.

Topics

- [Working with Query Results, Output Files, and Query History \(p. 107\)](#)
- [Working with Views \(p. 113\)](#)
- [Creating a Table from Query Results \(CTAS\) \(p. 118\)](#)
- [Handling Schema Updates \(p. 126\)](#)
- [Querying Arrays \(p. 135\)](#)
- [Querying JSON \(p. 151\)](#)
- [Querying Geospatial Data \(p. 157\)](#)
- [Using Machine Learning \(ML\) with Amazon Athena \(Preview\) \(p. 169\)](#)
- [Querying with User Defined Functions \(Preview\) \(p. 170\)](#)
- [Querying AWS Service Logs \(p. 178\)](#)

Working with Query Results, Output Files, and Query History

Amazon Athena automatically stores query results and metadata information for each query that runs in a *query result location* that you can specify in Amazon S3. If necessary, you can access the files in this location to work with them. You can also download query result files directly from the Athena console.

Output files are saved automatically for every query that runs regardless of whether the query itself was saved or not. To access and view query output files, IAM principals (users and roles) need permission to the Amazon S3 [GetObject](#) action for the query result location, as well as permission for the Athena [GetQueryResults](#) action. The query result location can be encrypted. If the location is encrypted, users must have the appropriate key permissions to encrypt and decrypt the query result location.

Important

IAM principals with permission to the Amazon S3 [GetObject](#) action for the query result location are able to retrieve query results from Amazon S3 even if permission to the Athena [GetQueryResults](#) action is denied.

Getting a Query ID

Each query that runs is known as a *query execution*. The query execution has a unique identifier known as the query ID or query execution ID. To work with query result files, and to quickly find query result files, you need the query ID. We refer to the query ID in this topic as **QueryID**.

To use the Athena console to get the *QueryID* of a query that ran

1. Choose **History** from the navigation bar.
2. From the list of queries, choose the query status under **State**—for example, **Failed**.
3. Choose the icon next to **Query ID** to copy the ID to the clipboard.

Identifying Query Output Files

Files are saved to the query result location in Amazon S3 based on the name of the query, the query ID, and the date that the query ran. Files for each query are named using the **QueryID**, which is a unique identifier that Athena assigns to each query when it runs.

The following file types are saved:

File type	File naming pattern	Description
Query results files	QueryID .csv	Query results files are saved in comma-separated values (CSV) format. They contain the tabular result of each query. You can download these files from the console from the Results pane when using the console or from the query History . For more information, see Downloading Query Results Files Using the Athena Console (p. 110) .
Query metadata files	QueryID .csv.metadata	Query metadata files are saved in binary format and are not human readable. Athena uses the metadata when reading query results using the GetQueryResults action. Although these files can be deleted, we do not recommend it because

File type	File naming pattern	Description
		important information about the query is lost.
Data manifest files	<i>QueryID</i> -manifest.csv	Data manifest files are generated to track files that Athena creates in Amazon S3 data source locations when an INSERT INTO (p. 303) query runs. If a query fails, the manifest also tracks files that the query intended to write. The manifest is useful for identifying orphaned files resulting from a failed query.

Query output files are stored in sub-folders according to the following pattern.

QueryResultsLocationInS3/[*QueryName* | *Unsaved*/yyyy/mm/dd/]

- *QueryResultsLocationInS3* is the query result location specified either by workgroup settings or client-side settings. See [the section called “Specifying a Query Result Location” \(p. 110\)](#) below.
- The following sub-folders are created only for queries that run from the console. Queries that run from the AWS CLI or using the Athena API are saved directly to the *QueryResultsLocationInS3*.
 - *QueryName* is the name of the query for which the results are saved. If the query ran but wasn't saved, *Unsaved* is used.
 - *yyyy/mm/dd* is the date that the query ran.

Files associated with a `CREATE TABLE AS SELECT` query are stored in a `tables` sub-folder of the above pattern.

To identify the query output location and query result files using the AWS CLI

- Use the `aws athena get-query-execution` command as shown in the following example. Replace *abc1234d-5efg-67hi-jklm-89n0op12qr34* with the query ID.

```
aws athena get-query-execution --query-execution-id abc1234d-5efg-67hi-
jklm-89n0op12qr34
```

The command returns output similar to the following. For descriptions of each output parameter, see [get-query-execution](#) in the *AWS CLI Command Reference*.

```
{
  "QueryExecution": {
    "Status": {
      "SubmissionDateTime": 1565649050.175,
      "State": "SUCCEEDED",
      "CompletionDateTime": 1565649056.6229999
    },
    "Statistics": {
      "DataScannedInBytes": 5944497,
      "DataManifestLocation": "s3://aws-athena-query-results-123456789012-us-
west-1/MyInsertQuery/2019/08/12/abc1234d-5efg-67hi-jklm-89n0op12qr34-manifest.csv",
      "EngineExecutionTimeInMillis": 5209
    }
  }
}
```

```
"ResultConfiguration": {  
    "EncryptionConfiguration": {  
        "EncryptionOption": "SSE_S3"  
    },  
    "OutputLocation": "s3://aws-athena-query-results-123456789012-us-west-1/  
MyInsertQuery/2019/08/12/abc1234d-5efg-67hi-jklm-89n0op12qr34"  
},  
"QueryExecutionId": "abc1234d-5efg-67hi-jklm-89n0op12qr34",  
"QueryExecutionContext": {},  
"Query": "INSERT INTO mydb.elb_log_backup SELECT * FROM mydb.elb_logs LIMIT  
100",  
"StatementType": "DML",  
"WorkGroup": "primary"  
}
```

Downloading Query Results Files Using the Athena Console

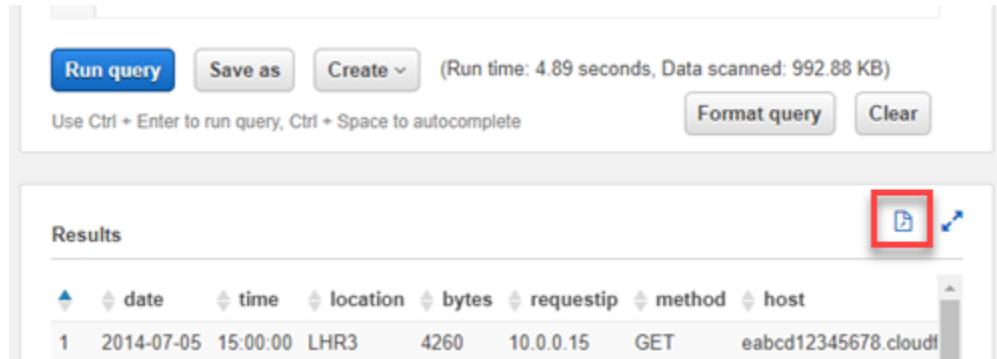
You can download the query results CSV file from the query pane immediately after you run a query, or using the query **History**.

To download the query results file of the most recent query

1. Enter your query in the query editor and then choose **Run query**.

When the query finishes running, the **Results** pane shows the query results.

2. To download the query results file, choose the file icon in the query results pane. Depending on your browser and browser configuration, you may need to confirm the download.



To download a query results file for an earlier query

1. Choose **History**.
2. Page through the list of queries until you find the query, and then choose **Download results** under **Action** for that query.

Specifying a Query Result Location

The query result location that Athena uses is determined by a combination of workgroup settings and *client-side settings*. Client-side settings are based on how you run the query. If you run the query using the Athena console, the **Query result location** entered under **Settings** in the navigation bar determines the client-side setting. If you run the query using the Athena API, the **OutputLocation** parameter of

the [StartQueryExecution](#) action determines the client-side setting. If you use the ODBC or JDBC drivers to run queries, the `S3OutputLocation` property specified in the connection URL determines the client-side setting.

Each workgroup configuration has an **Override client-side settings** option that can be enabled. When this option is enabled, the workgroup settings take precedence over the applicable client-side settings when an IAM principal associated with that workgroup runs the query.

Specifying a Query Result Location Using the Athena Console

Athena has a default query result location for the Athena console. Athena uses the default only if you haven't specified a different query result location in the console as described below, and your workgroup does not override client-side settings.

The following pattern is used for the default console query result location. `MyAcctID` is the AWS account ID of the IAM principal that ran the query, and `MyRegion` is the region where the query ran, for example `us-west-1`.

```
aws-athena-query-results-MyAcctID-MyRegion
```

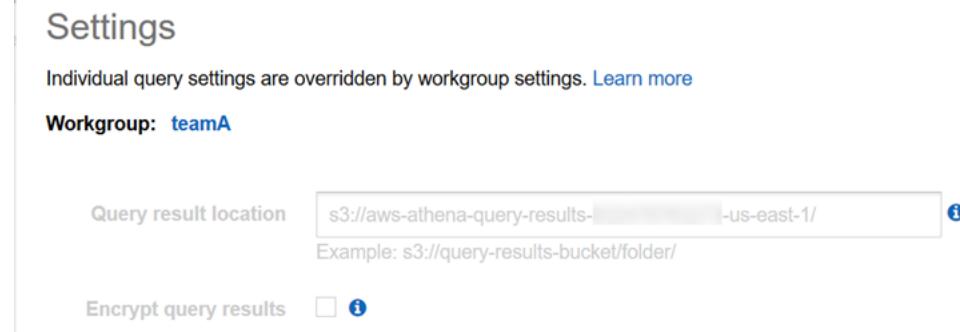
Important

When you run a query using the API or using the ODBC or JDBC driver, the console setting does not apply. The query result location must be specified either by workgroup settings or client-side settings. If no query location is specified, the query fails with an error.

To change the query result location for a query using the Athena console

1. From the navigation bar, choose **Settings**.
2. Enter a **Query result location**. The location you enter is used for subsequent queries unless you change it later.

If you are a member of a workgroup that specifies a query result location with **Override client-side settings** selected, the option to change the query result location and encryption options are unavailable, as shown below:



Specifying a Query Result Location Using a Workgroup

You can specify the query result location in a workgroup configuration using the AWS Management Console, the AWS CLI, or the Athena API.

When using the AWS CLI, specify the query result location using the `OutputLocation` parameter of the `--configuration` option when you run the [aws athena create-work-group](#) or [aws athena update-work-group](#) command.

To specify the query result location for a workgroup using the Athena console

1. Choose **Workgroup:***CurrentWorkgroupName* in the navigation bar.
2. Do one of the following:
 - If editing an existing workgroup, select it from the list, choose **View details**, and then choose **Edit Workgroup**.
 - If creating a new workgroup, choose **Create workgroup**.
3. For **Query result location**, choose the **Select** folder.
4. From the list of S3 locations, choose the blue arrow successively until the bucket and folder you want to use appears in the top line. Choose **Select**.
5. Under **Settings**, do one of the following:
 - Select **Override client-side settings** to save query files in the location that you specified above for all queries that members of this workgroup run.
 - Clear **Override client-side settings** to save query files in the location that you specified above have the query location that you specified above only when workgroup members run queries using the Athena API, ODBC driver, or JDBC driver without specifying an output location in Amazon S3.
6. If editing a workgroup, choose **Save**. If creating a workgroup, choose **Create workgroup**.

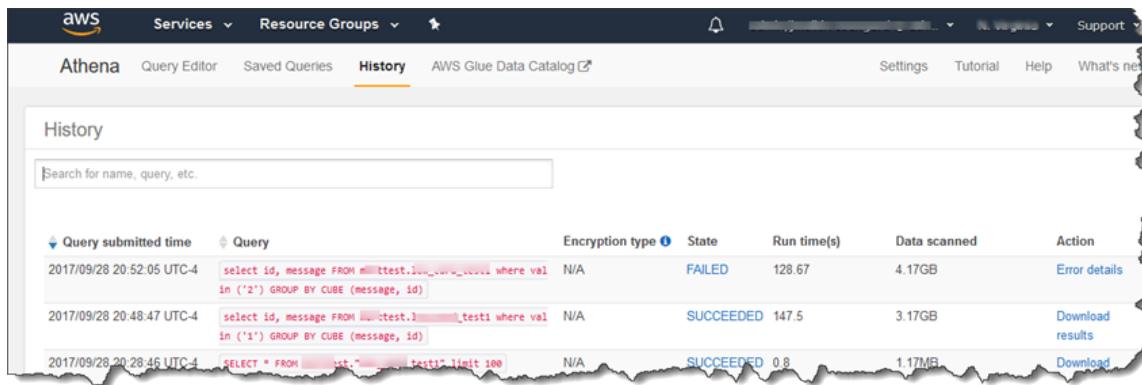
Viewing Query History

Athena keeps a query history for 45 days. To keep query history for longer, you can retrieve the query history and save it to a data store such as an Amazon S3 using the following Athena API actions. You can automate this process by programming or scripting the operations, or you can run them on demand using the AWS CLI. You can use query history in the Athena console to view errors for queries that failed, or to download query result files for successful queries.

1. Retrieve the query IDs with [ListQueryExecutions](#).
2. Retrieve information about each query based on its ID with [GetQueryExecution](#).
3. Save the obtained information in a data store, such as Amazon S3, using the [put-object](#) action from the Amazon S3 API.

Viewing Query History

1. To use the Athena console to view query history, choose **History** and select a query. You can also see which queries succeeded and failed, download their results, and view query IDs, by clicking the status value.



Working with Views

A view in Amazon Athena is a logical, not a physical table. The query that defines a view runs each time the view is referenced in a query.

You can create a view from a `SELECT` query and then reference this view in future queries. For more information, see [CREATE VIEW \(p. 318\)](#).

Topics

- [When to Use Views? \(p. 113\)](#)
- [Supported Actions for Views in Athena \(p. 114\)](#)
- [Considerations for Views \(p. 114\)](#)
- [Limitations for Views \(p. 115\)](#)
- [Working with Views in the Console \(p. 115\)](#)
- [Creating Views \(p. 116\)](#)
- [Examples of Views \(p. 117\)](#)
- [Updating Views \(p. 118\)](#)
- [Deleting Views \(p. 118\)](#)

When to Use Views?

You may want to create views to:

- *Query a subset of data.* For example, you can create a table with a subset of columns from the original table to simplify querying data.
- *Combine multiple tables in one query.* When you have multiple tables and want to combine them with `UNION ALL`, you can create a view with that expression to simplify queries against the combined tables.
- *Hide the complexity of existing base queries and simplify queries run by users.* Base queries often include joins between tables, expressions in the column list, and other SQL syntax that make it difficult to understand and debug them. You might create a view that hides the complexity and simplifies queries.
- *Experiment with optimization techniques and create optimized queries.* For example, if you find a combination of `WHERE` conditions, `JOIN` order, or other expressions that demonstrate the best performance, you can create a view with these clauses and expressions. Applications can then make relatively simple queries against this view. If you later find a better way to optimize the original query, when you recreate the view, all the applications immediately take advantage of the optimized base query.

- *Hide the underlying table and column names, and minimize maintenance problems* if those names change. In that case, you recreate the view using the new names. All queries that use the view rather than the underlying tables keep running with no changes.

Supported Actions for Views in Athena

Athena supports the following actions for views. You can run these commands in the Query Editor.

Statement	Description
CREATE VIEW (p. 318)	Creates a new view from a specified <code>SELECT</code> query. For more information, see Creating Views (p. 116) . The optional <code>OR REPLACE</code> clause lets you update the existing view by replacing it.
DESCRIBE VIEW (p. 319)	Shows the list of columns for the named view. This allows you to examine the attributes of a complex view.
DROP VIEW (p. 320)	Deletes an existing view. The optional <code>IF EXISTS</code> clause suppresses the error if the view does not exist. For more information, see Deleting Views (p. 118) .
SHOW CREATE VIEW (p. 322)	Shows the SQL statement that creates the specified view.
SHOW VIEWS (p. 324)	Lists the views in the specified database, or in the current database if you omit the database name. Use the optional <code>LIKE</code> clause with a regular expression to restrict the list of view names. You can also see the list of views in the left pane in the console.
SHOW COLUMNS (p. 321)	Lists the columns in the schema for a view.

Considerations for Views

The following considerations apply to creating and using views in Athena:

- In Athena, you can preview and work with views created in the Athena Console, in the AWS Glue Data Catalog, if you have migrated to using it, or with Presto running on the Amazon EMR cluster connected to the same catalog. You cannot preview or add to Athena views that were created in other ways.
- If you are creating views through the AWS GlueData Catalog, you must include the `PartitionKeys` parameter and set its value to an empty list, as follows: `"PartitionKeys":[]`. Otherwise, your view query will fail in Athena. The following example shows a view created from the Data Catalog with `"PartitionKeys":[]`:

```
aws glue create-table
--database-name mydb
--table-input '{
  "Name": "test",
  "TableType": "EXTERNAL_TABLE",
  "Owner": "hadoop",
  "StorageDescriptor": {
    "Columns": [
      {"Name": "a", "Type": "string"}, {"Name": "b", "Type": "string"}]
}
```

```
"Location": "s3://xxxxx/Oct2018/25Oct2018/",
"InputFormat": "org.apache.hadoop.mapred.TextInputFormat",
"OutputFormat": "org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat",
"SerdeInfo": {"SerializationLibrary": "org.apache.hadoop.hive.serde2.OpenCSVSerde",
"Parameters": {"separatorChar": "|", "serialization.format": "1"}}, "PartitionKeys":  
[]}'
```

- If you have created Athena views in the Data Catalog, then Data Catalog treats views as tables. You can use table level fine-grained access control in Data Catalog to [restrict access \(p. 207\)](#) to these views.
- Athena prevents you from running recursive views and displays an error message in such cases. A recursive view is a view query that references itself.
- Athena detects stale views and displays an error message in such cases. A stale view is a view query that references tables or databases that do not exist.
- You can create and run nested views as long as the query behind the nested view is valid and the tables and databases exist.

Limitations for Views

- Athena view names cannot contain special characters, other than underscore (_). For more information, see [Names for Tables, Databases, and Columns \(p. 32\)](#).
- Avoid using reserved keywords for naming views. If you use reserved keywords, use double quotes to enclose reserved keywords in your queries on views. See [Reserved Keywords \(p. 33\)](#).
- You cannot use views with geospatial functions.
- You cannot use views to manage access control on data in Amazon S3. To query a view, you need permissions to access the data stored in Amazon S3. For more information, see [Access to Amazon S3 \(p. 207\)](#).

Working with Views in the Console

In the Athena console, you can:

- Locate all views in the left pane, where tables are listed. Athena runs a [SHOW VIEWS \(p. 324\)](#) operation to present this list to you.
- Filter views.
- Preview a view, show its properties, edit it, or delete it.

To list the view actions in the console

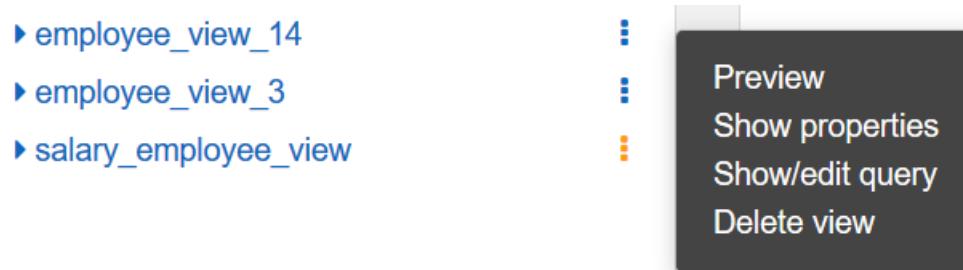
A view shows up in the console only if you have already created it.

1. In the Athena console, choose **Views**, choose a view, then expand it.

The view displays, with the columns it contains, as shown in the following example:



2. In the list of views, choose a view, and open the context (right-click) menu. The actions menu icon (:) is highlighted for the view that you chose, and the list of actions opens, as shown in the following example:



3. Choose an option. For example, **Show properties** shows the view name, the name of the database in which the table for the view is created in Athena, and the time stamp when it was created:

View properties	
Name	Value
View name	employee_view
Database Name	[REDACTED]
Create Time	2018/03/07 19:08:33 UTC-5

Creating Views

You can create a view from any `SELECT` query.

To create a view in the console

Before you create a view, choose a database and then choose a table. Run a `SELECT` query on a table and then create a view from it.

1. In the Athena console, choose **Create view**.

▶ Views (0) **Create view**

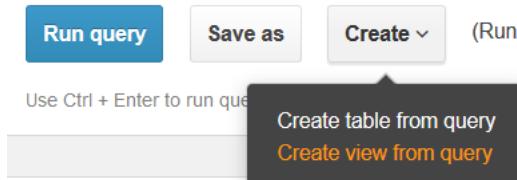
In the Query Editor, a sample view query displays.

2. Edit the sample view query. Specify the table name and add other syntax. For more information, see [CREATE VIEW \(p. 318\)](#) and [Examples of Views \(p. 117\)](#).

View names cannot contain special characters, other than underscore (_). See [Names for Tables, Databases, and Columns \(p. 32\)](#). Avoid using [Reserved Keywords \(p. 33\)](#) for naming views.

3. Run the view query, debug it if needed, and save it.

Alternatively, create a query in the Query Editor, and then use [Create view from query](#).



If you run a view that is not valid, Athena displays an error message.

If you delete a table from which the view was created, when you attempt to run the view, Athena displays an error message.

You can create a nested view, which is a view on top of an existing view. Athena prevents you from running a recursive view that references itself.

Examples of Views

To show the syntax of the view query, use [SHOW CREATE VIEW \(p. 322\)](#).

Example Example 1

Consider the following two tables: a table `employees` with two columns, `id` and `name`, and a table `salaries`, with two columns, `id` and `salary`.

In this example, we create a view named `name_salary` as a `SELECT` query that obtains a list of IDs mapped to salaries from the tables `employees` and `salaries`:

```
CREATE VIEW name_salary AS
SELECT
    employees.name,
    salaries.salary
FROM employees, salaries
WHERE employees.id = salaries.id
```

Example Example 2

In the following example, we create a view named `view1` that enables you to hide more complex query syntax.

This view runs on top of two tables, `table1` and `table2`, where each table is a different `SELECT` query. The view selects all columns from `table1` and joins the results with `table2`. The join is based on column `a` that is present in both tables.

```
CREATE VIEW view1 AS
WITH
    table1 AS (
        SELECT a,
               MAX(b) AS b
        FROM x
        GROUP BY a
    ),
    table2 AS (
        SELECT a,
               AVG(d) AS d
        FROM y
        GROUP BY a
    )
SELECT table1.* , table2.*
FROM table1
JOIN table2
ON table1.a = table2.a;
```

Updating Views

After you create a view, it appears in the **Views** list in the left pane.

To edit the view, choose it, choose the context (right-click) menu, and then choose **Show/edit query**. You can also edit the view in the Query Editor. For more information, see [CREATE VIEW \(p. 318\)](#).

Deleting Views

To delete a view, choose it, choose the context (right-click) menu, and then choose **Delete view**. For more information, see [DROP VIEW \(p. 320\)](#).

Creating a Table from Query Results (CTAS)

A `CREATE TABLE AS SELECT` (CTAS) query creates a new table in Athena from the results of a `SELECT` statement from another query. Athena stores data files created by the CTAS statement in a specified location in Amazon S3. For syntax, see [CREATE TABLE AS \(p. 316\)](#).

Use CTAS queries to:

- Create tables from query results in one step, without repeatedly querying raw data sets. This makes it easier to work with raw data sets.
- Transform query results into other storage formats, such as Parquet and ORC. This improves query performance and reduces query costs in Athena. For information, see [Columnar Storage Formats \(p. 39\)](#).
- Create copies of existing tables that contain only the data you need.

Topics

- [Considerations and Limitations for CTAS Queries \(p. 118\)](#)
- [Running CTAS Queries in the Console \(p. 119\)](#)
- [Bucketing vs Partitioning \(p. 122\)](#)
- [Examples of CTAS Queries \(p. 123\)](#)

Considerations and Limitations for CTAS Queries

The following table describes what you need to know about CTAS queries in Athena:

Item	What You Need to Know
CTAS query syntax	<p>The CTAS query syntax differs from the syntax of <code>CREATE [EXTERNAL] TABLE</code> used for creating tables. See CREATE TABLE AS (p. 316).</p> <p>Note</p> <p>Table, database, or column names for CTAS queries should not contain quotes or backticks. To ensure this, check that your table, database, or column names do not represent reserved words (p. 33), and do not contain special characters (which require enclosing them in quotes or backticks). For more information, see Names for Tables, Databases, and Columns (p. 32).</p>
CTAS queries vs views	CTAS queries write new data to a specified location in Amazon S3, whereas views do not write any data.

Item	What You Need to Know
Location of CTAS query results	<p>The location for storing CTAS query results in Amazon S3 must be empty. A CTAS query checks that the path location (prefix) in the bucket is empty and never overwrites the data if the location already has data in it. To use the same location again, delete the data in the key prefix location in the bucket, otherwise your CTAS query will fail.</p> <p>You can specify the location for storing your CTAS query results. If omitted and if your workgroup does not override client-side settings (p. 247), Athena uses this location by default: <code>s3://aws-athena-query-results-<account>-<region>/<query-name-or-unsaved>/<year>/<month/<date>/<query-id>/</code>.</p> <p>If your workgroup overrides client-side settings, this means that the workgroup's query result location is used for your CTAS queries. If you specify a different results location, your query will fail. To obtain the results location specified for the workgroup, view workgroup's details (p. 251).</p> <p>If the workgroup in which a query will run is configured with an enforced query results location (p. 247), do not specify an <code>external_location</code> for the CTAS query. Athena issues an error and fails a query that specifies an <code>external_location</code> in this case. For example, this query fails, if you override client-side settings for query results location, enforcing the workgroup to use its own location: <code>CREATE TABLE <DB>.<TABLE1> WITH (format='Parquet', external_location='s3://my_test/test/') AS SELECT * FROM <DB>.<TABLE2> LIMIT 10;</code></p>
Formats for storing query results	The results of CTAS queries are stored in Parquet by default if you don't specify a data storage format. You can store CTAS results in PARQUET, ORC, AVRO, JSON, and TEXTFILE. CTAS queries do not require specifying a SerDe to interpret format transformations. See Example: Writing Query Results to a Different Format (p. 124) .
Compression formats	GZIP compression is used for CTAS query results by default. For Parquet and ORC, you can also specify SNAPPY. See Example: Specifying Data Storage and Compression Formats (p. 124) .
Partition and Bucket Limits	<p>You can partition and bucket the results data of a CTAS query. For more information, see Bucketing vs Partitioning (p. 122). Athena supports writing to 100 unique partition and bucket combinations. For example, if no buckets are defined in the destination table, you can specify a maximum of 100 partitions. If you specify five buckets, 20 partitions (each with five buckets) is allowed. If you exceed this count, an error occurs.</p> <p>Include partitioning and bucketing predicates at the end of the <code>WITH</code> clause that specifies properties of the destination table. For more information, see Example: Creating Bucketed and Partitioned Tables (p. 126) and Bucketing vs Partitioning (p. 122).</p>
Encryption	You can encrypt CTAS query results in Amazon S3, similar to the way you encrypt other query results in Athena. For more information, see Configuring Encryption Options (p. 197) .
Data types	Column data types for a CTAS query are the same as specified for the original query.

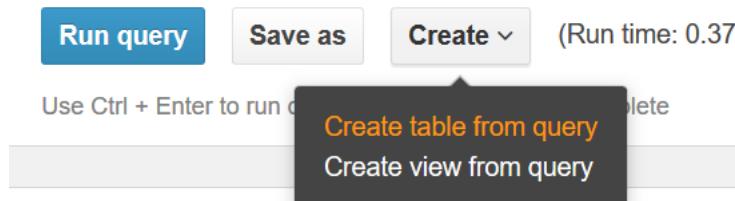
Running CTAS Queries in the Console

In the Athena console, you can:

- Create a CTAS query from another query (p. 120)
- Create a CTAS query from scratch (p. 120)

To create a CTAS query from another query

1. Run the query, choose **Create**, and then choose **Create table from query**.



2. In the **Create a new table on the results of a query** form, complete the fields as follows:
 - a. For **Database**, select the database in which your query ran.
 - b. For **Table name**, specify the name for your new table. Use only lowercase and underscores, such as `my_select_query_parquet`.
 - c. For **Description**, optionally add a comment to describe your query.
 - d. For **Output location**, optionally specify the location in Amazon S3, such as `s3://my_athena_results/mybucket/`. If you don't specify a location and your workgroup does not [Override Client-Side Settings \(p. 247\)](#), the following predefined location is used: `s3://aws-athena-query-results-<account>-<region>/<query-name-or-unsaved>/year/month/date/<query-id>/`.
 - e. For **Output data format**, select from the list of supported formats. Parquet is used if you don't specify a format. See [Columnar Storage Formats \(p. 39\)](#).

Create a new table on the results of a query

Data will be written to the default S3 location in the format specified. You can also customize the S3 location. See limitations [here](#).

Database	default
Table name*	my_ctas_table
Description	My table in Parquet
Output location	s3://my-bucket/my-folder/
Output data format	Parquet Columnar (recommended) Parquet ORC Storage by row Avro CSV JSON TSV

- f. Choose **Next** to review your query and revise it as needed. For query syntax, see [CREATE TABLE AS \(p. 316\)](#). The preview window opens, as shown in the following example:

Create a new table on the results of a query

Review your query and revise as needed.

Running the following query will create a table `das` in database `my_db` on the results of the query. The query will write data in `Parquet` at `s3://aws-athena-query-results-XXXXXXXXXX-us-west-2/<query-name-or-unsaved>/2018/9/4/<query-id>/`.

```
CREATE TABLE my_db.das
WITH (
    format='PARQUET'
) AS
SELECT * FROM "my_db"."json_test" limit 10;
```

[Cancel](#)

[Previous](#)

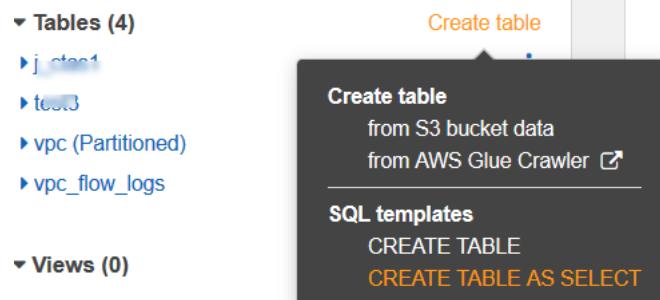
[Create](#)

- g. Choose **Create**.
3. Choose **Run query**.

To create a CTAS query from scratch

Use the `CREATE TABLE AS SELECT` template to create a CTAS query from scratch.

1. In the Athena console, choose **Create table**, and then choose **CREATE TABLE AS SELECT**.



2. In the Query Editor, edit the query as needed. For query syntax, see [CREATE TABLE AS \(p. 316\)](#).
3. Choose **Run query**.
4. Optionally, choose **Save as** to save the query.

See also [Examples of CTAS Queries \(p. 123\)](#).

Bucketing vs Partitioning

You can specify partitioning and bucketing, for storing data from CTAS query results in Amazon S3. For information about CTAS queries, see [CREATE TABLE AS SELECT \(CTAS\) \(p. 118\)](#).

This section discusses partitioning and bucketing as they apply to CTAS queries only. For general guidelines about using partitioning in CREATE TABLE queries, see [Top Performance Tuning Tips for Amazon Athena](#).

Use the following tips to decide whether to partition and/or to configure bucketing, and to select columns in your CTAS queries by which to do so:

- *Partitioning CTAS query results* works well when the number of partitions you plan to have is limited. When you run a CTAS query, Athena writes the results to a specified location in Amazon S3. If you specify partitions, it creates them and stores each partition in a separate partition folder in the same location. The maximum number of partitions you can configure with CTAS query results is 100.

Having partitions in Amazon S3 helps with Athena query performance, because this helps you run targeted queries for only specific partitions. Athena then scans only those partitions, saving you query costs and query time. For information about partitioning syntax, search for `partition_by` in [CREATE TABLE AS \(p. 316\)](#).

Partition data by those columns that have similar characteristics, such as records from the same department, and that can have a limited number of possible values, such as a limited number of distinct departments in an organization. This characteristic is known as *data cardinality*. For example, if you partition by the column `department`, and this column has a limited number of distinct values, partitioning by `department` works well and decreases query latency.

- *Bucketing CTAS query results* works well when you bucket data by the column that has high cardinality and evenly distributed values.

For example, columns storing `timestamp` data could potentially have a very large number of distinct values, and their data is evenly distributed across the data set. This means that a column storing `timestamp` type data will most likely have values and won't have nulls. This also means that data from such a column can be put in many buckets, where each bucket will have roughly the same amount of data stored in Amazon S3.

To choose the column by which to bucket the CTAS query results, use the column that has a high number of values (high cardinality) and whose data can be split for storage into many buckets that will have roughly the same amount of data. Columns that are sparsely populated with values are not good candidates for bucketing. This is because you will end up with buckets that have less data and other buckets that have a lot of data. By comparison, columns that you predict will almost always have values, such as `timestamp` type values, are good candidates for bucketing. This is because their data has high cardinality and can be stored in roughly equal chunks.

For more information about bucketing syntax, search for `bucketed_by` in [CREATE TABLE AS \(p. 316\)](#).

To conclude, you can partition and use bucketing for storing results of the same CTAS query. These techniques for writing data do not exclude each other. Typically, the columns you use for bucketing differ from those you use for partitioning.

For example, if your dataset has columns `department`, `sales_quarter`, and `ts` (for storing `timestamp` type data), you can partition your CTAS query results by `department` and `sales_quarter`. These columns have relatively low cardinality of values: a limited number of departments and sales quarters. Also, for partitions, it does not matter if some records in your dataset have null or no values

assigned for these columns. What matters is that data with the same characteristics, such as data from the same department, will be in one partition that you can query in Athena.

At the same time, because all of your data has `tstamp` type values stored in a `ts` column, you can configure bucketing for the same query results by the column `ts`. This column has high cardinality. You can store its data in more than one bucket in Amazon S3. Consider an opposite scenario: if you don't create buckets for timestamp type data and run a query for particular date or time values, then you would have to scan a very large amount of data stored in a single location in Amazon S3. Instead, if you configure buckets for storing your date- and time-related results, you can only scan and query buckets that have your value and avoid long-running queries that scan a large amount of data.

Examples of CTAS Queries

Use the following examples to create CTAS queries. For information about the CTAS syntax, see [CREATE TABLE AS \(p. 316\)](#).

In this section:

- [Example: Duplicating a Table by Selecting All Columns \(p. 123\)](#)
- [Example: Selecting Specific Columns From One or More Tables \(p. 123\)](#)
- [Example: Creating an Empty Copy of an Existing Table \(p. 124\)](#)
- [Example: Specifying Data Storage and Compression Formats \(p. 124\)](#)
- [Example: Writing Query Results to a Different Format \(p. 124\)](#)
- [Example: Creating Unpartitioned Tables \(p. 124\)](#)
- [Example: Creating Partitioned Tables \(p. 125\)](#)
- [Example: Creating Bucketed and Partitioned Tables \(p. 126\)](#)

Example Example: Duplicating a Table by Selecting All Columns

The following example creates a table by copying all columns from a table:

```
CREATE TABLE new_table AS
SELECT *
FROM old_table;
```

In the following variation of the same example, your `SELECT` statement also includes a `WHERE` clause. In this case, the query selects only those rows from the table that satisfy the `WHERE` clause:

```
CREATE TABLE new_table AS
SELECT *
FROM old_table
WHERE condition;
```

Example Example: Selecting Specific Columns from One or More Tables

The following example creates a new query that runs on a set of columns from another table:

```
CREATE TABLE new_table AS
SELECT column_1, column_2, ... column_n
FROM old_table;
```

This variation of the same example creates a new table from specific columns from multiple tables:

```
CREATE TABLE new_table AS
SELECT column_1, column_2, ... column_n
FROM old_table_1, old_table_2, ... old_table_n;
```

Example Example: Creating an Empty Copy of an Existing Table

The following example uses `WITH NO DATA` to create a new table that is empty and has the same schema as the original table:

```
CREATE TABLE new_table
AS SELECT *
FROM old_table
WITH NO DATA;
```

Example Example: Specifying Data Storage and Compression Formats

The following example uses a CTAS query to create a new table with Parquet data from a source table in a different format. You can specify `PARQUET`, `ORC`, `AVRO`, `JSON`, and `TEXTFILE` in a similar way.

This example also specifies compression as `SNAPPY`. If omitted, `GZIP` is used. `GZIP` and `SNAPPY` are the supported compression formats for CTAS query results stored in Parquet and `ORC`.

```
CREATE TABLE new_table
WITH (
    format = 'Parquet',
    parquet_compression = 'SNAPPY')
AS SELECT *
FROM old_table;
```

The following example is similar, but it stores the CTAS query results in `ORC` and uses the `orc_compression` parameter to specify the compression format. If you omit the compression format, Athena uses `GZIP` by default.

```
CREATE TABLE new_table
WITH (format = 'ORC',
      orc_compression = 'SNAPPY')
AS SELECT *
FROM old_table ;
```

Example Example: Writing Query Results to a Different Format

The following CTAS query selects all records from `old_table`, which could be stored in CSV or another format, and creates a new table with underlying data saved to Amazon S3 in `ORC` format:

```
CREATE TABLE my_orc_ctas_table
WITH (
    external_location = 's3://my_athena_results/my_orc_stas_table/',
    format = 'ORC')
AS SELECT *
FROM old_table;
```

Example Example: Creating Unpartitioned Tables

The following examples create tables that are not partitioned. The table data is stored in different formats. Some of these examples specify the external location.

The following example creates a CTAS query that stores the results as a text file:

```
CREATE TABLE ctas_csv_unpartitioned
WITH (
    format = 'TEXTFILE',
    external_location = 's3://my_athena_results/ctas_csv_unpartitioned/')
AS SELECT key1, name1, address1, comment1
FROM table1;
```

In the following example, results are stored in Parquet, and the default results location is used:

```
CREATE TABLE ctas_parquet_unpartitioned
WITH (format = 'PARQUET')
AS SELECT key1, name1, comment1
FROM table1;
```

In the following query, the table is stored in JSON, and specific columns are selected from the original table's results:

```
CREATE TABLE ctas_json_unpartitioned
WITH (
    format = 'JSON',
    external_location = 's3://my_athena_results/ctas_json_unpartitioned/')
AS SELECT key1, name1, address1, comment1
FROM table1;
```

In the following example, the format is ORC:

```
CREATE TABLE ctas_orc_unpartitioned
WITH (
    format = 'ORC')
AS SELECT key1, name1, comment1
FROM table1;
```

In the following example, the format is Avro:

```
CREATE TABLE ctas_avro_unpartitioned
WITH (
    format = 'AVRO',
    external_location = 's3://my_athena_results/ctas_avro_unpartitioned/')
AS SELECT key1, name1, comment1
FROM table1;
```

Example Example: Creating Partitioned Tables

The following examples show CREATE TABLE AS SELECT queries for partitioned tables in different storage formats, using `partitioned_by`, and other properties in the WITH clause. For syntax, see [CTAS Table Properties \(p. 317\)](#). For more information about choosing the columns for partitioning, see [Bucketing vs Partitioning \(p. 122\)](#).

Note

List partition columns at the end of the list of columns in the SELECT statement. You can partition by more than one column, and have up to 100 unique partition and bucket combinations. For example, you can have 100 partitions if no buckets are specified.

```
CREATE TABLE ctas_csv_partitioned
WITH (
```

```
    format = 'TEXTFILE',
    external_location = 's3://my_athena_results/ctas_csv_partitioned/',
    partitioned_by = ARRAY['key1'])
AS SELECT name1, address1, comment1, key1
FROM table1;
```

```
CREATE TABLE ctas_json_partitioned
WITH (
    format = 'JSON',
    external_location = 's3://my_athena_results/ctas_json_partitioned/',
    partitioned_by = ARRAY['key1'])
AS select name1, address1, comment1, key1
FROM table1;
```

Example Example: Creating Bucketed and Partitioned Tables

The following example shows a `CREATE TABLE AS SELECT` query that uses both partitioning and bucketing for storing query results in Amazon S3. The table results are partitioned and bucketed by different columns. Athena supports a maximum of 100 unique bucket and partition combinations. For example, if you create a table with five buckets, 20 partitions with five buckets each are supported. For syntax, see [CTAS Table Properties \(p. 317\)](#).

For information about choosing the columns for bucketing, see [Bucketing vs Partitioning \(p. 122\)](#).

```
CREATE TABLE ctas_avro_bucketed
WITH (
    format = 'AVRO',
    external_location = 's3://my_athena_results/ctas_avro_bucketed/',
    partitioned_by = ARRAY['nationkey'],
    bucketed_by = ARRAY['mktsegment'],
    bucket_count = 3)
AS SELECT key1, name1, address1, phone1, acctbal, mktsegment, comment1, nationkey
FROM table1;
```

Handling Schema Updates

This section provides guidance on handling schema updates for various data formats. Athena is a schema-on-read query engine. This means that when you create a table in Athena, it applies schemas when reading the data. It does not change or rewrite the underlying data.

If you anticipate changes in table schemas, consider creating them in a data format that is suitable for your needs. Your goals are to reuse existing Athena queries against evolving schemas, and avoid schema mismatch errors when querying tables with partitions.

Important

Schema updates described in this section do not work on tables with complex or nested data types, such as arrays and structs.

To achieve these goals, choose a table's data format based on the table in the following topic.

Topics

- [Summary: Updates and Data Formats in Athena \(p. 127\)](#)
- [Index Access in ORC and Parquet \(p. 128\)](#)
- [Types of Updates \(p. 129\)](#)
- [Updates in Tables with Partitions \(p. 134\)](#)

Summary: Updates and Data Formats in Athena

The following table summarizes data storage formats and their supported schema manipulations. Use this table to help you choose the format that will enable you to continue using Athena queries even as your schemas change over time.

In this table, observe that Parquet and ORC are columnar formats with different default column access methods. By default, Parquet will access columns by name and ORC by index (ordinal value). Therefore, Athena provides a SerDe property defined when creating a table to toggle the default column access method which enables greater flexibility with schema evolution.

For Parquet, the `parquet.column.index.access` property may be set to `TRUE`, which sets the column access method to use the column's ordinal number. Setting this property to `FALSE` will change the column access method to use column name. Similarly, for ORC use the `orc.column.index.access` property to control the column access method. For more information, see [Index Access in ORC and Parquet \(p. 128\)](#).

CSV and TSV allow you to do all schema manipulations except reordering of columns, or adding columns at the beginning of the table. For example, if your schema evolution requires only renaming columns but not removing them, you can choose to create your tables in CSV or TSV. If you require removing columns, do not use CSV or TSV, and instead use any of the other supported formats, preferably, a columnar format, such as Parquet or ORC.

Schema Updates and Data Formats in Athena

Expected Type of Schema Update	Summary	CSV (with and without headers) and TSV	JSON	AVR	PARQUET Read by Name (default)	PARQUET Read by Index	ORC: Read by Index (default)	ORC: Read by Name
Rename columns (p. 132)	Store your data in CSV and TSV, or in ORC and Parquet if they are read by index.	Y	N	N	N	Y	Y	N
Add columns at the beginning or in the middle of the table (p. 130)	Store your data in JSON, AVRO, or in Parquet and ORC if they are read by name. Do not use CSV and TSV.	N	Y	Y	Y	N	N	Y
Add columns at the end of the table (p. 131)	Store your data in CSV or TSV, JSON, AVRO, ORC, or Parquet.	Y	Y	Y	Y	Y	Y	Y
Remove columns (p. 131)	Store your data in JSON, AVRO, or Parquet and ORC, if they are read by name. Do not use CSV and TSV.	N	Y	Y	Y	N	N	Y

Expected Type of Schema Update	Summary	CSV (with and without headers) and TSV	JSON	AVR	PARQUET Read by Name (default)	PARQUET Read by Index	ORC: Read by Index (default)	ORC: Read by Name
Reorder columns (p. 133)	Store your data in AVRO, JSON or ORC and Parquet if they are read by name.	N	Y	Y	Y	N	N	Y
Change a column's data type (p. 133)	Store your data in any format, but test your query in Athena to make sure the data types are compatible. For Parquet and ORC, changing a data type works only for partitioned tables.	Y	Y	Y	Y	Y	Y	Y

Index Access in ORC and Parquet

PARQUET and ORC are columnar data storage formats that can be read by index, or by name. Storing your data in either of these formats lets you perform all operations on schemas and run Athena queries without schema mismatch errors.

- Athena reads *ORC by index by default*, as defined in SERDEPROPERTIES (`'orc.column.index.access'='true'`). For more information, see [ORC: Read by Index \(p. 128\)](#).
- Athena reads *Parquet by name by default*, as defined in SERDEPROPERTIES (`'parquet.column.index.access'='false'`). For more information, see [PARQUET: Read by Name \(p. 129\)](#).

Since these are defaults, specifying these SerDe properties in your `CREATE TABLE` queries is optional, they are used implicitly. When used, they allow you to run some schema update operations while preventing other such operations. To enable those operations, run another `CREATE TABLE` query and change the SerDe settings.

Note

The SerDe properties are *not* automatically propagated to each partition. Use `ALTER TABLE ADD PARTITION` statements to set the SerDe properties for each partition. To automate this process, write a script that runs `ALTER TABLE ADD PARTITION` statements.

The following sections describe these cases in detail.

ORC: Read by Index

A table in ORC is *read by index*, by default. This is defined by the following syntax:

```
WITH SERDEPROPERTIES (
    'orc.column.index.access'='true')
```

Reading by index allows you to rename columns. But then you lose the ability to remove columns or add them in the middle of the table.

To make ORC read by name, which will allow you to add columns in the middle of the table or remove columns in ORC, set the SerDe property `orc.column.index.access` to `FALSE` in the `CREATE TABLE` statement. In this configuration, you will lose the ability to rename columns.

The following example illustrates how to change the ORC to make it read by name:

```
CREATE EXTERNAL TABLE orders_orc_read_by_name (
    `o_comment` string,
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderpriority` string,
    `o_orderstatus` string,
    `o_clerk` string,
    `o_shipppriority` int,
    `o_orderdate` string
)
ROW FORMAT SERDE
    'org.apache.hadoop.hive.ql.io.orc.OrcSerde'
WITH SERDEPROPERTIES (
    'orc.column.index.access'='false')
STORED AS INPUTFORMAT
    'org.apache.hadoop.hive.ql.io.orc.OrcInputFormat'
OUTPUTFORMAT
    'org.apache.hadoop.hive.ql.io.orc.OrcOutputFormat'
LOCATION 's3://schema_updates/orders_orc/';
```

Parquet: Read by Name

A table in *Parquet* is *read by name*, by default. This is defined by the following syntax:

```
WITH SERDEPROPERTIES (
    'parquet.column.index.access'='false')
```

Reading by name allows you to add columns in the middle of the table and remove columns. But then you lose the ability to rename columns.

To make Parquet read by index, which will allow you to rename columns, you must create a table with `parquet.column.index.access` SerDe property set to `TRUE`.

Types of Updates

Here are the types of updates that a table's schema can have. We review each type of schema update and specify which data formats allow you to have them in Athena.

Important

Schema updates described in this section do not work on tables with complex or nested data types, such as arrays and structs.

- [Adding Columns at the Beginning or Middle of the Table \(p. 130\)](#)
- [Adding Columns at the End of the Table \(p. 131\)](#)
- [Removing Columns \(p. 131\)](#)
- [Renaming Columns \(p. 132\)](#)
- [Reordering Columns \(p. 133\)](#)

- [Changing a Column's Data Type \(p. 133\)](#)

Depending on how you expect your schemas to evolve, to continue using Athena queries, choose a compatible data format.

Let's consider an application that reads orders information from an `orders` table that exists in two formats: CSV and Parquet.

The following example creates a table in Parquet:

```
CREATE EXTERNAL TABLE orders_parquet (
    `orderkey` int,
    `orderstatus` string,
    `totalprice` double,
    `orderdate` string,
    `orderpriority` string,
    `clerk` string,
    `shippriority` int
) STORED AS PARQUET
LOCATION 's3://schema_updates/orders_parquet/';
```

The following example creates the same table in CSV:

```
CREATE EXTERNAL TABLE orders_csv (
    `orderkey` int,
    `orderstatus` string,
    `totalprice` double,
    `orderdate` string,
    `orderpriority` string,
    `clerk` string,
    `shippriority` int
)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
LOCATION 's3://schema_updates/orders_csv/';
```

In the following sections, we review how updates to these tables affect Athena queries.

Adding Columns at the Beginning or in the Middle of the Table

Adding columns is one of the most frequent schema changes. For example, you may add a new column to enrich the table with new data. Or, you may add a new column if the source for an existing column has changed, and keep the previous version of this column, to adjust applications that depend on them.

To add columns at the beginning or in the middle of the table, and continue running queries against existing tables, use AVRO, JSON, and Parquet and ORC if their SerDe property is set to read by name. For information, see [Index Access in ORC and Parquet \(p. 128\)](#).

Do not add columns at the beginning or in the middle of the table in CSV and TSV, as these formats depend on ordering. Adding a column in such cases will lead to schema mismatch errors when the schema of partitions changes.

The following example shows adding a column to a JSON table in the middle of the table:

```
CREATE EXTERNAL TABLE orders_json_column_addition (
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderstatus` string,
    `o_comment` string,
    `o_totalprice` double,
```

```
    `o_orderdate` string,
    `o_orderpriority` string,
    `o_clerk` string,
    `o_shipppriority` int,
    `o_comment` string
)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
LOCATION 's3://schema_updates/orders_json/';
```

Adding Columns at the End of the Table

If you create tables in any of the formats that Athena supports, such as Parquet, ORC, Avro, JSON, CSV, and TSV, you can add new columns *at the end of the table*. For tables in Parquet and ORC, you can add columns at the end of the table regardless of the type of [index access \(p. 128\)](#) they use.

In the following example, drop an existing table in Parquet, and add a new Parquet table with a new `comment` column at the end of the table:

```
DROP TABLE orders_parquet;
CREATE EXTERNAL TABLE orders_parquet (
    `orderkey` int,
    `orderstatus` string,
    `totalprice` double,
    `orderdate` string,
    `orderpriority` string,
    `clerk` string,
    `shippriority` int
    `comment` string
)
STORED AS PARQUET
LOCATION 's3://schema_updates/orders_parquet/';
```

In the following example, drop an existing table in CSV and add a new CSV table with a new `comment` column at the end of the table:

```
DROP TABLE orders_csv;
CREATE EXTERNAL TABLE orders_csv (
    `orderkey` int,
    `orderstatus` string,
    `totalprice` double,
    `orderdate` string,
    `orderpriority` string,
    `clerk` string,
    `shippriority` int
    `comment` string
)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
LOCATION 's3://schema_updates/orders_csv/';
```

Removing Columns

You may need to remove columns from tables if they no longer contain data, or to restrict access to the data in them.

- You can remove columns from tables in JSON, Avro, and in Parquet and ORC if they are read by name. For information, see [Index Access in ORC and Parquet \(p. 128\)](#).
- We do not recommend removing columns from tables in CSV and TSV if you want to retain the tables you have already created in Athena. Removing a column breaks the schema and requires that you recreate the table without the removed column.

In this example, remove a column `totalprice` from a table in Parquet and run a query. In Athena, Parquet is read by name by default, this is why we omit the SERDEPROPERTIES configuration that specifies reading by name. Notice that the following query succeeds, even though you changed the schema:

```
CREATE EXTERNAL TABLE orders_parquet_column_removed (
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderstatus` string,
    `o_orderdate` string,
    `o_orderpriority` string,
    `o_clerk` string,
    `o_shipppriority` int,
    `o_comment` string
)
STORED AS PARQUET
LOCATION 's3://schema_updates/orders_parquet/';
```

Renaming Columns

You may want to rename columns in your tables to correct spelling, make column names more descriptive, or to reuse an existing column to avoid column reordering.

You can rename columns if you store your data in CSV and TSV, or in Parquet and ORC that are configured to read by index. For information, see [Index Access in ORC and Parquet \(p. 128\)](#).

Athena reads data in CSV and TSV in the order of the columns in the schema and returns them in the same order. It does not use column names for mapping data to a column, which is why you can rename columns in CSV or TSV without breaking Athena queries.

In this example, rename the column `o_totalprice` to `o_total_price` in the Parquet table, and then run a query in Athena:

```
CREATE EXTERNAL TABLE orders_parquet_column_renamed (
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderstatus` string,
    `o_total_price` double,
    `o_orderdate` string,
    `o_orderpriority` string,
    `o_clerk` string,
    `o_shipppriority` int,
    `o_comment` string
)
STORED AS PARQUET
LOCATION 's3://TBD/schema_updates/orders_parquet/';
```

In the Parquet table case, the following query runs, but the renamed column does not show data because the column was being accessed by name (a default in Parquet) rather than by index:

```
SELECT *
FROM orders_parquet_column_renamed;
```

A query with a table in CSV looks similar:

```
CREATE EXTERNAL TABLE orders_csv_column_renamed (
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderstatus` string,
```

```
`o_total_price` double,  
`o_orderdate` string,  
`o_orderpriority` string,  
`o_clerk` string,  
`o_shipppriority` int,  
`o_comment` string  
)  
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','  
LOCATION 's3://schema_updates/orders_csv/';
```

In the CSV table case, the following query runs and the data displays in all columns, including the one that was renamed:

```
SELECT *  
FROM orders_csv_column_renamed;
```

Reordering Columns

You can reorder columns only for tables with data in formats that read by name, such as JSON or ORC, which reads by name by default. You can also make Parquet read by name, if needed. For information, see [Index Access in ORC and Parquet \(p. 128\)](#).

The following example illustrates reordering of columns:

```
CREATE EXTERNAL TABLE orders_parquet_columns_reordered (  
`o_comment` string,  
`o_orderkey` int,  
`o_custkey` int,  
`o_orderpriority` string,  
`o_orderstatus` string,  
`o_clerk` string,  
`o_shipppriority` int,  
`o_orderdate` string  
)  
STORED AS PARQUET  
LOCATION 's3://schema_updates/orders_parquet/';
```

Changing a Column's Data Type

You change column types because a column's data type can no longer hold the amount of information, for example, when an ID column exceeds the size of an `INT` data type and has to change to a `BIGINT` data type.

Changing a column's data type has these limitations:

- Only certain data types can be converted to other data types. See the table in this section for data types that can change.
- For data in Parquet and ORC, you cannot change a column's data type if the table is not partitioned.

For partitioned tables in Parquet and ORC, a partition's column type can be different from another partition's column type, and Athena will `CAST` to the desired type, if possible. For information, see [Avoiding Schema Mismatch Errors for Tables with Partitions \(p. 135\)](#).

Important

We strongly suggest that you test and verify your queries before performing data type translations. If Athena cannot convert the data type from the original data type to the target data type, the `CREATE TABLE` query may fail.

The following table lists data types that you can change:

Compatible Data Types

Original Data Type	Available Target Data Types
STRING	BYTE, TINYINT, SMALLINT, INT, BIGINT
BYTE	TINYINT, SMALLINT, INT, BIGINT
TINYINT	SMALLINT, INT, BIGINT
SMALLINT	INT, BIGINT
INT	BIGINT
FLOAT	DOUBLE

In the following example of the `orders_json` table, change the data type for the column ``o_shippriority`` to `BIGINT`:

```
CREATE EXTERNAL TABLE orders_json (
    `o_orderkey` int,
    `o_custkey` int,
    `o_orderstatus` string,
    `o_totalprice` double,
    `o_orderdate` string,
    `o_orderpriority` string,
    `o_clerk` string,
    `o_shippriority` BIGINT
)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
LOCATION 's3://schema_updates/orders_json';
```

The following query runs successfully, similar to the original `SELECT` query, before the data type change:

```
Select * from orders_json
LIMIT 10;
```

Updates in Tables with Partitions

In Athena, a table and its partitions must use the same data formats but their schemas may differ. When you create a new partition, that partition usually inherits the schema of the table. Over time, the schemas may start to differ. Reasons include:

- If your table's schema changes, the schemas for partitions are not updated to remain in sync with the table's schema.
- The AWS Glue Crawler allows you to discover data in partitions with different schemas. This means that if you create a table in Athena with AWS Glue, after the crawler finishes processing, the schemas for the table and its partitions may be different.
- If you add partitions directly using an AWS API.

Athena processes tables with partitions successfully if they meet the following constraints. If these constraints are not met, Athena issues a `HIVE_PARTITION_SCHEMA_MISMATCH` error.

- Each partition's schema is compatible with the table's schema.

- The table's data format allows the type of update you want to perform: add, delete, reorder columns, or change a column's data type.

For example, for CSV and TSV formats, you can rename columns, add new columns at the end of the table, and change a column's data type if the types are compatible, but you cannot remove columns. For other formats, you can add or remove columns, or change a column's data type to another if the types are compatible. For information, see [Summary: Updates and Data Formats in Athena \(p. 127\)](#).

Important

Schema updates described in this section do not work on tables with complex or nested data types, such as arrays and structs.

Avoiding Schema Mismatch Errors for Tables with Partitions

At the beginning of query execution, Athena verifies the table's schema by checking that each column data type is compatible between the table and the partition.

- For Parquet and ORC data storage types, Athena relies on the column names and uses them for its column name-based schema verification. This eliminates `HIVE_PARTITION_SCHEMA_MISMATCH` errors for tables with partitions in Parquet and ORC. (This is true for ORC if the SerDe property is set to access the index by name: `orc.column.index.access=FALSE`. Parquet reads the index by name by default).
- For CSV, JSON, and Avro, Athena uses an index-based schema verification. This means that if you encounter a schema mismatch error, you should drop the partition that is causing a schema mismatch and recreate it, so that Athena can query it without failing.

Athena compares the table's schema to the partition schemas. If you create a table in CSV, JSON, and AVRO in Athena with AWS Glue Crawler, after the Crawler finishes processing, the schemas for the table and its partitions may be different. If there is a mismatch between the table's schema and the partition schemas, your queries fail in Athena due to the schema verification error similar to this: 'crawler_test.click_avro' is declared as type 'string', but partition 'partition_0=2017-01-17' declared column 'col68' as type 'double'."

A typical workaround for such errors is to drop the partition that is causing the error and recreate it.

Querying Arrays

Amazon Athena lets you create arrays, concatenate them, convert them to different data types, and then filter, flatten, and sort them.

Topics

- [Creating Arrays \(p. 136\)](#)
- [Concatenating Arrays \(p. 137\)](#)
- [Converting Array Data Types \(p. 138\)](#)
- [Finding Lengths \(p. 138\)](#)
- [Accessing Array Elements \(p. 139\)](#)
- [Flattening Nested Arrays \(p. 140\)](#)
- [Creating Arrays from Subqueries \(p. 142\)](#)
- [Filtering Arrays \(p. 143\)](#)
- [Sorting Arrays \(p. 143\)](#)
- [Using Aggregation Functions with Arrays \(p. 144\)](#)

- [Converting Arrays to Strings \(p. 144\)](#)
- [Using Arrays to Create Maps \(p. 145\)](#)
- [Querying Arrays with Complex Types and Nested Structures \(p. 146\)](#)

Creating Arrays

To build an array literal in Athena, use the `ARRAY` keyword, followed by brackets [], and include the array elements separated by commas.

Examples

This query creates one array with four elements.

```
SELECT ARRAY [1,2,3,4] AS items
```

It returns:

```
+-----+
| items      |
+-----+
| [1,2,3,4] |
+-----+
```

This query creates two arrays.

```
SELECT ARRAY[ ARRAY[1,2], ARRAY[3,4] ] AS items
```

It returns:

```
+-----+
| items          |
+-----+
| [[1, 2], [3, 4]] |
+-----+
```

To create an array from selected columns of compatible types, use a query, as in this example:

```
WITH
dataset AS (
    SELECT 1 AS x, 2 AS y, 3 AS z
)
SELECT ARRAY [x,y,z] AS items FROM dataset
```

This query returns:

```
+-----+
| items      |
+-----+
| [1,2,3]   |
+-----+
```

In the following example, two arrays are selected and returned as a welcome message.

```
WITH
dataset AS (
    SELECT
        ARRAY ['hello', 'amazon', 'athena'] AS words,
        ARRAY ['hi', 'alexa'] AS alexa
)
SELECT ARRAY[words, alexa] AS welcome_msg
FROM dataset
```

This query returns:

```
+-----+
| welcome_msg
+-----+
| [[hello, amazon, athena], [hi, alexa]] |
+-----+
```

To create an array of key-value pairs, use the `MAP` operator that takes an array of keys followed by an array of values, as in this example:

```
SELECT ARRAY[
    MAP(ARRAY['first', 'last', 'age'], ARRAY['Bob', 'Smith', '40']),
    MAP(ARRAY['first', 'last', 'age'], ARRAY['Jane', 'Doe', '30']),
    MAP(ARRAY['first', 'last', 'age'], ARRAY['Billy', 'Smith', '8'])
] AS people
```

This query returns:

```
+-----+
+
| people
|
+-----+
+
| [{last=Smith, first=Bob, age=40}, {last=Doe, first=Jane, age=30}, {last=Smith,
first=Billy, age=8}] |
+-----+
+
```

Concatenating Arrays

To concatenate multiple arrays, use the double pipe `||` operator between them.

```
SELECT ARRAY [4,5] || ARRAY[ ARRAY[1,2], ARRAY[3,4] ] AS items
```

This query returns:

```
+-----+
| items
+-----+
| [[4, 5], [1, 2], [3, 4]] |
+-----+
```

To combine multiple arrays into a single array, use the `concat` function.

```
WITH
```

```
dataset AS (
    SELECT
        ARRAY ['hello', 'amazon', 'athena'] AS words,
        ARRAY ['hi', 'alexa'] AS alexa
    )
SELECT concat(words, alexa) AS welcome_msg
FROM dataset
```

This query returns:

```
+-----+
| welcome_msg |
+-----+
| [hello, amazon, athena, hi, alexa] |
+-----+
```

Converting Array Data Types

To convert data in arrays to supported data types, use the `CAST` operator, as `CAST(value AS type)`. Athena supports all of the native Presto data types.

```
SELECT
    ARRAY [CAST(4 AS VARCHAR), CAST(5 AS VARCHAR)]
AS items
```

This query returns:

```
+-----+
| items |
+-----+
| [4,5] |
+-----+
```

Create two arrays with key-value pair elements, convert them to JSON, and concatenate, as in this example:

```
SELECT
    ARRAY[CAST(MAP(ARRAY['a1', 'a2', 'a3'], ARRAY[1, 2, 3]) AS JSON)] ||
    ARRAY[CAST(MAP(ARRAY['b1', 'b2', 'b3'], ARRAY[4, 5, 6]) AS JSON)]
AS items
```

This query returns:

```
+-----+
| items |
+-----+
| [{"a1":1,"a2":2,"a3":3}, {"b1":4,"b2":5,"b3":6}] |
+-----+
```

Finding Lengths

The `cardinality` function returns the length of an array, as in this example:

```
SELECT cardinality(ARRAY[1,2,3,4]) AS item_count
```

This query returns:

```
+-----+
| item_count |
+-----+
| 4          |
+-----+
```

Accessing Array Elements

To access array elements, use the [] operator, with 1 specifying the first element, 2 specifying the second element, and so on, as in this example:

```
WITH dataset AS (
SELECT
    ARRAY[CAST(MAP(ARRAY['a1', 'a2', 'a3'], ARRAY[1, 2, 3]) AS JSON)] ||
    ARRAY[CAST(MAP(ARRAY['b1', 'b2', 'b3'], ARRAY[4, 5, 6]) AS JSON)]
AS items )
SELECT items[1] AS item FROM dataset
```

This query returns:

```
+-----+
| item           |
+-----+
| {"a1":1,"a2":2,"a3":3} |
+-----+
```

To access the elements of an array at a given position (known as the index position), use the `element_at()` function and specify the array name and the index position:

- If the index is greater than 0, `element_at()` returns the element that you specify, counting from the beginning to the end of the array. It behaves as the [] operator.
- If the index is less than 0, `element_at()` returns the element counting from the end to the beginning of the array.

The following query creates an array `words`, and selects the first element `hello` from it as the `first_word`, the second element `amazon` (counting from the end of the array) as the `middle_word`, and the third element `athena`, as the `last_word`.

```
WITH dataset AS (
    SELECT ARRAY ['hello', 'amazon', 'athena'] AS words
)
SELECT
    element_at(words, 1) AS first_word,
    element_at(words, -2) AS middle_word,
    element_at(words, cardinality(words)) AS last_word
FROM dataset
```

This query returns:

```
+-----+
| first_word | middle_word | last_word |
+-----+
| hello      | amazon     | athena   |
+-----+
```

Flattening Nested Arrays

When working with nested arrays, you often need to expand nested array elements into a single array, or expand the array into multiple rows.

Examples

To flatten a nested array's elements into a single array of values, use the `flatten` function. This query returns a row for each element in the array.

```
SELECT flatten(ARRAY[ ARRAY[1,2], ARRAY[3,4] ]) AS items
```

This query returns:

items
[1,2,3,4]

To flatten an array into multiple rows, use `CROSS JOIN` in conjunction with the `UNNEST` operator, as in this example:

```
WITH dataset AS (
    SELECT
        'engineering' as department,
        ARRAY['Sharon', 'John', 'Bob', 'Sally'] as users
)
SELECT department, names FROM dataset
CROSS JOIN UNNEST(users) as t(names)
```

This query returns:

department	names
engineering	Sharon
engineering	John
engineering	Bob
engineering	Sally

To flatten an array of key-value pairs, transpose selected keys into columns, as in this example:

```
WITH
dataset AS (
    SELECT
        'engineering' as department,
        ARRAY[
            MAP(ARRAY['first', 'last', 'age'],ARRAY['Bob', 'Smith', '40']),
            MAP(ARRAY['first', 'last', 'age'],ARRAY['Jane', 'Doe', '30']),
            MAP(ARRAY['first', 'last', 'age'],ARRAY['Billy', 'Smith', '8'])
        ] AS people
)
```

```
SELECT names['first'] AS
    first_name,
    names['last'] AS last_name,
    department FROM dataset
CROSS JOIN UNNEST(people) AS t(names)
```

This query returns:

first_name	last_name	department
Bob	Smith	engineering
Jane	Doe	engineering
Billy	Smith	engineering

From a list of employees, select the employee with the highest combined scores. UNNEST can be used in the `FROM` clause without a preceding `CROSS JOIN` as it is the default join operator and therefore implied.

```
WITH
dataset AS (
    SELECT ARRAY[
        CAST(ROW('Sally', 'engineering', ARRAY[1,2,3,4]) AS ROW(name VARCHAR, department
VARCHAR, scores ARRAY(INTEGER))),
        CAST(ROW('John', 'finance', ARRAY[7,8,9]) AS ROW(name VARCHAR, department VARCHAR,
scores ARRAY(INTEGER))),
        CAST(ROW('Amy', 'devops', ARRAY[12,13,14,15]) AS ROW(name VARCHAR, department VARCHAR,
scores ARRAY(INTEGER)))
    ] AS users
),
users AS (
    SELECT person, score
    FROM
        dataset,
        UNNEST(dataset.users) AS t(person),
        UNNEST(person.scores) AS t(score)
)
SELECT person.name, person.department, SUM(score) AS total_score FROM users
GROUP BY (person.name, person.department)
ORDER BY (total_score) DESC
LIMIT 1
```

This query returns:

name	department	total_score
Amy	devops	54

From a list of employees, select the employee with the highest individual score.

```
WITH
dataset AS (
    SELECT ARRAY[
        CAST(ROW('Sally', 'engineering', ARRAY[1,2,3,4]) AS ROW(name VARCHAR, department
VARCHAR, scores ARRAY(INTEGER))),
        CAST(ROW('John', 'finance', ARRAY[7,8,9]) AS ROW(name VARCHAR, department VARCHAR,
scores ARRAY(INTEGER))),
```

```

    CAST(ROW('Amy', 'devops', ARRAY[12,13,14,15]) AS ROW(name VARCHAR, department VARCHAR,
      scores ARRAY(INTEGER)))
  ] AS users
),
users AS (
  SELECT person, score
  FROM
    dataset,
    UNNEST(dataset.users) AS t(person),
    UNNEST(person.scores) AS t(score)
)
SELECT person.name, score FROM users
ORDER BY (score) DESC
LIMIT 1

```

This query returns:

name	score
+-----+	+-----+
Amy	15
+-----+	+-----+

Creating Arrays from Subqueries

Create an array from a collection of rows.

```

WITH
dataset AS (
  SELECT ARRAY[1,2,3,4,5] AS items
)
SELECT array_agg(i) AS array_items
FROM dataset
CROSS JOIN UNNEST(items) AS t(i)

```

This query returns:

array_items	
+-----+	+-----+
[1, 2, 3, 4, 5]	
+-----+	+-----+

To create an array of unique values from a set of rows, use the `distinct` keyword.

```

WITH
dataset AS (
  SELECT ARRAY [1,2,2,3,3,4,5] AS items
)
SELECT array_agg(distinct i) AS array_items
FROM dataset
CROSS JOIN UNNEST(items) AS t(i)

```

This query returns the following result. Note that ordering is not guaranteed.

array_items	
+-----+	+-----+

```
+-----+  
| [1, 2, 3, 4, 5] |  
+-----+
```

Filtering Arrays

Create an array from a collection of rows if they match the filter criteria.

```
WITH  
dataset AS (  
    SELECT ARRAY[1,2,3,4,5] AS items  
)  
SELECT array_agg(i) AS array_items  
FROM dataset  
CROSS JOIN UNNEST(items) AS t(i)  
WHERE i > 3
```

This query returns:

```
+-----+  
| array_items |  
+-----+  
| [4, 5] |  
+-----+
```

Filter an array based on whether one of its elements contain a specific value, such as 2, as in this example:

```
WITH  
dataset AS (  
    SELECT ARRAY  
    [  
        ARRAY[1,2,3,4],  
        ARRAY[5,6,7,8],  
        ARRAY[9,0]  
    ] AS items  
)  
SELECT i AS array_items FROM dataset  
CROSS JOIN UNNEST(items) AS t(i)  
WHERE contains(i, 2)
```

This query returns:

```
+-----+  
| array_items |  
+-----+  
| [1, 2, 3, 4] |  
+-----+
```

Sorting Arrays

Create a sorted array of unique values from a set of rows.

```
WITH  
dataset AS (  
    SELECT ARRAY[3,1,2,5,2,3,6,3,4,5] AS items  
)  
SELECT array_sort(array_agg(distinct i)) AS array_items
```

```
FROM dataset
CROSS JOIN UNNEST(items) AS t(i)
```

This query returns:

```
+-----+
| array_items      |
+-----+
| [1, 2, 3, 4, 5, 6] |
+-----+
```

Using Aggregation Functions with Arrays

- To add values within an array, use `SUM`, as in the following example.
- To aggregate multiple rows within an array, use `array_agg`. For information, see [Creating Arrays from Subqueries \(p. 142\)](#).

Note

`ORDER BY` is not supported for aggregation functions, for example, you cannot use it within `array_agg(x)`.

```
WITH
dataset AS (
    SELECT ARRAY
    [
        ARRAY[1,2,3,4],
        ARRAY[5,6,7,8],
        ARRAY[9,0]
    ] AS items
),
item AS (
    SELECT i AS array_items
    FROM dataset, UNNEST(items) AS t(i)
)
SELECT array_items, sum(val) AS total
FROM item, UNNEST(array_items) AS t(val)
GROUP BY array_items;
```

This query returns the following results. The order of returned results is not guaranteed.

```
+-----+
| array_items | total |
+-----+
| [1, 2, 3, 4] | 10   |
| [5, 6, 7, 8] | 26   |
| [9, 0]       | 9    |
+-----+
```

Converting Arrays to Strings

To convert an array into a single string, use the `array_join` function.

```
WITH
dataset AS (
    SELECT ARRAY ['hello', 'amazon', 'athena'] AS words
)
```

```
SELECT array_join(words, ' ') AS welcome_msg
FROM dataset
```

This query returns:

```
+-----+
| welcome_msg      |
+-----+
| hello amazon athena |
+-----+
```

Using Arrays to Create Maps

Maps are key-value pairs that consist of data types available in Athena. To create maps, use the `MAP` operator and pass it two arrays: the first is the column (key) names, and the second is values. All values in the arrays must be of the same type. If any of the map value array elements need to be of different types, you can convert them later.

Examples

This example selects a user from a dataset. It uses the `MAP` operator and passes it two arrays. The first array includes values for column names, such as "first", "last", and "age". The second array consists of values for each of these columns, such as "Bob", "Smith", "35".

```
WITH dataset AS (
    SELECT MAP(
        ARRAY['first', 'last', 'age'],
        ARRAY['Bob', 'Smith', '35']
    ) AS user
)
SELECT user FROM dataset
```

This query returns:

```
+-----+
| user          |
+-----+
| {last=Smith, first=Bob, age=35} |
+-----+
```

You can retrieve Map values by selecting the field name followed by `[key_name]`, as in this example:

```
WITH dataset AS (
    SELECT MAP(
        ARRAY['first', 'last', 'age'],
        ARRAY['Bob', 'Smith', '35']
    ) AS user
)
SELECT user['first'] AS first_name FROM dataset
```

This query returns:

```
+-----+
| first_name   |
+-----+
| Bob          |
+-----+
```

+-----+

Querying Arrays with Complex Types and Nested Structures

Your source data often contains arrays with complex data types and nested structures. Examples in this section show how to change element's data type, locate elements within arrays, and find keywords using Athena queries.

- [Creating a ROW \(p. 146\)](#)
- [Changing Field Names in Arrays Using CAST \(p. 146\)](#)
- [Filtering Arrays Using the . Notation \(p. 147\)](#)
- [Filtering Arrays with Nested Values \(p. 147\)](#)
- [Filtering Arrays Using UNNEST \(p. 148\)](#)
- [Finding Keywords in Arrays Using `regexp_like` \(p. 149\)](#)

Creating a ROW

Note

The examples in this section use ROW as a means to create sample data to work with. When you query tables within Athena, you do not need to create ROW data types, as they are already created from your data source. When you use `CREATE_TABLE`, Athena defines a `STRUCT` in it, populates it with data, and creates the ROW data type for you, for each row in the dataset. The underlying ROW data type consists of named fields of any supported SQL data types.

```
WITH dataset AS (
    SELECT
        ROW('Bob', 38) AS users
    )
SELECT * FROM dataset
```

This query returns:

```
+-----+
| users           |
+-----+
| {field0=Bob, field1=38} |
+-----+
```

Changing Field Names in Arrays Using CAST

To change the field name in an array that contains ROW values, you can `CAST` the `ROW` declaration:

```
WITH dataset AS (
    SELECT
        CAST(
            ROW('Bob', 38) AS ROW(name VARCHAR, age INTEGER)
        ) AS users
    )
SELECT * FROM dataset
```

This query returns:

```
+-----+
| users           |
+-----+
| {NAME=Bob, AGE=38} |
+-----+
```

Note

In the example above, you declare `name` as a `VARCHAR` because this is its type in Presto. If you declare this `STRUCT` inside a `CREATE TABLE` statement, use `String` type because Hive defines this data type as `String`.

Filtering Arrays Using the . Notation

In the following example, select the `accountId` field from the `userIdentity` column of a AWS CloudTrail logs table by using the dot `. notation`. For more information, see [Querying AWS CloudTrail Logs \(p. 178\)](#).

```
SELECT
  CAST(useridentity.accountid AS bigint) as newid
FROM clouptrail_logs
LIMIT 2;
```

This query returns:

```
+-----+
| newid          |
+-----+
| 112233445566 |
+-----+
| 998877665544 |
+-----+
```

To query an array of values, issue this query:

```
WITH dataset AS (
  SELECT ARRAY[
    CAST(ROW('Bob', 38) AS ROW(name VARCHAR, age INTEGER)),
    CAST(ROW('Alice', 35) AS ROW(name VARCHAR, age INTEGER)),
    CAST(ROW('Jane', 27) AS ROW(name VARCHAR, age INTEGER))
  ] AS users
)
SELECT * FROM dataset
```

It returns this result:

```
+-----+
| users           |
+-----+
| [{NAME=Bob, AGE=38}, {NAME=Alice, AGE=35}, {NAME=Jane, AGE=27}] |
+-----+
```

Filtering Arrays with Nested Values

Large arrays often contain nested structures, and you need to be able to filter, or search, for values within them.

To define a dataset for an array of values that includes a nested `BOOLEAN` value, issue this query:

```
WITH dataset AS (
    SELECT
        CAST(
            ROW('aws.amazon.com', ROW(true)) AS ROW(hostname VARCHAR, flaggedActivity ROW(isNew
BOOLEAN))
        ) AS sites
)
SELECT * FROM dataset
```

It returns this result:

sites
{HOSTNAME=aws.amazon.com, FLAGGEDACTIVITY={ISNEW=true}}

Next, to filter and access the BOOLEAN value of that element, continue to use the dot . notation.

```
WITH dataset AS (
    SELECT
        CAST(
            ROW('aws.amazon.com', ROW(true)) AS ROW(hostname VARCHAR, flaggedActivity ROW(isNew
BOOLEAN))
        ) AS sites
)
SELECT sites.hostname, sites.flaggedactivity.isnew
FROM dataset
```

This query selects the nested fields and returns this result:

hostname	isnew
aws.amazon.com	true

Filtering Arrays Using UNNEST

To filter an array that includes a nested structure by one of its child elements, issue a query with an UNNEST operator. For more information about UNNEST, see [Flattening Nested Arrays \(p. 140\)](#).

For example, this query finds hostnames of sites in the dataset.

```
WITH dataset AS (
    SELECT ARRAY[
        CAST(
            ROW('aws.amazon.com', ROW(true)) AS ROW(hostname VARCHAR, flaggedActivity ROW(isNew
BOOLEAN))
        ),
        CAST(
            ROW('news.cnn.com', ROW(false)) AS ROW(hostname VARCHAR, flaggedActivity ROW(isNew
BOOLEAN))
        ),
        CAST(
            ROW('netflix.com', ROW(false)) AS ROW(hostname VARCHAR, flaggedActivity ROW(isNew
BOOLEAN))
        )
    ] as items
```

```

)
SELECT sites.hostname, sites.flaggedActivity.isNew
FROM dataset, UNNEST(items) t(sites)
WHERE sites.flaggedActivity.isNew = true

```

It returns:

hostname	isnew
aws.amazon.com	true

Finding Keywords in Arrays Using `regexp_like`

The following examples illustrate how to search a dataset for a keyword within an element inside an array, using the `regexp_like` function. It takes as an input a regular expression pattern to evaluate, or a list of terms separated by a pipe (|), evaluates the pattern, and determines if the specified string contains it.

The regular expression pattern needs to be contained within the string, and does not have to match it. To match the entire string, enclose the pattern with ^ at the beginning of it, and \$ at the end, such as '`^pattern$`'.

Consider an array of sites containing their hostname, and a `flaggedActivity` element. This element includes an ARRAY, containing several MAP elements, each listing different popular keywords and their popularity count. Assume you want to find a particular keyword inside a MAP in this array.

To search this dataset for sites with a specific keyword, we use `regexp_like` instead of the similar SQL `LIKE` operator, because searching for a large number of keywords is more efficient with `regexp_like`.

Example Example 1: Using `regexp_like`

The query in this example uses the `regexp_like` function to search for terms '`politics|bigdata`', found in values within arrays:

```

WITH dataset AS (
    SELECT ARRAY[
        CAST(
            ROW('aws.amazon.com', ROW(ARRAY[
                MAP(ARRAY['term', 'count'], ARRAY['bigdata', '10']),
                MAP(ARRAY['term', 'count'], ARRAY['serverless', '50']),
                MAP(ARRAY['term', 'count'], ARRAY['analytics', '82']),
                MAP(ARRAY['term', 'count'], ARRAY['iot', '74']))
            ])
            ) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
        ),
        CAST(
            ROW('news.cnn.com', ROW(ARRAY[
                MAP(ARRAY['term', 'count'], ARRAY['politics', '241']),
                MAP(ARRAY['term', 'count'], ARRAY['technology', '211']),
                MAP(ARRAY['term', 'count'], ARRAY['serverless', '25']),
                MAP(ARRAY['term', 'count'], ARRAY['iot', '170']))
            ])
            ) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
        ),
        CAST(
            ROW('netflix.com', ROW(ARRAY[
                MAP(ARRAY['term', 'count'], ARRAY['cartoons', '1020']),
                MAP(ARRAY['term', 'count'], ARRAY['house of cards', '112042']))
            ])
            )
    ]
)

```

```

        MAP(ARRAY['term', 'count'], ARRAY['orange is the new black', '342']),
        MAP(ARRAY['term', 'count'], ARRAY['iot', '4']))
    ])
) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
)
] AS items
),
sites AS (
    SELECT sites.hostname, sites.flaggedactivity
    FROM dataset, UNNEST(items) t(sites)
)
SELECT hostname
FROM sites, UNNEST(sites.flaggedActivity.flags) t(flags)
WHERE regexp_like(flags['term'], 'politics|bigdata')
GROUP BY (hostname)

```

This query returns two sites:

hostname
aws.amazon.com
news.cnn.com

Example Example 2: Using `regexp_like`

The query in the following example adds up the total popularity scores for the sites matching your search terms with the `regexp_like` function, and then orders them from highest to lowest.

```

WITH dataset AS (
    SELECT ARRAY[
        CAST(
            ROW('aws.amazon.com', ROW(ARRAY[
                MAP(ARRAY['term', 'count'], ARRAY['bigdata', '10']),
                MAP(ARRAY['term', 'count'], ARRAY['serverless', '50']),
                MAP(ARRAY['term', 'count'], ARRAY['analytics', '82']),
                MAP(ARRAY['term', 'count'], ARRAY['iot', '74']))
            ]))
        ) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
    ),
    CAST(
        ROW('news.cnn.com', ROW(ARRAY[
            MAP(ARRAY['term', 'count'], ARRAY['politics', '241']),
            MAP(ARRAY['term', 'count'], ARRAY['technology', '211']),
            MAP(ARRAY['term', 'count'], ARRAY['serverless', '25']),
            MAP(ARRAY['term', 'count'], ARRAY['iot', '170']))
        ]))
        ) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
    ),
    CAST(
        ROW('netflix.com', ROW(ARRAY[
            MAP(ARRAY['term', 'count'], ARRAY['cartoons', '1020']),
            MAP(ARRAY['term', 'count'], ARRAY['house of cards', '112042']),
            MAP(ARRAY['term', 'count'], ARRAY['orange is the new black', '342']),
            MAP(ARRAY['term', 'count'], ARRAY['iot', '4']))
        ]))
        ) AS ROW(hostname VARCHAR, flaggedActivity ROW(flags ARRAY(MAP(VARCHAR, VARCHAR)) ))
    )
] AS items
),
sites AS (

```

```
    SELECT sites.hostname, sites.flaggedactivity
    FROM dataset, UNNEST(items) t(sites)
)
SELECT hostname, array_agg(flags['term']) AS terms, SUM(CAST(flags['count'] AS INTEGER)) AS
total
FROM sites, UNNEST(sites.flaggedActivity.flags) t(flags)
WHERE regexp_like(flags['term'], 'politics|bigdata')
GROUP BY (hostname)
ORDER BY total DESC
```

This query returns two sites:

hostname	terms	total
news.cnn.com	politics	241
aws.amazon.com	big data	10

Querying JSON

Amazon Athena lets you parse JSON-encoded values, extract data from JSON, search for values, and find length and size of JSON arrays.

Topics

- [Best Practices for Reading JSON Data \(p. 151\)](#)
- [Extracting Data from JSON \(p. 153\)](#)
- [Searching for Values in JSON Arrays \(p. 155\)](#)
- [Obtaining Length and Size of JSON Arrays \(p. 156\)](#)

Best Practices for Reading JSON Data

JavaScript Object Notation (JSON) is a common method for encoding data structures as text. Many applications and tools output data that is JSON-encoded.

In Amazon Athena, you can create tables from external data and include the JSON-encoded data in them. For such types of source data, use Athena together with [JSON SerDe Libraries \(p. 285\)](#).

Use the following tips to read JSON-encoded data:

- Choose the right SerDe, a native JSON SerDe, org.apache.hive.hcatalog.data.JsonSerDe, or an OpenX SerDe, org.openx.data.jsonserde.JsonSerDe. For more information, see [JSON SerDe Libraries \(p. 285\)](#).
- Make sure that each JSON-encoded record is represented on a separate line.
- Generate your JSON-encoded data in case-insensitive columns.
- Provide an option to ignore malformed records, as in this example.

```
CREATE EXTERNAL TABLE json_table (
    column_a string
    column_b int
)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
WITH SERDEPROPERTIES ('ignore.malformed.json' = 'true')
```

```
LOCATION 's3://bucket/path/' ;
```

- Convert fields in source data that have an undetermined schema to JSON-encoded strings in Athena.

When Athena creates tables backed by JSON data, it parses the data based on the existing and predefined schema. However, not all of your data may have a predefined schema. To simplify schema management in such cases, it is often useful to convert fields in source data that have an undetermined schema to JSON strings in Athena, and then use [JSON SerDe Libraries \(p. 285\)](#).

For example, consider an IoT application that publishes events with common fields from different sensors. One of those fields must store a custom payload that is unique to the sensor sending the event. In this case, since you don't know the schema, we recommend that you store the information as a JSON-encoded string. To do this, convert data in your Athena table to JSON, as in the following example. You can also convert JSON-encoded data to Athena data types.

- [Converting Athena Data Types to JSON \(p. 152\)](#)
- [Converting JSON to Athena Data Types \(p. 152\)](#)

Converting Athena Data Types to JSON

To convert Athena data types to JSON, use `CAST`.

```
WITH dataset AS (
    SELECT
        CAST('HELLO ATHENA' AS JSON) AS hello_msg,
        CAST(12345 AS JSON) AS some_int,
        CAST(MAP(ARRAY['a', 'b'], ARRAY[1,2]) AS JSON) AS some_map
)
SELECT * FROM dataset
```

This query returns:

```
+-----+
| hello_msg      | some_int   | some_map      |
+-----+
| "HELLO ATHENA" | 12345     | {"a":1,"b":2} |
+-----+
```

Converting JSON to Athena Data Types

To convert JSON data to Athena data types, use `CAST`.

Note

In this example, to denote strings as JSON-encoded, start with the `JSON` keyword and use single quotes, such as `JSON '12345'`

```
WITH dataset AS (
    SELECT
        CAST(JSON '"HELLO ATHENA"' AS VARCHAR) AS hello_msg,
        CAST(JSON '12345' AS INTEGER) AS some_int,
        CAST(JSON '{"a":1,"b":2}' AS MAP(VARCHAR, INTEGER)) AS some_map
)
SELECT * FROM dataset
```

This query returns:

```
+-----+
| hello_msg | some_int | some_map |
+-----+
| HELLO ATHENA | 12345 | {a:1,b:2} |
+-----+
```

Extracting Data from JSON

You may have source data with containing JSON-encoded strings that you do not necessarily want to deserialize into a table in Athena. In this case, you can still run SQL operations on this data, using the JSON functions available in Presto.

Consider this JSON string as an example dataset.

```
{"name": "Susan Smith",
"org": "engineering",
"projects":
[
    {
        "name": "project1", "completed": false},
        {"name": "project2", "completed": true}
    ]
}
```

Examples: extracting properties

To extract the name and projects properties from the JSON string, use the `json_extract` function as in the following example. The `json_extract` function takes the column containing the JSON string, and searches it using a JSONPath-like expression with the dot `.` notation.

Note

JSONPath performs a simple tree traversal. It uses the `$` sign to denote the root of the JSON document, followed by a period and an element nested directly under the root, such as `$.name`.

```
WITH dataset AS (
    SELECT '{"name": "Susan Smith",
            "org": "engineering",
            "projects": [{"name": "project1", "completed": false},
                        {"name": "project2", "completed": true}]}'
        AS blob
)
SELECT
    json_extract(blob, '$.name') AS name,
    json_extract(blob, '$.projects') AS projects
FROM dataset
```

The returned value is a JSON-encoded string, and not a native Athena data type.

```
+-----+
+          |
| name      | projects
|           |
+-----+
+          |
| "Susan Smith" | [{"name": "project1", "completed": false},
| {"name": "project2", "completed": true}] |
+-----+
+          |
```

To extract the scalar value from the JSON string, use the `json_extract_scalar` function. It is similar to `json_extract`, but returns only scalar values (Boolean, number, or string).

Note

Do not use the `json_extract_scalar` function on arrays, maps, or structs.

```
WITH dataset AS (
    SELECT '{"name": "Susan Smith",
            "org": "engineering",
            "projects": [{"name": "project1", "completed": false}, {"name": "project2",
            "completed": true}]}'
            AS blob
)
SELECT
    json_extract_scalar(blob, '$.name') AS name,
    json_extract_scalar(blob, '$.projects') AS projects
FROM dataset
```

This query returns:

name	projects
Susan Smith	

To obtain the first element of the `projects` property in the example array, use the `json_array_get` function and specify the index position.

```
WITH dataset AS (
    SELECT '{"name": "Bob Smith",
            "org": "engineering",
            "projects": [{"name": "project1", "completed": false}, {"name": "project2",
            "completed": true}]}'
            AS blob
)
SELECT json_array_get(json_extract(blob, '$.projects'), 0) AS item
FROM dataset
```

It returns the value at the specified index position in the JSON-encoded array.

item
{ "name": "project1", "completed": false }

To return an Athena string type, use the `[]` operator inside a JSONPath expression, then Use the `json_extract_scalar` function. For more information about `[]`, see [Accessing Array Elements \(p. 139\)](#).

```
WITH dataset AS (
    SELECT '{"name": "Bob Smith",
            "org": "engineering",
            "projects": [{"name": "project1", "completed": false}, {"name": "project2",
            "completed": true}]}'
            AS blob
)
SELECT json_extract_scalar(blob, '$.projects[0].name') AS project_name
```

```
FROM dataset
```

It returns this result:

```
+-----+  
| project_name |  
+-----+  
| project1     |  
+-----+
```

Searching for Values in JSON Arrays

To determine if a specific value exists inside a JSON-encoded array, use the `json_array_contains` function.

The following query lists the names of the users who are participating in "project2".

```
WITH dataset AS (  
    SELECT * FROM (VALUES  
        (JSON '{"name": "Bob Smith", "org": "legal", "projects": ["project1"]}'),  
        (JSON '{"name": "Susan Smith", "org": "engineering", "projects": ["project1",  
        "project2", "project3"]}',  
        (JSON '{"name": "Jane Smith", "org": "finance", "projects": ["project1", "project2"]}'))  
    ) AS t (users)  
)  
SELECT json_extract_scalar(users, '$.name') AS user  
FROM dataset  
WHERE json_array_contains(json_extract(users, '$.projects'), 'project2')
```

This query returns a list of users.

```
+-----+  
| user      |  
+-----+  
| Susan Smith |  
+-----+  
| Jane Smith  |  
+-----+
```

The following query example lists the names of users who have completed projects along with the total number of completed projects. It performs these actions:

- Uses nested `SELECT` statements for clarity.
- Extracts the array of projects.
- Converts the array to a native array of key-value pairs using `CAST`.
- Extracts each individual array element using the `UNNEST` operator.
- Filters obtained values by completed projects and counts them.

Note

When using `CAST` to `MAP` you can specify the key element as `VARCHAR` (native `String` in Presto), but leave the value as `JSON`, because the values in the `MAP` are of different types: `String` for the first key-value pair, and `Boolean` for the second.

```
WITH dataset AS (  
    SELECT * FROM (VALUES
```

```
(JSON '{"name": "Bob Smith",
        "org": "legal",
        "projects": [{"name": "project1", "completed": false}]}),
(JSON '{"name": "Susan Smith",
        "org": "engineering",
        "projects": [{"name": "project2", "completed": true},
                    {"name": "project3", "completed": true}]}),
(JSON '{"name": "Jane Smith",
        "org": "finance",
        "projects": [{"name": "project2", "completed": true}]})
) AS t (users)
),
employees AS (
    SELECT users, CAST(json_extract(users, '$.projects') AS
        ARRAY(MAP(VARCHAR, JSON))) AS projects_array
    FROM dataset
),
names AS (
    SELECT json_extract_scalar(users, '$.name') AS name, projects
    FROM employees, UNNEST (projects_array) AS t(projects)
)
SELECT name, count(projects) AS completed_projects FROM names
WHERE cast(element_at(projects, 'completed') AS BOOLEAN) = true
GROUP BY name
```

This query returns the following result:

name	completed_projects
Susan Smith	2
Jane Smith	1

Obtaining Length and Size of JSON Arrays

Example: `json_array_length`

To obtain the length of a JSON-encoded array, use the `json_array_length` function.

```
WITH dataset AS (
    SELECT * FROM (VALUES
        (JSON '{"name":
            "Bob Smith",
            "org":
            "legal",
            "projects": [{"name": "project1", "completed": false}]}),
        (JSON '{"name": "Susan Smith",
            "org": "engineering",
            "projects": [{"name": "project2", "completed": true},
                        {"name": "project3", "completed": true}]}),
        (JSON '{"name": "Jane Smith",
            "org": "finance",
            "projects": [{"name": "project2", "completed": true}]})
    ) AS t (users)
)
SELECT
    json_extract_scalar(users, '$.name') as name,
    json_array_length(json_extract(users, '$.projects')) as count
FROM dataset
```

```
| ORDER BY count DESC
```

This query returns this result:

name	count
Susan Smith	2
Bob Smith	1
Jane Smith	1

Example: json_size

To obtain the size of a JSON-encoded array or object, use the `json_size` function, and specify the column containing the JSON string and the JSONPath expression to the array or object.

```
WITH dataset AS (
    SELECT * FROM (VALUES
        (JSON '{"name": "Bob Smith", "org": "legal", "projects": [{"name": "project1", "completed": false}]}' ),
        (JSON '{"name": "Susan Smith", "org": "engineering", "projects": [{"name": "project2", "completed": true}, {"name": "project3", "completed": true}]}'),
        (JSON '{"name": "Jane Smith", "org": "finance", "projects": [{"name": "project2", "completed": true}]}')
    ) AS t (users)
)
SELECT
    json_extract_scalar(users, '$.name') as name,
    json_size(users, '$.projects') as count
FROM dataset
ORDER BY count DESC
```

This query returns this result:

name	count
Susan Smith	2
Bob Smith	1
Jane Smith	1

Querying Geospatial Data

Geospatial data contains identifiers that specify a geographic position for an object. Examples of this type of data include weather reports, map directions, tweets with geographic positions, store locations, and airline routes. Geospatial data plays an important role in business analytics, reporting, and forecasting.

Geospatial identifiers, such as latitude and longitude, allow you to convert any mailing address into a set of geographic coordinates.

Topics

- [What is a Geospatial Query? \(p. 158\)](#)
- [Input Data Formats and Geometry Data Types \(p. 158\)](#)
- [List of Supported Geospatial Functions \(p. 159\)](#)
- [Examples: Geospatial Queries \(p. 167\)](#)

What is a Geospatial Query?

Geospatial queries are specialized types of SQL queries supported in Athena. They differ from non-spatial SQL queries in the following ways:

- Using the following specialized geometry data types: `point`, `line`, `multiline`, `polygon`, and `multipolygon`.
- Expressing relationships between geometry data types, such as `distance`, `equals`, `crosses`, `touches`, `overlaps`, `disjoint`, and others.

Using geospatial queries in Athena, you can run these and other similar operations:

- Find the distance between two points.
- Check whether one area (polygon) contains another.
- Check whether one line crosses or touches another line or polygon.

For example, to obtain a point geometry data type from a pair of double values for the geographic coordinates of Mount Rainier in Athena, use the `ST_POINT (double, double) (longitude, latitude)` geospatial function, specifying the longitude first, then latitude:

```
ST_POINT(-121.7602, 46.8527) (longitude, latitude)
```

Input Data Formats and Geometry Data Types

To use geospatial functions in Athena, input your data in the WKT format, or use the Hive JSON SerDe. You can also use the geometry data types supported in Athena.

Input Data Formats

To handle geospatial queries, Athena supports input data in these data formats:

- **WKT (Well-known Text).** In Athena, WKT is represented as a `varchar` data type.
- **JSON-encoded geospatial data.** To parse JSON files with geospatial data and create tables for them, Athena uses the [Hive JSON SerDe](#). For more information about using this SerDe in Athena, see [JSON SerDe Libraries \(p. 285\)](#).

Geometry Data Types

To handle geospatial queries, Athena supports these specialized geometry data types:

- `point`
- `line`
- `polygon`

- `multiline`
- `multipolygon`

List of Supported Geospatial Functions

Geospatial functions in Athena have these characteristics:

- The functions follow the general principles of [Spatial Query](#).
- The functions are implemented as a Presto plugin that uses the ESRI Java Geometry Library. This library has an Apache 2 license.
- The functions rely on the [ESRI Geometry API](#).
- Not all of the ESRI-supported functions are available in Athena. This topic lists only the ESRI geospatial functions that are supported in Athena.
- You cannot use views with geospatial functions.

Athena supports four types of geospatial functions:

- [Constructor Functions \(p. 160\)](#)
- [Geospatial Relationship Functions \(p. 161\)](#)
- [Operation Functions \(p. 163\)](#)
- [Accessor Functions \(p. 164\)](#)

Before You Begin

Create two tables, `earthquakes` and `counties`, as follows:

```
CREATE external TABLE earthquakes
(
    earthquake_date STRING,
    latitude DOUBLE,
    longitude DOUBLE,
    depth DOUBLE,
    magnitude DOUBLE,
    magtype string,
    mbstations string,
    gap string,
    distance string,
    rms string,
    source string,
    eventid string
)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
STORED AS TEXTFILE LOCATION 's3://my-query-log/csv'
```

```
CREATE external TABLE IF NOT EXISTS counties
(
    Name string,
    BoundaryShape binary
)
ROW FORMAT SERDE 'com.esri.hadoop.hive.serde.JsonSerde'
STORED AS INPUTFORMAT 'com.esri.json.hadoop.EnclosedJsonInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://my-query-log/json'
```

Some of the subsequent examples are based on these tables and rely on two sample files stored in the Amazon S3 location. These files are not included with Athena and are used for illustration purposes only:

- An `earthquakes.csv` file, which lists earthquakes that occurred in California. This file has fields that correspond to the fields in the table `earthquakes`.
- A `california-counties.json` file, which lists JSON-encoded county data in the ESRI-compliant format, and includes many fields, such as `AREA`, `PERIMETER`, `STATE`, `COUNTY`, and `NAME`. The `counties` table is based on this file and has two fields only: `Name` (string), and `BoundaryShape` (binary).

Constructor Functions

Use constructor functions to obtain binary representations of point, line, or polygon geometry data types. You can also use these functions to convert binary data to text, and obtain binary values for geometry data that is expressed as Well-Known Text (WKT).

`ST_POINT(double, double)`

Returns a binary representation of a point geometry data type.

To obtain the point geometry data type, use the `ST_POINT` function in Athena. For the input data values to this function, use geometric values, such as values in the Universal Transverse Mercator (UTM) Cartesian coordinate system, or geographic map units (longitude and latitude) in decimal degrees. The longitude and latitude values use the World Geodetic System, also known as WGS 1984, or EPSG:4326. WGS 1984 is the coordinate system used by the Global Positioning System (GPS).

For example, in the following notation, the map coordinates are specified in longitude and latitude, and the value `.072284`, which is the buffer distance, is specified in angular units as decimal degrees:

```
ST_BUFFER(ST_POINT(-74.006801, 40.705220), .072284)
```

Syntax:

```
SELECT ST_POINT(longitude, latitude) FROM earthquakes LIMIT 1;
```

In the alternative syntax, you can also specify the coordinates as a point data type with two values:

```
SELECT ST_POINT('point (-74.006801 40.705220)');
```

Example. This example uses specific longitude and latitude coordinates from `earthquakes.csv`:

```
SELECT ST_POINT(61.56, -158.54)
FROM earthquakes
LIMIT 1;
```

It returns this binary representation of a geometry data type point:

```
00 00 00 00 01 01 00 00 00 48 e1 7a 14 ae c7 4e 40 e1 7a 14 ae 47 d1 63 c0
```

The next example uses specific longitude and latitude coordinates:

```
SELECT ST_POINT(-74.006801, 40.705220);
```

It returns this binary representation of a geometry data type point:

```
00 00 00 00 01 01 00 00 00 20 25 76 6d 6f 80 52 c0 18 3e 22 a6 44 5a 44 40
```

In the following example, we use the ST_Geometry_TO_Text function to obtain the binary values from WKT:

```
SELECT ST_Geometry_TO_Text(ST_Point(-74.006801, 40.705220)) AS WKT;
```

This query returns a WKT representation of the point geometry type: 1 POINT (-74.006801 40.70522).

ST_Line(varchar)

Returns a value in the line data type, which is a binary representation of the [geometry data type \(p. 158\)](#) line. Example:

```
SELECT ST_Line('linestring(1 1, 2 2, 3 3)')
```

ST_Polygon(varchar)

Returns a value in the polygon data type, which is a binary representation of the [geometry data type \(p. 158\)](#) polygon. Example:

```
SELECT ST_Polygon('polygon ((1 1, 1 4, 4 4, 4 1))')
```

ST_Geometry_TO_Text (varbinary)

Converts each of the specified [geometry data types \(p. 158\)](#) to text. Returns a value in a geometry data type, which is a WKT representation of the geometry data type. Example:

```
SELECT ST_Geometry_TO_Text(ST_Point(61.56, -158.54))
```

ST_Geometry_From_Text (varchar)

Converts text into a geometry data type. Returns a value in a geometry data type, which is a binary representation of the geometry data type. Example:

```
SELECT ST_Geometry_From_Text(ST_Geometry_TO_Text(ST_Point(1, 2)))
```

Geospatial Relationship Functions

The following functions express relationships between two different geometries that you specify as input. They return results of type boolean. The order in which you specify the pair of geometries matters: the first geometry value is called the left geometry, the second geometry value is called the right geometry.

These functions return:

- TRUE if and only if the relationship described by the function is satisfied.
- FALSE if and only if the relationship described by the function is not satisfied.

ST_CONTAINS (geometry, geometry)

Returns TRUE if and only if the left geometry contains the right geometry. Examples:

```
SELECT ST_CONTAINS('POLYGON((0 2,1 1,0 -1,0 2))', 'POLYGON((-1 3,2 1,0 -3,-1 3))')
```

```
SELECT ST_CONTAINS('POLYGON((0 2,1 1,0 -1,0 2))', ST_Point(0, 0));
```

```
SELECT ST_CONTAINS(ST_Geometry_From_Text('POLYGON((0 2,1 1,0 -1,0 2))'),  
                  ST_Geometry_From_Text('POLYGON((-1 3,2 1,0 -3,-1 3))'))
```

ST_CROSSES (geometry, geometry)

Returns TRUE if and only if the left geometry crosses the right geometry. Example:

```
SELECT ST_CROSSES(ST_LINE('linestring(1 1, 2 2)'), ST_LINE('linestring(0 1, 2 2)'))
```

ST_DISJOINT (geometry, geometry)

Returns TRUE if and only if the intersection of the left geometry and the right geometry is empty. Example:

```
SELECT ST_Disjoint(ST_LINE('linestring(0 0, 0 1)'), ST_LINE('linestring(1 1, 1 0)'))
```

ST_EQUALS (geometry, geometry)

Returns TRUE if and only if the left geometry equals the right geometry. Example:

```
SELECT ST_Equals(ST_LINE('linestring( 0 0, 1 1)'), ST_LINE('linestring(1 3, 2 2)'))
```

ST_INTERSECTS (geometry, geometry)

Returns TRUE if and only if the left geometry intersects the right geometry. Example:

```
SELECT ST_Intersects(ST_LINE('linestring(8 7, 7 8)'), ST_Polygon('polygon((1 1, 4 1, 4 4, 1  
4))'))
```

ST_OVERLAPS (geometry, geometry)

Returns TRUE if and only if the left geometry overlaps the right geometry. Example:

```
SELECT ST_Overlaps(ST_Polygon('polygon((2 0, 2 1, 3 1))'), ST_Polygon('polygon((1 1, 1 4, 4  
4, 4 1))'))
```

ST_RELATE (geometry, geometry)

Returns TRUE if and only if the left geometry has the specified Dimensionally Extended nine-Intersection Model (DE-9IM) relationship with the right geometry. For more information, see the Wikipedia topic [DE-9IM](#). Example:

```
SELECT ST_Relate(ST_LINE('linestring(0 0, 3 3)'), ST_LINE('linestring(1 1, 4 4)'),  
                 '*****')
```

ST_TOUCHES (geometry, geometry)

Returns TRUE if and only if the left geometry touches the right geometry.

Example:

```
SELECT ST_TOUCHES(ST_POINT(8, 8), ST_POLYGON('polygon((1 1, 1 4, 4 4, 4 1))'))
```

ST_WITHIN (geometry, geometry)

Returns TRUE if and only if the left geometry is within the right geometry.

Example:

```
SELECT ST_WITHIN(ST_POINT(8, 8), ST_POLYGON('polygon((1 1, 1 4, 4 4, 4 1))'))
```

Operation Functions

Use operation functions to perform operations on geometry data type values. For example, you can obtain the boundaries of a single geometry data type; intersections between two geometry data types; difference between left and right geometries, where each is of the same geometry data type; or an exterior buffer or ring around a particular geometry data type.

All operation functions take as an input one of the geometry data types and return their binary representations.

ST_BOUNDARY (geometry)

Takes as an input one of the geometry data types, and returns a binary representation of the boundary geometry data type.

Examples:

```
SELECT ST_BOUNDARY(ST_LINE('linestring(0 1, 1 0)'))
```

```
SELECT ST_BOUNDARY(ST_POLYGON('polygon((1 1, 1 4, 4 4, 4 1))'))
```

ST_BUFFER (geometry, double)

Takes as an input one of the geometry data types, such as point, line, polygon, multiline, or multipolygon, and a distance as type double). Returns a binary representation of the geometry data type buffered by the specified distance (or radius). Example:

```
SELECT ST_BUFFER(ST_Point(1, 2), 2.0)
```

In the following example, the map coordinates are specified in longitude and latitude, and the value .072284, which is the buffer distance, is specified in angular units as decimal degrees:

```
ST_BUFFER(ST_POINT(-74.006801, 40.705220), .072284)
```

ST_DIFFERENCE (geometry, geometry)

Returns a binary representation of a difference between the left geometry and right geometry. Example:

```
SELECT ST_Geometry_TO_Text(ST_Difference(ST_Polygon('polygon((0 0, 0 10, 10 10, 10 0))'),  
ST_Polygon('polygon((0 0, 0 5, 5 5, 5 0))')))
```

ST_ENVELOPE (geometry)

Takes as an input line, polygon, multiline, and multipolygon geometry data types. Does not support point geometry data type. Returns a binary representation of an envelope, where an envelope is a rectangle around the specified geometry data type. Examples:

```
SELECT ST_Envelope(ST_Line('linestring(0 1, 1 0)'))
```

```
SELECT ST_Envelope(ST_Polygon('polygon((1 1, 1 4, 4 4, 4 1))'))
```

ST_EXTERIOR_RING (geometry)

Returns a binary representation of the exterior ring of the input type polygon. Examples:

```
SELECT ST_ExteriorRing(ST_Polygon(1,1, 1,4, 4,1))
```

```
SELECT ST_ExteriorRing(ST_Polygon('polygon ((0 0, 8 0, 0 8, 0 0), (1 1, 1 5, 5 1, 1 1))'))
```

ST_INTERSECTION (geometry, geometry)

Returns a binary representation of the intersection of the left geometry and right geometry. Examples:

```
SELECT ST_Intersection(ST_Point(1,1), ST_Point(1,1))
```

```
SELECT ST_Intersection(ST_Line('linestring(0 1, 1 0)'), ST_Polygon('polygon((1 1, 1 4, 4 4, 4 1))'))
```

```
SELECT ST_Geometry_TO_Text(ST_Intersection(ST_Polygon('polygon((2 0, 2 3, 3 0))'),  
ST_Polygon('polygon((1 1, 4 1, 4 4, 1 4))')))
```

ST_SYMMETRIC_DIFFERENCE (geometry, geometry)

Returns a binary representation of the geometrically symmetric difference between left geometry and right geometry. Example:

```
SELECT ST_Geometry_TO_Text(ST_SymmetricDifference(ST_Line('linestring(0 2, 2 2)'),  
ST_Line('linestring(1 2, 3 2)')))
```

Accessor Functions

Accessor functions are useful to obtain values in types `varchar`, `bigint`, or `double` from different geometry data types, where `geometry` is any of the geometry data types supported in Athena: `point`, `line`, `polygon`, `multiline`, and `multipolygon`. For example, you can obtain an area of a `polygon` geometry data type, maximum and minimum X and Y values for a specified geometry data type, obtain the length of a `line`, or receive the number of points in a specified geometry data type.

ST_AREA (geometry)

Takes as an input a geometry data type `polygon` and returns an area in type `double`. Example:

```
SELECT ST_AREA(ST_POLYGON('polygon((1 1, 4 1, 4 4, 1 4))'))
```

ST_CENTROID (geometry)

Takes as an input a [geometry data type \(p. 158\)](#) polygon, and returns a point that is the center of the polygon's envelope in type varchar. Examples:

```
SELECT ST_CENTROID(ST_Geometry_From_Text('polygon ((0 0, 3 6, 6 0, 0 0))'))
```

```
SELECT ST_Geometry_To_Text(ST_Centroid(ST_Envelope(ST_Geometry_From_Text('POINT (53 27)'))))
```

ST_COORDINATE_DIMENSION (geometry)

Takes as input one of the supported [geometry data types \(p. 158\)](#), and returns the count of coordinate components in type bigint. Example:

```
SELECT ST_Coordinate_Dimension(ST_Point(1.5,2.5))
```

ST_DIMENSION (geometry)

Takes as an input one of the supported [geometry data types \(p. 158\)](#), and returns the spatial dimension of a geometry in type bigint. Example:

```
SELECT ST_Dimension(ST_Polygon('polygon((1 1, 4 1, 4 4, 1 4))'))
```

ST_DISTANCE (geometry, geometry)

Returns the distance in type double between the left geometry and the right geometry. Example:

```
SELECT ST_Distance(ST_Point(0.0,0.0), ST_Point(3.0,4.0))
```

ST_IS_CLOSED (geometry)

Returns TRUE (type boolean) if and only if the line is closed. Example:

```
SELECT ST_Is_Closed(ST_Line('linestring(0 2, 2 2)'))
```

ST_IS_EMPTY (geometry)

Takes as an input only line and multiline [geometry data types \(p. 158\)](#). Returns TRUE (type boolean) if and only if the specified geometry is empty, in other words, when the line start and end values co-inside. Example:

```
SELECT ST_Is_Empty(ST_Point(1.5, 2.5))
```

ST_IS_RING (geometry)

Returns TRUE (type boolean) if and only if the line type is closed and simple. Example:

```
SELECT ST_Is_Ring(ST_Line('linestring(0 2, 2 2)'))
```

ST_LENGTH (geometry)

Returns the length of line in type double. Example:

```
SELECT ST_LENGTH(ST_LINE('linestring(0 2, 2 2)'))
```

ST_MAX_X (geometry)

Returns the maximum X coordinate of a geometry in type double. Example:

```
SELECT ST_MAX_X(ST_LINE('linestring(0 2, 2 2)'))
```

ST_MAX_Y (geometry)

Returns the maximum Y coordinate of a geometry in type double. Example:

```
SELECT ST_MAX_Y(ST_LINE('linestring(0 2, 2 2)'))
```

ST_MIN_X (geometry)

Returns the minimum X coordinate of a geometry in type double. Example:

```
SELECT ST_MIN_X(ST_LINE('linestring(0 2, 2 2)'))
```

ST_MIN_Y (geometry)

Returns the minimum Y coordinate of a geometry in type double. Example:

```
SELECT ST_MIN_Y(ST_LINE('linestring(0 2, 2 2)'))
```

ST_START_POINT (geometry)

Returns the first point of a line geometry data type in type point. Example:

```
SELECT ST_START_POINT(ST_LINE('linestring(0 2, 2 2)'))
```

ST_END_POINT (geometry)

Returns the last point of a line geometry data type in type point. Example:

```
SELECT ST_END_POINT(ST_LINE('linestring(0 2, 2 2)'))
```

ST_X (point)

Returns the X coordinate of a point in type double. Example:

```
SELECT ST_X(ST_POINT(1.5, 2.5))
```

ST_Y (point)

Returns the Y coordinate of a point in type double. Example:

```
SELECT ST_Y(ST_POINT(1.5, 2.5))
```

[ST_POINT_NUMBER \(geometry\)](#)

Returns the number of points in the geometry in type bigint. Example:

```
SELECT ST_POINT_NUMBER(ST_POINT(1.5, 2.5))
```

[ST_INTERIOR_RING_NUMBER \(geometry\)](#)

Returns the number of interior rings in the polygon geometry in type bigint. Example:

```
SELECT ST_INTERIOR_RING_NUMBER(ST_POLYGON('polygon ((0 0, 8 0, 0 8, 0 0), (1 1, 1 5, 5 1, 1 1))'))
```

Examples: Geospatial Queries

The following examples create two tables and issue a query against them.

Note

These files are *not* included with the product and are used in the documentation for illustration purposes only. They contain sample data and are not guaranteed to be accurate.

These examples rely on two files:

- An `earthquakes.csv` sample file, which lists earthquakes that occurred in California. This file has fields that correspond to the fields in the table `earthquakes` in the following example.
- A `california-counties.json` file, which lists JSON-encoded county data in the ESRI-compliant format, and includes many fields such as `AREA`, `PERIMETER`, `STATE`, `COUNTY`, and `NAME`. The following example shows the `counties` table from this file with two fields only: `Name` (string), and `BoundaryShape` (binary).

For additional examples of geospatial queries, see these blog posts:

- [Querying OpenStreetMap with Amazon Athena](#)
- [Visualize over 200 years of global climate data using Amazon Athena and Amazon QuickSight](#).

The following code example creates a table called `earthquakes`:

```
CREATE external TABLE earthquakes
(
    earthquake_date string,
    latitude double,
    longitude double,
    depth double,
    magnitude double,
    magtype string,
    mbstations string,
    gap string,
    distance string,
    rms string,
    source string,
    eventid string
)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
STORED AS TEXTFILE LOCATION 's3://my-query-log/csv/';
```

The following code example creates a table called counties:

```
CREATE external TABLE IF NOT EXISTS counties
(
    Name string,
    BoundaryShape binary
)
ROW FORMAT SERDE 'com.esri.hadoop.hive.serde.JsonSerde'
STORED AS INPUTFORMAT 'com.esri.json.hadoop.EnclosedJsonInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://my-query-log/json/';
```

The following code example uses the CROSS JOIN function for the two tables created earlier. Additionally, for both tables, it uses ST_CONTAINS and asks for counties whose boundaries include a geographical location of the earthquakes, specified with ST_POINT. It then groups such counties by name, orders them by count, and returns them in descending order.

```
SELECT counties.name,
       COUNT(*) cnt
FROM counties
CROSS JOIN earthquakes
WHERE ST_CONTAINS (counties.boundaryshape, ST_POINT(earthquakes.longitude,
   earthquakes.latitude))
GROUP BY counties.name
ORDER BY cnt DESC
```

This query returns:

name	cnt
Kern	36
San Bernardino	35
Imperial	28
Inyo	20
Los Angeles	18
Riverside	14
Monterey	14
Santa Clara	12
San Benito	11
Fresno	11
San Diego	7
Santa Cruz	5
Ventura	3
San Luis Obispo	3
Orange	2
San Mateo	1

Using Machine Learning (ML) with Amazon Athena (Preview)

Machine Learning (ML) with Amazon Athena (Preview) lets you use Athena to write SQL statements that run Machine Learning (ML) inference using Amazon SageMaker. This feature simplifies access to ML models for data analysis, eliminating the need to use complex programming methods to run inference.

To use ML with Athena (Preview), you define an ML with Athena (Preview) function with the `USING FUNCTION` clause. The function points to the Amazon SageMaker model endpoint that you want to use and specifies the variable names and data types to pass to the model. Subsequent clauses in the query reference the function to pass values to the model. The model runs inference based on the values that the query passes and then returns inference results. For more information about Amazon SageMaker and how Amazon SageMaker endpoints work, see [Deploy a Model on Amazon SageMaker Hosting Services](#) in the [Amazon SageMaker Developer Guide](#).

Considerations and Limitations

- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named `AmazonAthenaPreviewFunctionality` and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).
- **Amazon SageMaker model endpoint must accept and return `text/csv`** – For more information about data formats, see [Common Data Formats for Inference](#) in the [Amazon SageMaker Developer Guide](#).
- **Amazon SageMaker endpoint scaling** – Make sure that the referenced Amazon SageMaker model endpoint is sufficiently scaled up for Athena calls to the endpoint. For more information, see [Automatically Scale Amazon SageMaker Models](#) in the [Amazon SageMaker Developer Guide](#) and [CreateEndpointConfig](#) in the [Amazon SageMaker API Reference](#).
- **IAM permissions** – To run a query that specifies an ML with Athena (Preview) function, the IAM principal running the query must be allowed to perform the `sagemaker:InvokeEndpoint` action for the referenced Amazon SageMaker model endpoint. For more information, see [Allowing Access for ML with Athena \(Preview\) \(p. 225\)](#).
- **ML with Athena (Preview) functions cannot be used in `GROUP BY` clauses directly**

ML with Athena (Preview) Syntax

The `USING FUNCTION` clause specifies an ML with Athena (Preview) function or multiple functions that can be referenced by a subsequent `SELECT` statement in the query. You define the function name, variable names, and data types for the variables and return values.

Synopsis

The following example illustrates a `USING FUNCTION` clause that specifies ML with Athena (Preview) function.

```
USING FUNCTION ML_function_name(variable1 data_type[, variable2 data_type][,...])
RETURNS data_type TYPE SAGEMAKER_INVOKE_ENDPOINT WITH (sagemaker_endpoint=
'my_sagemaker_endpoint'[, FUNCTION...][, ...] SELECT [...] ML_function_name(expression)
[...]
```

Parameters

USING FUNCTION *ML_function_name*(*variable1 data_type*[, *variable2 data_type*][,...])

ML_function_name defines the function name, which can be used in subsequent query clauses. Each *variable data_type* specifies a named variable with its corresponding data type, which the Amazon SageMaker model can accept as input. Specify *data_type* as one of the supported Athena data types that the Amazon SageMaker model can accept as input.

RETURNS *data_type* TYPE

data_type specifies the SQL data type that *ML_function_name* returns to the query as output from the Amazon SageMaker model.

SAGEMAKER_INVOKE_ENDPOINT WITH (*sagemaker_endpoint*= '*my_sagemaker_endpoint*')

my_sagemaker_endpoint specifies the endpoint of the Amazon SageMaker model.

SELECT [...] *ML_function_name*(*expression*) [...]

The SELECT query that passes values to function variables and the Amazon SageMaker model to return a result. *ML_function_name* specifies the function defined earlier in the query, followed by an *expression* that is evaluated to pass values. Values that are passed and returned must match the corresponding data types specified for the function in the USING FUNCTION clause.

Examples

The following example demonstrates a query using ML with Athena (Preview).

Example

```
USING FUNCTION predict_customer_registration(age INTEGER)
    RETURNS DOUBLE TYPE
    SAGEMAKER_INVOKE_ENDPOINT WITH (sagemaker_endpoint =
    'xgboost-2019-09-20-04-49-29-303')
SELECT predict_customer_registration(age) AS probability_of_enrolling, customer_id
    FROM "sampleddb"."ml_test_dataset"
    WHERE predict_customer_registration(age) < 0.5;
```

Querying with User Defined Functions (Preview)

User Defined Functions (UDF) in Amazon Athena allow you to create custom functions to process records or groups of records. A UDF accepts parameters, performs work, and then returns a result.

To use a UDF in Athena, you write a USING FUNCTION clause before a SELECT statement in a SQL query. The SELECT statement references the UDF and defines the variables that are passed to the UDF when the query runs. The SQL query invokes a Lambda function using the Java runtime when it calls the UDF. UDFs are defined within the Lambda function as methods in a Java deployment package. Multiple UDFs can be defined in the same Java deployment package for a Lambda function. You also specify the name of the Lambda function in the USING FUNCTION clause.

You have two options for deploying a Lambda function for Athena UDFs. You can deploy the function directly using Lambda, or you can use the AWS Serverless Application Repository. To find existing Lambda functions for UDFs, you can search the public AWS Serverless Application Repository or your private repository and then deploy to Lambda. You can also create or modify Java source code, package it into a JAR file, and deploy it using Lambda or the AWS Serverless Application Repository. We provide example Java source code and packages to get you started. For more information about Lambda, see [AWS Lambda Developer Guide](#). For more information about AWS Serverless Application Repository, see the [AWS Serverless Application Repository Developer Guide](#).

Considerations and Limitations

- **AmazonAthenaPreviewFunctionality workgroup** – To use this feature in preview, you must create an Athena workgroup named AmazonAthenaPreviewFunctionality and join that workgroup. For more information, see [Managing Workgroups \(p. 248\)](#).
- **Built-in Athena functions** – Built-in Presto functions in Athena are designed to be highly performant. We recommend that you use built-in functions over UDFs when possible. For more information about built-in functions, see [Presto Functions in Amazon Athena \(p. 306\)](#).
- **Scalar UDFs only** – Athena only supports scalar UDFs, which process one row at a time and return a single column value. Athena passes a batch of rows, potentially in parallel, to the UDF each time it invokes Lambda. When designing UDFs and queries, be mindful of the potential impact to network traffic that this processing design can have.
- **Java runtime only** – Currently, Athena UDFs support only the Java 8 runtime for Lambda.
- **IAM permissions** – To run a query in Athena that contains a UDF query statement and to create UDF statements, the IAM principal running the query must be allowed to perform actions in addition to Athena functions. For more information, see [Example IAM Permissions Policies to Allow Amazon Athena User Defined Functions \(UDF\) \(p. 221\)](#).
- **Lambda limits** – Lambda limits apply to UDFs. For more information, see [AWS Lambda Limits](#) in the [AWS Lambda Developer Guide](#).
- **Known issues** – For the most up-to-date list of known issues, see [Limitations and Issues](#) in the Athena Federated Query (Preview)

UDF Query Syntax

The `USING FUNCTION` clause specifies a UDF or multiple UDFs that can be referenced by a subsequent `SELECT` statement in the query. You need the method name for the UDF and the name of the Lambda function that hosts the UDF.

Synopsis

```
USING FUNCTION UDF_name(variable1 data_type[, variable2 data_type][,...]) RETURNS data_type
    TYPE
        LAMBDA_INVOKE WITH (lambda_name = 'my_lambda_function')[, FUNCTION][, ...] SELECT
    [...] UDF_name(expression) [...]
```

Parameters

USING FUNCTION *UDF_name*(*variable1 data_type*[, *variable2 data_type*][,...])

UDF_name specifies the name of the UDF, which must correspond to a Java method within the referenced Lambda function. Each *variable data_type* specifies a named variable with its corresponding data type, which the UDF can accept as input. Specify *data_type* as one of the supported Athena data types listed in the following table. The data type must map to the corresponding Java data type.

Athena data type	Java data type
TIMESTAMP	java.time.LocalDateTime (UTC)
DATE	java.time.LocalDate (UTC)
TINYINT	java.lang.Byte

Athena data type	Java data type
SMALLINT	java.lang.Short
REAL	java.lang.Float
DOUBLE	java.lang.Double
DECIMAL	java.math.BigDecimal
BIGINT	java.lang.Long
INTEGER	java.lang.Int
VARCHAR	java.lang.String
VARBINARY	byte[]
BOOLEAN	java.lang.Boolean
ARRAY	java.util.List
ROW	java.util.Map<String, Object>

RETURNS data_type TYPE

`data_type` specifies the SQL data type that the UDF returns as output. Athena data types listed in the table above are supported.

LAMBDA_INVOKE WITH (lambda_name = '*my_lambda_function*')

`my_lambda_function` specifies the name of the Lambda function to be invoked when running the UDF.

SELECT [...] UDF_name(expression) [...]

The SELECT query that passes values to the UDF and returns a result. `UDF_name` specifies the UDF to use, followed by an expression that is evaluated to pass values. Values that are passed and returned must match the corresponding data types specified for the UDF in the `USING FUNCTION` clause.

Examples

The following examples demonstrate queries using UDFs. The Athena query examples are based on the [AthenaUDFHandler.java](#) code in GitHub.

Example – Compress and Decompress a String

Athena SQL

The following example demonstrates using the `compress` UDF defined in a Lambda function named `MyAthenaUDFLambda`.

```
USING FUNCTION compress(col1 VARCHAR)
RETURNS VARCHAR TYPE
LAMBDA_INVOKE WITH (lambda_name = 'MyAthenaUDFLambda')
SELECT
    compress('StringToBeCompressed');
```

The query result returns `ewLLinKzEsPyXdKdc7PLShKLS5OTQEAUrEH9w==`.

The following example demonstrates using the decompress UDF defined in the same Lambda function.

```
USING FUNCTION decompress(col1 VARCHAR)
RETURNS VARCHAR TYPE
LAMBDA_INVOKE WITH (lambda_name = 'MyAthenaUDFLambda')
SELECT
decompress('ewLLinKzEsPyXdKdc7PLShKLS5OTQEAUrEH9w==');
```

The query result returns StringToBeCompressed.

Creating and Deploying a UDF Using Lambda

To create a custom UDF, you create a new Java class by extending the `UserDefinedFunctionHandler` class. The source code for the `UserDefinedFunctionHandler.java` in the SDK is available on GitHub in the [awslabs/aws-athena-query-federation/athena-federation-sdk repository](#), along with [example UDF implementations](#) that you can examine and modify to create a custom UDF.

The steps in this section demonstrate writing and building a custom UDF Jar file using [Apache Maven](#) from the command line and a deploy.

Steps to Create a Custom UDF for Athena Using Maven

- [Clone the SDK and Prepare Your Development Environment \(p. 173\)](#)
- [Create your Maven Project \(p. 174\)](#)
- [Add Dependencies and Plugins to Your Maven Project \(p. 174\)](#)
- [Write Java Code for the UDFs \(p. 175\)](#)
- [Build the JAR File \(p. 176\)](#)
- [Deploy the JAR to AWS Lambda \(p. 176\)](#)

Clone the SDK and Prepare Your Development Environment

Before you begin, make sure that git is installed on your system using `sudo yum install git -y`.

To install the AWS Query Federation SDK

- Enter the following at the command line to clone the SDK repository. This repository includes the SDK, examples and a suite of data source connectors. For more information about data source connectors, see [Using Amazon Athena Federated Query \(Preview\) \(p. 62\)](#).

```
git clone https://github.com/awslabs/aws-athena-query-federation.git
```

To install prerequisites for this procedure

If you are working on a development machine that already has Apache Maven, the AWS CLI, and the AWS Serverless Application Model build tool installed, you can skip this step.

1. From the root of the `aws-athena-query-federation` directory that you created when you cloned, run the `prepare_dev_env.sh` script that prepares your development environment.

```
source ~/.profile
```

Important

If you skip this step, you will get errors later about the AWS CLI or AWS SAM build tool not being able to publish your Lambda function.

Create your Maven Project

Run the following command to create your Maven project. Replace *groupId* with the unique ID of your organization, and replace *my-athena-udf* with the name of your application. For more information, see [How do I make my first Maven project?](#) in Apache Maven documentation.

```
mvn -B archetype:generate \
-DarchetypeGroupId=org.apache.maven.archetypes \
-DgroupId=groupId \
-DartifactId=my-athena-udf
```

Add Dependencies and Plugins to Your Maven Project

Add the following configurations to your Maven project `pom.xml` file. For an example, see the `pom.xml` file in GitHub.

```
<properties>
    <aws-athena-federation-sdk.version>2019.48.1</aws-athena-federation-sdk.version>
</properties>

<dependencies>
    <dependency>
        <groupId>com.amazonaws</groupId>
        <artifactId>aws-athena-federation-sdk</artifactId>
        <version>${aws-athena-federation-sdk.version}</version>
    </dependency>
</dependencies>

<build>
    <plugins>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-shade-plugin</artifactId>
            <version>3.2.1</version>
            <configuration>
                <createDependencyReducedPom>false</createDependencyReducedPom>
                <filters>
                    <filter>
                        <artifact>*:*</artifact>
                        <excludes>
                            <exclude>META-INF/*.SF</exclude>
                            <exclude>META-INF/*.DSA</exclude>
                            <exclude>META-INF/*.RSA</exclude>
                        </excludes>
                    </filter>
                </filters>
            </configuration>
            <executions>
                <execution>
                    <phase>package</phase>
                    <goals>
                        <goal>shade</goal>
                    </goals>
                </execution>
            </executions>
        </plugin>
    </plugins>
</build>
```

```
</plugins>
</build>
```

Write Java Code for the UDFs

Create a new class by extending [UserDefinedFunctionHandler.java](#). Write your UDFs inside the class.

In the following example, two Java methods for UDFs, `compress()` and `decompress()`, are created inside the class `MyUserDefinedFunctions`.

```
*package *com.mycompany.athena.udfs;

public class MyUserDefinedFunctions
    extends UserDefinedFunctionHandler
{
    private static final String SOURCE_TYPE = "MyCompany";

    public MyUserDefinedFunctions()
    {
        super(SOURCE_TYPE);
    }

    /**
     * Compresses a valid UTF-8 String using the zlib compression library.
     * Encodes bytes with Base64 encoding scheme.
     *
     * @param input the String to be compressed
     * @return the compressed String
     */
    public String compress(String input)
    {
        byte[] inputBytes = input.getBytes(StandardCharsets.UTF_8);

        // create compressor
        Deflater compressor = new Deflater();
        compressor.setInput(inputBytes);
        compressor.finish();

        // compress bytes to output stream
        byte[] buffer = new byte[4096];
        ByteArrayOutputStream byteArrayOutputStream = new
        ByteArrayOutputStream(inputBytes.length);
        while (!compressor.finished()) {
            int bytes = compressor.deflate(buffer);
            byteArrayOutputStream.write(buffer, 0, bytes);
        }

        try {
            byteArrayOutputStream.close();
        }
        catch (IOException e) {
            throw new RuntimeException("Failed to close ByteArrayOutputStream", e);
        }

        // return encoded string
        byte[] compressedBytes = byteArrayOutputStream.toByteArray();
        return Base64.getEncoder().encodeToString(compressedBytes);
    }

    /**
     * Decompresses a valid String that has been compressed using the zlib compression
     * library.
     * Decodes bytes with Base64 decoding scheme.
     *
```

```

    * @param input the String to be decompressed
    * @return the decompressed String
    */
public String decompress(String input)
{
    byte[] inputBytes = Base64.getDecoder().decode((input));

    // create decompressor
    Inflater decompressor = new Inflater();
    decompressor.setInput(inputBytes, 0, inputBytes.length);

    // decompress bytes to output stream
    byte[] buffer = new byte[4096];
    ByteArrayOutputStream byteArrayOutputStream = new
    ByteArrayOutputStream(inputBytes.length);
    try {
        while (!decompressor.finished()) {
            int bytes = decompressor.inflate(buffer);
            if (bytes == 0 && decompressor.needsInput()) {
                throw new DataFormatException("Input is truncated");
            }
            byteArrayOutputStream.write(buffer, 0, bytes);
        }
    }
    catch (DataFormatException e) {
        throw new RuntimeException("Failed to decompress string", e);
    }

    try {
        byteArrayOutputStream.close();
    }
    catch (IOException e) {
        throw new RuntimeException("Failed to close ByteArrayOutputStream", e);
    }

    // return decoded string
    byte[] decompressedBytes = byteArrayOutputStream.toByteArray();
    return new String(decompressedBytes, StandardCharsets.UTF_8);
}
}

```

Build the JAR File

Run `mvn clean install` to build your project. After it successfully builds, a JAR file is created in the target folder of your project named `artifactId-version.jar`, where `artifactId` is the name you provided in the Maven project, for example, `my-athena-udfs`.

Deploy the JAR to AWS Lambda

You have two options to deploy your code to Lambda:

- Deploy Using AWS Serverless Application Repository (Recommended)
- Create a Lambda Function from the JAR file

Option 1: Deploying to the AWS Serverless Application Repository

When you deploy your JAR file to the AWS Serverless Application Repository, you create an AWS SAM template YAML file that represents the architecture of your application. You then specify this YAML file and an Amazon S3 bucket where artifacts for your application are uploaded and made available in the AWS Serverless Application Repository. The procedure below uses the `publish.sh` script located in the

athena-query-federation/tools directory of the Athena Query Federation SDK that you cloned earlier.

For more information and requirements, see [Publishing Applications](#) in the *AWS Serverless Application Repository Developer Guide*, [AWS SAM Template Concepts](#) in the *AWS Serverless Application Model Developer Guide*, and [Publishing Serverless Applications Using the AWS SAM CLI](#).

The following example demonstrates parameters in a YAML file. Add similar parameters to your YAML file and save it in your project directory. See [athena-udf.yaml](#) in GitHub for a full example.

```
Transform: 'AWS::Serverless-2016-10-31'
Metadata:
  'AWS::ServerlessRepo::Application':
    Name: MyApplicationName
    Description: 'The description I write for my application'
    Author: 'Author Name'
    Labels:
      - athena-federation
    SemanticVersion: 1.0.0
Parameters:
  LambdaFunctionName:
    Description: 'The name of the Lambda function that will contain your UDFs.' 
    Type: String
  LambdaTimeout:
    Description: 'Maximum Lambda invocation runtime in seconds. (min 1 - 900 max)'
    Default: 900
    Type: Number
  LambdaMemory:
    Description: 'Lambda memory in MB (min 128 - 3008 max).'
    Default: 3008
    Type: Number
Resources:
  ConnectorConfig:
    Type: 'AWS::Serverless::Function'
    Properties:
      FunctionName: !Ref LambdaFunctionName
      Handler: "full.path.to.your.handler. For example, com.amazonaws.athena.connectors.udfs.MyUDFHandler"
      CodeUri: "Relative path to your JAR file. For example, ./target/athena-udfs-1.0.jar"
      Description: "My description of the UDFs that this Lambda function enables."
      Runtime: java8
      Timeout: !Ref LambdaTimeout
      MemorySize: !Ref LambdaMemory
```

Copy the `publish.sh` script to the project directory where you saved your YAML file, and run the following command:

```
./publish.sh MyS3Location MyYamlFile
```

For example, if your bucket location is `s3://mybucket/mysarapps/athenaudf` and your YAML file was saved as `my-athena-udfs.yaml`:

```
./publish.sh mybucket/mysarapps/athenaudf my-athena-udfs
```

To create a Lambda function

1. Open the Lambda console at <https://console.aws.amazon.com/lambda/>, choose **Create function**, and then choose **Browse serverless app repository**
2. Choose **Private applications**, find your application in the list, or search for it using key words, and select it.

3. Review and provide application details, and then choose **Deploy**.

You can now use the method names defined in your Lambda function JAR file as UDFs in Athena.

Option 2: Creating a Lambda Function Directly

You can also create a Lambda function directly using the console or AWS CLI. The following example demonstrates using the Lambda `create-function` CLI command. Replace

```
aws lambda create-function \
--function-name MyLambdaFunctionName \
--runtime java8 \
--role arn:aws:iam::1234567890123:role/my_lambda_role \
--handler com.mycompany.athena.udfs.MyUserDefinedFunctions \
--timeout 900 \
--zip-file fileb://./target/my-athena-udfs-1.0-SNAPSHOT.jar
```

Querying AWS Service Logs

This section includes several procedures for using Amazon Athena to query popular datasets, such as AWS CloudTrail logs, Amazon CloudFront logs, Classic Load Balancer logs, Application Load Balancer logs, Amazon VPC flow logs, and Network Load Balancer logs.

The tasks in this section use the Athena console, but you can also use other tools that connect via JDBC. For more information, see [Using Athena with the JDBC Driver \(p. 71\)](#), the [AWS CLI](#), or the [Amazon Athena API Reference](#).

The topics in this section assume that you have set up both an IAM user with appropriate permissions to access Athena and the Amazon S3 bucket where the data to query should reside. For more information, see [Setting Up \(p. 21\)](#) and [Getting Started \(p. 23\)](#).

Topics

- [Querying AWS CloudTrail Logs \(p. 178\)](#)
- [Querying Amazon CloudFront Logs \(p. 182\)](#)
- [Querying Amazon EMR Logs \(p. 183\)](#)
- [Querying Classic Load Balancer Logs \(p. 187\)](#)
- [Querying Network Load Balancer Logs \(p. 188\)](#)
- [Querying Application Load Balancer Logs \(p. 189\)](#)
- [Querying Amazon VPC Flow Logs \(p. 191\)](#)
- [Querying AWS WAF Logs \(p. 193\)](#)

Querying AWS CloudTrail Logs

AWS CloudTrail is a service that records AWS API calls and events for AWS accounts.

CloudTrail logs include details about any API calls made to your AWS services, including the console. CloudTrail generates encrypted log files and stores them in Amazon S3. For more information, see the [AWS CloudTrail User Guide](#).

Using Athena with CloudTrail logs is a powerful way to enhance your analysis of AWS service activity. For example, you can use queries to identify trends and further isolate activity by attributes, such as source IP address or user.

A common application is to use CloudTrail logs to analyze operational activity for security and compliance. For information about a detailed example, see the AWS Big Data Blog post, [Analyze Security, Compliance, and Operational Activity Using AWS CloudTrail and Amazon Athena](#).

You can use Athena to query these log files directly from Amazon S3, specifying the `LOCATION` of log files. You can do this one of two ways:

- By creating tables for CloudTrail log files directly from the CloudTrail console.
- By manually creating tables for CloudTrail log files in the Athena console.

Topics

- [Understanding CloudTrail Logs and Athena Tables \(p. 179\)](#)
- [Creating a Table for CloudTrail Logs in the CloudTrail Console \(p. 180\)](#)
- [Manually Creating the Table for CloudTrail Logs in Athena \(p. 180\)](#)
- [Example Query for CloudTrail Logs \(p. 181\)](#)
- [Tips for Querying CloudTrail Logs \(p. 181\)](#)

Understanding CloudTrail Logs and Athena Tables

Before you begin creating tables, you should understand a little more about CloudTrail and how it stores data. This can help you create the tables that you need, whether you create them from the CloudTrail console or from Athena.

CloudTrail saves logs as JSON text files in compressed gzip format (*.json.gz). The location of the log files depends on how you set up trails, the AWS Region or Regions in which you are logging, and other factors.

For more information about where logs are stored, the JSON structure, and the record file contents, see the following topics in the [AWS CloudTrail User Guide](#):

- [Finding Your CloudTrail Log Files](#)
- [CloudTrail Log File Examples](#)
- [CloudTrail Record Contents](#)
- [CloudTrail Event Reference](#)

To collect logs and save them to Amazon S3, enable CloudTrail for the console. For more information, see [Creating a Trail](#) in the [AWS CloudTrail User Guide](#).

Note the destination Amazon S3 bucket where you save the logs. Replace the `LOCATION` clause with the path to the CloudTrail log location and the set of objects with which to work. The example uses a `LOCATION` value of logs for a particular account, but you can use the degree of specificity that suits your application.

For example:

- To analyze data from multiple accounts, you can roll back the `LOCATION` specifier to indicate all `AWSLogs` by using `LOCATION 's3://MyLogFile/AWSLogs/'`.
- To analyze data from a specific date, account, and Region, use `LOCATION `s3://MyLogFile/123456789012/CloudTrail/us-east-1/2016/03/14/'`.

Using the highest level in the object hierarchy gives you the greatest flexibility when you query using Athena.

Creating a Table for CloudTrail Logs in the CloudTrail Console

You can automatically create tables for querying CloudTrail logs directly from the CloudTrail console. This is a fairly straightforward method of creating tables, but you can only create tables this way if the Amazon S3 bucket that contains the log files for the trail is in a Region supported by Amazon Athena, and you are logged in with an IAM user or role that has sufficient permissions to create tables in Athena. For more information, see [Setting Up \(p. 21\)](#).

To create a table for a CloudTrail trail in the CloudTrail console

1. Open the CloudTrail console at <https://console.aws.amazon.com/cloudtrail/>.
2. In the navigation pane, choose **Event history**.
3. In **Event history**, choose **Run advanced queries in Amazon Athena**.
4. For **Storage location**, choose the Amazon S3 bucket where log files are stored for the trail to query.

Note

You can find out what bucket is associated with a trail by going to **Trails** and choosing the trail. The bucket name is displayed in **Storage location**.

5. Choose **Create table**. The table is created with a default name that includes the name of the Amazon S3 bucket.

Manually Creating the Table for CloudTrail Logs in Athena

You can manually create tables for CloudTrail log files in the Athena console, and then run queries in Athena.

To create a table for a CloudTrail trail in the CloudTrail console

1. Copy and paste the following DDL statement into the Athena console.
2. Modify the `s3://CloudTrail_bucket_name/AWSLogs/Account_ID/` to point to the Amazon S3 bucket that contains your logs data.
3. Verify that fields are listed correctly. For more information about the full list of fields in a CloudTrail record, see [CloudTrail Record Contents](#).

In this example, the fields `requestparameters`, `responseelements`, and `additionaleventdata` are listed as type `STRING` in the query, but are `STRUCT` data type used in JSON. Therefore, to get data out of these fields, use `JSON_EXTRACT` functions. For more information, see [the section called "Extracting Data from JSON" \(p. 153\)](#).

```
CREATE EXTERNAL TABLE cloudtrail_logs (
    eventversion STRING,
    useridentity STRUCT<
        type:STRING,
        principalid:STRING,
        arn:STRING,
        accountid:STRING,
        invokedby:STRING,
        accesskeyid:STRING,
        userName:STRING,
    sessioncontext:STRUCT<
    attributes:STRUCT<
        mfaauthenticated:STRING,
        creationdate:STRING>,
    sessionissuer:STRUCT<
        type:STRING,
        principalid:STRING,
        arn:STRING,
```

```

        accountId:STRING,
        userName:STRING>>>,
eventtime STRING,
eventsource STRING,
eventname STRING,
awsregion STRING,
sourceipaddress STRING,
useragent STRING,
errorcode STRING,
errormessage STRING,
requestparameters STRING,
responseelements STRING,
additionaleventdata STRING,
requestid STRING,
eventid STRING,
resources ARRAY<STRUCT<
            ARN:STRING,
            accountId:STRING,
            type:STRING>>,
eventtype STRING,
apiversion STRING,
readonly STRING,
recipientaccountid STRING,
serviceeventdetails STRING,
sharedeventid STRING,
vpcendpointid STRING
)
ROW FORMAT SERDE 'com.amazon.emr.hive.serde.CloudTrailSerde'
STORED AS INPUTFORMAT 'com.amazon.emr.cloudtrail.CloudTrailInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://CloudTrail_bucket_name/AWSLogs/Account_ID/';

```

- Run the query in the Athena console. After the query completes, Athena registers `cloudtrail_logs`, making the data in it ready for you to issue queries.

Example Query for CloudTrail Logs

The following example shows a portion of a query that returns all anonymous (unsigned) requests from the table created on top of CloudTrail event logs. This query selects those requests where `useridentity.accountid` is anonymous, and `useridentity.arn` is not specified:

```

SELECT *
FROM cloudtrail_logs
WHERE
    eventsource = 's3.amazonaws.com' AND
    eventname in ('GetObject') AND
    useridentity.accountid LIKE '%ANONYMOUS%' AND
    useridentity.arn IS NULL AND
    requestparameters LIKE '%[your bucket name ]%';

```

For more information, see the AWS Big Data blog post [Analyze Security, Compliance, and Operational Activity Using AWS CloudTrail and Amazon Athena](#).

Tips for Querying CloudTrail Logs

To explore the CloudTrail logs data, use these tips:

- Before querying the logs, verify that your logs table looks the same as the one in the section called ["Manually Creating the Table for CloudTrail Logs in Athena" \(p. 180\)](#). If it is not the first table, delete the existing table using the following command: `DROP TABLE cloudtrail_logs;`.

- After you drop the existing table, re-create it. For more information, see [Creating the Table for CloudTrail Logs \(p. 180\)](#).

Verify that fields in your Athena query are listed correctly. For information about the full list of fields in a CloudTrail record, see [CloudTrail Record Contents](#).

If your query includes fields in JSON formats, such as STRUCT, extract data from JSON. For more information, see [Extracting Data From JSON \(p. 153\)](#).

Now you are ready to issue queries against your CloudTrail table.

- Start by looking at which IAM users called which API operations and from which source IP addresses.
- Use the following basic SQL query as your template. Paste the query to the Athena console and run it.

```
SELECT
    useridentity.arn,
    eventname,
    sourceipaddress,
    eventtime
FROM cloudtrail_logs
LIMIT 100;
```

- Modify the earlier query to further explore your data.
- To improve performance, include the `LIMIT` clause to return a specified subset of rows.

Querying Amazon CloudFront Logs

You can configure Amazon CloudFront CDN to export Web distribution access logs to Amazon Simple Storage Service. Use these logs to explore users' surfing patterns across your web properties served by CloudFront.

Before you begin querying the logs, enable Web distributions access log on your preferred CloudFront distribution. For information, see [Access Logs](#) in the *Amazon CloudFront Developer Guide*.

Make a note of the Amazon S3 bucket to which to save these logs.

Note

This procedure works for the Web distribution access logs in CloudFront. It does not apply to streaming logs from RTMP distributions.

- [Creating the Table for CloudFront Logs \(p. 182\)](#)
- [Example Query for CloudFront logs \(p. 183\)](#)

Creating the Table for CloudFront Logs

To create the CloudFront table

1. Copy and paste the following DDL statement into the Athena console. Modify the `LOCATION` for the Amazon S3 bucket that stores your logs.

This query uses the [LazySimpleSerDe \(p. 288\)](#) by default and it is omitted.

The column `date` is escaped using backticks (`) because it is a reserved word in Athena. For information, see [Reserved Keywords \(p. 33\)](#).

```
CREATE EXTERNAL TABLE IF NOT EXISTS default.cloudfront_logs (
    `date` DATE,
```

```

    time STRING,
    location STRING,
    bytes BIGINT,
    request_ip STRING,
    method STRING,
    host STRING,
    uri STRING,
    status INT,
    referrer STRING,
    user_agent STRING,
    query_string STRING,
    cookie STRING,
    result_type STRING,
    request_id STRING,
    host_header STRING,
    request_protocol STRING,
    request_bytes BIGINT,
    time_taken FLOAT,
    xforwarded_for STRING,
    ssl_protocol STRING,
    ssl_cipher STRING,
    response_result_type STRING,
    http_version STRING,
    file_status STRING,
    file_encrypted_fields INT
)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '\t'
LOCATION 's3://<CloudFront_bucket_name>/AWSLogs/<ACCOUNT_ID>/'
TBLPROPERTIES ('skip.header.line.count'=2')

```

- Run the query in Athena console. After the query completes, Athena registers the `cloudfront_logs` table, making the data in it ready for you to issue queries.

Example Query for CloudFront Logs

The following query adds up the number of bytes served by CloudFront between June 9 and June 11, 2018. Surround the date column name with double quotes because it is a reserved word.

```

SELECT SUM(bytes) AS total_bytes
FROM cloudfront_logs
WHERE "date" BETWEEN DATE '2018-06-09' AND DATE '2018-06-11'
LIMIT 100;

```

In some cases, you need to eliminate empty values from the results of `CREATE TABLE` query for CloudFront. To do so, run:

```

SELECT DISTINCT *
FROM cloudfront_logs
LIMIT 10;

```

For more information, see the AWS Big Data Blog post [Build a Serverless Architecture to Analyze Amazon CloudFront Access Logs Using AWS Lambda, Amazon Athena, and Amazon Kinesis Analytics](#).

Querying Amazon EMR Logs

Amazon EMR and big data applications that run on Amazon EMR produce log files. Logs files are written to the master node, and you can also configure Amazon EMR to archive log files to Amazon S3 automatically. You can use Amazon Athena to query these logs to identify events and trends for

applications and clusters. For more information about the types of log files in Amazon EMR and saving them to Amazon S3, see [View Log Files](#) in the *Amazon EMR Management Guide*.

Creating and Querying a Basic Table Based on Amazon EMR Log Files

The following example creates a basic table, `myemrlogs`, based on log files saved to `s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/elasticmapreduce/`. The Amazon S3 location used in the examples below reflects the pattern of the default log location for an EMR cluster created by AWS account `123456789012` in Region `us-west-2`. If you use a custom location, the pattern is `s3://PathToEMRLogs/ClusterID`.

For information about creating a partitioned table to potentially improve query performance and reduce data transfer, see [Creating and Querying a Partitioned Table Based on Amazon EMR Logs \(p. 185\)](#).

```
CREATE EXTERNAL TABLE `myemrlogs`(
    `data` string COMMENT 'from deserializer'
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n'
STORED AS INPUTFORMAT
    'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT
    'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION
    's3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6'
```

The following example queries can be run on the `myemrlogs` table created by the previous example.

Example – Query Step Logs for Occurrences of ERROR, WARN, INFO, EXCEPTION, FATAL, or DEBUG

```
SELECT data,
    "$PATH"
FROM "default"."myemrlogs"
WHERE regexp_like("$PATH", 's-86URH188Z6B1')
    AND regexp_like(data, 'ERROR|WARN|INFO|EXCEPTION|FATAL|DEBUG') limit 100;
```

Example – Query a Specific Instance Log, i-00b3c0a839ece0a9c, for ERROR, WARN, INFO, EXCEPTION, FATAL, or DEBUG

```
SELECT "data",
    "$PATH" AS filepath
FROM "default"."myemrlogs"
WHERE regexp_like("$PATH", 'i-00b3c0a839ece0a9c')
    AND regexp_like("$PATH", 'state')
    AND regexp_like(data, 'ERROR|WARN|INFO|EXCEPTION|FATAL|DEBUG') limit 100;
```

Example – Query Presto Application Logs for ERROR, WARN, INFO, EXCEPTION, FATAL, or DEBUG

```
SELECT "data",
    "$PATH" AS filepath
FROM "default"."myemrlogs"
WHERE regexp_like("$PATH", 'presto')
    AND regexp_like(data, 'ERROR|WARN|INFO|EXCEPTION|FATAL|DEBUG') limit 100;
```

Example – Query Namenode Application Logs for ERROR, WARN, INFO, EXCEPTION, FATAL, or DEBUG

```
SELECT "data",
       "$PATH" AS filepath
FROM "default"."myemrlogs"
WHERE regexp_like("$PATH", 'namenode')
      AND regexp_like(data, 'ERROR|WARN|INFO|EXCEPTION|FATAL|DEBUG') limit 100;
```

Example – Query All Logs by Date and Hour for ERROR, WARN, INFO, EXCEPTION, FATAL, or DEBUG

```
SELECT distinct("$PATH") AS filepath
FROM "default"."myemrlogs"
WHERE regexp_like("$PATH", '2019-07-23-10')
      AND regexp_like(data, 'ERROR|WARN|INFO|EXCEPTION|FATAL|DEBUG') limit 100;
```

Creating and Querying a Partitioned Table Based on Amazon EMR Logs

These examples use the same log location to create an Athena table, but the table is partitioned, and a partition is then created for each log location. For more information, see [Partitioning Data \(p. 36\)](#).

The following query creates the partitioned table named `mypartitionedemrlogs`:

```
CREATE EXTERNAL TABLE `mypypartitionedemrlogs`(
    `data` string COMMENT 'from deserializer'
    partitioned by (logtype string)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n'
STORED AS INPUTFORMAT
    'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT
    'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION
    's3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6'
```

The following query statements then create table partitions based on sub-directories for different log types that Amazon EMR creates in Amazon S3:

```
ALTER TABLE mypartitionedemrlogs ADD
    PARTITION
        (logtype='containers') LOCATION
        s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/containers/
```

```
ALTER TABLE mypartitionedemrlogs ADD
    PARTITION
        (logtype='hadoop-mapreduce') LOCATION
        s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/hadoop-
mapreduce/
```

```
ALTER TABLE mypartitionedemrlogs ADD
    PARTITION
        (logtype='hadoop-state-pusher') LOCATION
        s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/hadoop-state-
pusher/
```

```
ALTER TABLE mypartitionedemrlogs ADD
PARTITION
(logtype='node') LOCATION
s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/node/
```

```
ALTER TABLE mypartitionedemrlogs ADD
PARTITION
(logtype='steps') LOCATION
s3://aws-logs-123456789012-us-west-2/elasticmapreduce/j-2ABCDE34F5GH6/steps/
```

After you create the partitions, you can run a `SHOW PARTITIONS` query on the table to confirm:

```
SHOW PARTITIONS mypartitionedemrlogs;
```

The following examples demonstrate queries for specific log entries use the table and partitions created by the examples above.

Example – Querying Application application_1561661818238_0002 Logs in the Containers Partition for ERROR or WARN

```
SELECT data,
      "$PATH"
FROM "default"."mypartitionedemrlogs"
WHERE logtype='containers'
      AND regexp_like("$PATH",'application_1561661818238_0002')
      AND regexp_like(data, 'ERROR|WARN') limit 100;
```

Example – Querying the Hadoop-Mapreduce Partition for Job job_1561661818238_0004 and Failed Reduces

```
SELECT data,
      "$PATH"
FROM "default"."mypartitionedemrlogs"
WHERE logtype='hadoop-mapreduce'
      AND regexp_like(data,'job_1561661818238_0004|Failed Reduces') limit 100;
```

Example – Querying Hive Logs in the Node Partition for Query ID 056e0609-33e1-4611-956c-7a31b42d2663

```
SELECT data,
      "$PATH"
FROM "default"."mypartitionedemrlogs"
WHERE logtype='node'
      AND regexp_like("$PATH",'hive')
      AND regexp_like(data,'056e0609-33e1-4611-956c-7a31b42d2663') limit 100;
```

Example – Querying Resourcemanager Logs in the Node Partition for Application 1567660019320_0001_01_000001

```
SELECT data,
      "$PATH"
FROM "default"."mypartitionedemrlogs"
WHERE logtype='node'
      AND regexp_like(data,'resourcemanager')
      AND regexp_like(data,'1567660019320_0001_01_000001') limit 100
```

Querying Classic Load Balancer Logs

Use Classic Load Balancer logs to analyze and understand traffic patterns to and from Elastic Load Balancing instances and backend applications. You can see the source of traffic, latency, and bytes that have been transferred.

Before you analyze the Elastic Load Balancing logs, configure them for saving in the destination Amazon S3 bucket. For more information, see [Enable Access Logs for Your Classic Load Balancer](#).

- Create the table for Elastic Load Balancing logs (p. 187)
 - Elastic Load Balancing Example Queries (p. 187)

To create the table for Elastic Load Balancing logs

1. Copy and paste the following DDL statement into the Athena console. Check the [syntax](#) of the Elastic Load Balancing log records. You may need to update the following query to include the columns and the Regex syntax for latest version of the record.

2. Modify the `LOCATION` Amazon S3 bucket to specify the destination of your Elastic Load Balancing logs.
 3. Run the query in the Athena console. After the query completes, Athena registers the `elb_logs` table, making the data in it ready for queries. For more information, see [Elastic Load Balancing Example Queries \(p. 187\)](#)

Elastic Load Balancing Example Queries

Use a query similar to the following example. It lists the backend application servers that returned a 4XX or 5XX error response code. Use the `LIMIT` operator to limit the number of logs to query at a time.

```
SELECT
    request_timestamp,
    elb_name,
    backend_ip,
    backend_response_code
FROM elb_logs
WHERE backend_response_code LIKE '4%' OR
      backend_response_code LIKE '5%'
LIMIT 100;
```

Use a subsequent query to sum up the response time of all the transactions grouped by the backend IP address and Elastic Load Balancing instance name.

```
SELECT sum(backend_processing_time) AS
    total_ms,
    elb_name,
    backend_ip
FROM elb_logs WHERE backend_ip <> ''
GROUP BY backend_ip, elb_name
LIMIT 100;
```

For more information, see [Analyzing Data in S3 using Athena](#).

Querying Network Load Balancer Logs

Use Athena to analyze and process logs from Network Load Balancer. These logs receive detailed information about the Transport Layer Security (TLS) requests sent to the Network Load Balancer. You can use these access logs to analyze traffic patterns and troubleshoot issues.

Before you analyze the Network Load Balancer access logs, enable and configure them for saving in the destination Amazon S3 bucket. For more information, see [Access Logs for Your Network Load Balancer](#).

- [Create the table for Network Load Balancer logs \(p. 188\)](#)
- [Network Load Balancer Example Queries \(p. 189\)](#)

To create the table for Network Load Balancer logs

1. Copy and paste the following DDL statement into the Athena console. Check the [syntax](#) of the Network Load Balancer log records. You may need to update the following query to include the columns and the Regex syntax for latest version of the record.

```
CREATE EXTERNAL TABLE IF NOT EXISTS nlb_tls_logs (
    type string,
    version string,
    time string,
    elb string,
    listener_id string,
    client_ip string,
    client_port int,
    target_ip string,
    target_port int,
    tcp_connection_time_ms double,
    tls_handshake_time_ms double,
    received_bytes bigint,
    sent_bytes bigint,
    incoming_tls_alert int,
    cert_arn string,
    certificate_serial string,
```

```
    tls_cipher_suite string,
    tls_protocol_version string,
    tls_named_group string,
    domain_name string,
    new_field string
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES (
    'serialization.format' = '1',
    'input.regex' =
        '([^\n]*) ([^\n]*) ([^\n]*) ([^\n]*) ([^\n]*) ([^\n]*):([0-9]*)([^\n]*):([0-9]*)
([-.0-9]*)([-.0-9]*)([-0-9]*)([-0-9]*)([^ ]*)([^ ]*)([^ ]*)([^ ]*)([^ ]*)
([^\n]*)([^ ]*)(\$| [^\n]*')
    LOCATION 's3://your_log_bucket/prefix/AWSLogs/AWS_account_ID
elasticloadbalancing/region';
```

2. Modify the `LOCATION` Amazon S3 bucket to specify the destination of your Network Load Balancer logs.
 3. Run the query in the Athena console. After the query completes, Athena registers the `nlb_tls_logs` table, making the data in it ready for queries.

Network Load Balancer Example Queries

To see how many times a certificate is used, use a query similar to this example:

```
SELECT count(*) AS  
      ct,  
      cert_arn  
FROM "nlb_tls_logs"  
GROUP BY cert_arn;
```

The following query shows how many users are using the older TLS version:

```
SELECT tls_protocol_version,
       COUNT(tls_protocol_version) AS num_connections,
       client_ip
  FROM "nlb_tls_logs"
 WHERE tls_protocol_version < 'tlsv12'
 GROUP BY tls_protocol_version, client_ip;
```

Use the following query to identify connections that take a long TLS handshake time:

```
SELECT *
FROM "nlb_tls_logs"
ORDER BY tls_handshake_time_ms DESC
LIMIT 10;
```

Querying Application Load Balancer Logs

An Application Load Balancer is a load balancing option for Elastic Load Balancing that enables traffic distribution in a microservices deployment using containers. Querying Application Load Balancer logs allows you to see the source of traffic, latency, and bytes transferred to and from Elastic Load Balancing instances and backend applications.

Before you begin, [enable access logging](#) for Application Load Balancer logs to be saved to your Amazon S3 bucket.

- Creating the Table for ALB Logs (p. 190)
 - Example Queries for ALB logs (p. 191)

Creating the Table for ALB Logs

1. Copy and paste the following DDL statement into the Athena console, and modify values in LOCATION '`s3://your-alb-logs-directory/AWSLogs/<ACCOUNT-ID>/elasticloadbalancing/<REGION>/'`.

Create the alb_logs table as follows.

Note

This query includes all fields present in the list of current Application Load Balancer [Access Log Entries](#). It also includes a table column `new_field` at the end, in case you require additions to the ALB logs. This field does not break your query. The regular expression in the SerDe properties ignores this field if your logs don't have it.

- Run the query in the Athena console. After the query completes, Athena registers the `alb_logs` table, making the data in it ready for you to issue queries.

Example Queries for ALB Logs

The following query counts the number of HTTP GET requests received by the load balancer grouped by the client IP address:

```
SELECT COUNT(request_verb) AS
  count,
  request_verb,
  client_ip
FROM alb_logs
GROUP BY request_verb, client_ip
LIMIT 100;
```

Another query shows the URLs visited by Safari browser users:

```
SELECT request_url
FROM alb_logs
WHERE user_agent LIKE '%Safari%'
LIMIT 10;
```

The following example shows how to parse the logs by datetime:

```
SELECT client_ip, sum(received_bytes)
FROM alb_logs_config_us
WHERE parse_datetime(time, 'yyyy-MM-dd''T''HH:mm:ss.SSSSSS''Z')
    BETWEEN parse_datetime('2018-05-30-12:00:00', 'yyyy-MM-dd-HH:mm:ss')
        AND parse_datetime('2018-05-31-00:00:00', 'yyyy-MM-dd-HH:mm:ss')
GROUP BY client_ip;
```

Querying Amazon VPC Flow Logs

Amazon Virtual Private Cloud flow logs capture information about the IP traffic going to and from network interfaces in a VPC. Use the logs to investigate network traffic patterns and identify threats and risks across your VPC network.

Before you begin querying the logs in Athena, [enable VPC flow logs](#), and configure them to be saved to your Amazon S3 bucket. After you create the logs, let them run for a few minutes to collect some data. The logs are created in a GZIP compression format that Athena lets you query directly.

When you create a VPC flow log, you can use the default format, or you can specify a custom format. A custom format is where you specify which fields to return in the flow log, and the order in which they should appear. For more information, see [Flow Log Records](#) in the [Amazon VPC User Guide](#).

- [Creating the Table for VPC Flow Logs \(p. 191\)](#)
- [Example Queries for Amazon VPC Flow Logs \(p. 192\)](#)

Creating the Table for VPC Flow Logs

The following section creates an Amazon VPC table for VPC flow logs that use the default format. If you create a flow log with a custom format, you must create a table with fields that match the fields that you specified when you created the flow log, in the same order that you specified them.

To create the Amazon VPC table

1. Copy and paste the following DDL statement into the Athena console. This query specifies `ROW FORMAT DELIMITED` and omits specifying a SerDe. This means that the query uses the

[LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files \(p. 288\)](#). In addition, in this query, fields are terminated by a space. For a VPC flow log with a custom format, modify the fields to match the fields that you specified when you created the flow log.

2. Modify the LOCATION '`s3://your_log_bucket/prefix/AWSLogs/{subscribe_account_id}/vpcflowlogs/{region_code}/`' to point to the Amazon S3 bucket that contains your log data.

```
CREATE EXTERNAL TABLE IF NOT EXISTS vpc_flow_logs (
    version int,
    account string,
    interfaceid string,
    sourceaddress string,
    destinationaddress string,
    sourceport int,
    destinationport int,
    protocol int,
    numpackets int,
    numbytes bigint,
    starttime int,
    endtime int,
    action string,
    logstatus string
)
PARTITIONED BY (dt string)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY ' '
LOCATION 's3://your_log_bucket/prefix/AWSLogs/{subscribe_account_id}/vpcflowlogs/
{region_code}/'
TBLPROPERTIES ("skip.header.line.count"="1");
```

3. Run the query in Athena console. After the query completes, Athena registers the `vpc_flow_logs` table, making the data in it ready for you to issue queries.
4. Create partitions to be able to read the data, as in the following sample query. This query creates a single partition for a specified date. Replace the placeholders for date and location as needed.

Note

This query creates a single partition only, for a date that you specify. To automate the process, use a script that runs this query and creates partitions this way for the year/month/day, or use AWS Glue Crawler to create partitions for a given Amazon S3 bucket. For information, see [Scheduling a Crawler to Keep the AWS Glue Data Catalog and Amazon S3 in Sync \(p. 49\)](#).

```
ALTER TABLE vpc_flow_logs
ADD PARTITION (dt='YYYY-MM-dd')
location 's3://your_log_bucket/prefix/AWSLogs/{account_id}/vpcflowlogs/{region_code}/
YYYY/MM/dd';
```

Example Queries for Amazon VPC Flow Logs

The following query lists all of the rejected TCP connections and uses the newly created date partition column, `dt`, to extract from it the day of the week for which these events occurred.

This query uses [Date and Time Functions and Operators](#). It converts values in the `dt` String column to timestamp with the date function `from_iso8601_timestamp(string)`, and extracts the day of the week from timestamp with `day_of_week`.

```
SELECT day_of_week(from_iso8601_timestamp(dt)) AS
    day,
    dt,
```

```
interfaceid,  
sourceaddress,  
action,  
protocol  
FROM vpc_flow_logs  
WHERE action = 'REJECT' AND protocol = 6  
LIMIT 100;
```

To see which one of your servers is receiving the highest number of HTTPS requests, use this query. It counts the number of packets received on HTTPS port 443, groups them by destination IP address, and returns the top 10.

```
SELECT SUM(numpackets) AS  
    packetcount,  
    destinationaddress  
FROM vpc_flow_logs  
WHERE destinationport = 443  
GROUP BY destinationaddress  
ORDER BY packetcount DESC  
LIMIT 10;
```

For more information, see the AWS Big Data blog post [Analyzing VPC Flow Logs with Amazon Kinesis Firehose, Athena, and Amazon QuickSight](#).

Querying AWS WAF Logs

AWS WAF logs include information about the traffic that is analyzed by your web ACL, such as the time that AWS WAF received the request from your AWS resource, detailed information about the request, and the action for the rule that each request matched.

You can enable access logging for AWS WAF logs, save them to Amazon S3, and query the logs in Athena. For more information about enabling AWS WAF logs and about the log record structure, see [Logging Web ACL Traffic Information](#) in the *AWS WAF Developer Guide*.

Make a note of the Amazon S3 bucket to which you save these logs.

- [Creating the Table for AWS WAF Logs \(p. 193\)](#)
- [Example Queries for AWS WAF logs \(p. 194\)](#)

Creating the Table for AWS WAF Logs

To create the AWS WAF table

1. Copy and paste the following DDL statement into the Athena console. Modify the `LOCATION` for the Amazon S3 bucket that stores your logs.

This query uses the [Hive JSON SerDe \(p. 285\)](#). The table format and the SerDe are suggested by the AWS Glue crawler when it analyzes AWS WAF logs.

```
CREATE EXTERNAL TABLE `waf_logs`(`  
    timestamp` bigint,  
    `formatversion` int,  
    `webaclid` string,  
    `terminatingruleid` string,  
    `terminatingrulename` string,  
    `action` string,  
    `httpsourcename` string,
```

```

`httpsourceid` string,
`rulegrouplist` array<string>,
`ratebasedrulelist` array<
    struct<
        ratebasedruleid:string,
        limitkey:string,
        maxrateallowed:int
    >
>,
`nonterminatingmatchingrules` array<
    struct<
        ruleid:string,
        action:string
    >
>,
`httprequest` struct<
    clientip:string,
    country:string,
    headers:array<
        struct<
            name:string,
            value:string
        >
    >,
    uri:string,
    args:string,
    httpversion:string,
    httpmethod:string,
    requestid:string
>
>
)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
WITH SERDEPROPERTIES (
    'paths'='action,formatVersion,httpRequest,httpSourceId,httpSourceName,nonTerminatingMatchingRules,ra
STORED AS INPUTFORMAT 'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://athenawaflogs/WebACL/'

```

- Run the query in the Athena console. After the query completes, Athena registers the `waf_logs` table, making the data in it available for queries.

Example Queries for AWS WAF Logs

The following query counts the number of times an IP address has been blocked by the `RATE_BASED` terminating rule.

```

SELECT COUNT(httpRequest.clientIp) as count,
httpRequest.clientIp
FROM waf_logs
WHERE terminatingruletype='RATE_BASED' AND action='BLOCK'
GROUP BY httpRequest.clientIp
ORDER BY count
LIMIT 100;

```

The following query counts the number of times the request has arrived from an IP address that belongs to Ireland (IE) and has been blocked by the `RATE_BASED` terminating rule.

```

SELECT COUNT(httpRequest.country) as count,
httpRequest.country
FROM waf_logs
WHERE
terminatingruletype='RATE_BASED' AND

```

```
httpRequest.country='IE'  
GROUP BY httpRequest.country  
ORDER BY count  
LIMIT 100;
```

The following query counts the number of times the request has been blocked, with results grouped by WebACL, RuleId, ClientIP, and HTTP Request URI.

```
SELECT COUNT(*) AS  
count,  
webaclid,  
terminatingruleid,  
httprequest.clientip,  
httprequest.uri  
FROM waf_logs  
WHERE action='BLOCK'  
GROUP BY webaclid, terminatingruleid, httprequest.clientip, httprequest.uri  
ORDER BY count DESC  
LIMIT 100;
```

The following query counts the number of times a specific terminating rule ID has been matched (WHERE terminatingruleid='e9dd190d-7a43-4c06-bcea-409613d9506e'). The query then groups the results by WebACL, Action, ClientIP, and HTTP Request URI.

```
SELECT COUNT(*) AS  
count,  
webaclid,  
action,  
httprequest.clientip,  
httprequest.uri  
FROM waf_logs  
WHERE terminatingruleid='e9dd190d-7a43-4c06-bcea-409613d9506e'  
GROUP BY webaclid, action, httprequest.clientip, httprequest.uri  
ORDER BY count DESC  
LIMIT 100;
```

Amazon Athena Security

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that is 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. The effectiveness of our security is regularly tested and verified by third-party auditors as part of the [AWS compliance programs](#). To learn about the compliance programs that apply to Athena, 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 will help you understand how to apply the shared responsibility model when using Amazon Athena. The following topics show you how to configure Athena to meet your security and compliance objectives. You'll also learn how to use other AWS services that can help you to monitor and secure your Athena resources.

Topics

- [Data Protection in Athena \(p. 196\)](#)
- [Identity and Access Management in Athena \(p. 203\)](#)
- [Logging and Monitoring in Athena \(p. 229\)](#)
- [Compliance Validation for Amazon Athena \(p. 229\)](#)
- [Resilience in Athena \(p. 230\)](#)
- [Infrastructure Security in Athena \(p. 230\)](#)
- [Configuration and Vulnerability Analysis in Athena \(p. 232\)](#)
- [Using Athena to Query Data Registered With AWS Lake Formation \(p. 232\)](#)

Data Protection in Athena

Multiple types of data are involved when you use Athena to create databases and tables. These data types include source data stored in Amazon S3, metadata for databases and tables that you create when you run queries or the AWS Glue Crawler to discover data, query results data, and query history. This section discusses each type of data and provides guidance about protecting it.

- **Source data** – You store the data for databases and tables in Amazon S3, and Athena does not modify it. For more information, see [Protecting Data in Amazon S3](#) in the *Amazon Simple Storage Service Developer Guide*. You control access to your source data and can encrypt it in Amazon S3. You can use Athena to [create tables based on encrypted datasets in Amazon S3 \(p. 200\)](#).
- **Database and table metadata (schema)** – Athena uses schema-on-read technology, which means that your table definitions are applied to your data in Amazon S3 when Athena runs queries. Any schemas you define are automatically saved unless you explicitly delete them. In Athena, you can modify the Data Catalog metadata using DDL statements. You can also delete table definitions and schema without impacting the underlying data stored in Amazon S3.

Note

The metadata for databases and tables you use in Athena is stored in the AWS Glue Data Catalog. We highly recommend that you [upgrade \(p. 56\)](#) to using the AWS Glue Data

Catalog with Athena. For more information about the benefits of using the AWS Glue Data Catalog, see [FAQ: Upgrading to the AWS Glue Data Catalog \(p. 58\)](#).

You can [define fine-grained access policies to databases and tables \(p. 207\)](#) registered in the AWS Glue Data Catalog using AWS Identity and Access Management (IAM). You can [encrypt metadata in the AWS Glue Data Catalog](#). You can also encrypt metadata in the AWS Glue Data Catalog. If you encrypt the metadata, use [permissions to encrypted metadata \(p. 201\)](#) for access.

- **Query results and query history, including saved queries** – Query results are stored in a location in Amazon S3 that you can choose to specify globally, or for each workgroup. If not specified, Athena uses the default location in each case. You control access to Amazon S3 buckets where you store query results and saved queries. Additionally, you can choose to encrypt query results that you store in Amazon S3. Your users must have the appropriate permissions to access the Amazon S3 locations and decrypt files. For more information, see [Encrypting Query Results Stored in Amazon S3 \(p. 198\)](#) in this document.

Athena retains query history for 45 days. You can [view query history \(p. 112\)](#) using Athena APIs, in the console, and with AWS CLI. To store the queries for longer than 45 days, save them. To protect access to saved queries, [use workgroups \(p. 239\)](#) in Athena, restricting access to saved queries only to users who are authorized to view them.

Topics

- [Encryption at Rest \(p. 197\)](#)
- [Encryption in Transit \(p. 202\)](#)
- [Key Management \(p. 202\)](#)
- [Internetwork Traffic Privacy \(p. 202\)](#)

Encryption at Rest

You can run queries in Amazon Athena on encrypted data in Amazon S3 in the same Region. You can also encrypt the query results in Amazon S3 and the data in the AWS Glue Data Catalog.

You can encrypt the following assets in Athena:

- The results of all queries in Amazon S3, which Athena stores in a location known as the Amazon S3 results location. You can encrypt query results stored in Amazon S3 whether the underlying dataset is encrypted in Amazon S3 or not. For information, see [Permissions to Encrypted Query Results Stored in Amazon S3 \(p. 198\)](#).
- The data in the AWS Glue Data Catalog. For information, see [Permissions to Encrypted Metadata in the AWS Glue Data Catalog \(p. 201\)](#).

Supported Amazon S3 Encryption Options

Athena supports the following Amazon S3 encryption options, both for encrypted datasets in Amazon S3 in the same Region and for encrypted query results:

- Server side encryption (SSE) with an Amazon S3-managed key ([SSE-S3](#))
- Server-side encryption (SSE) with a AWS Key Management Service customer managed key ([SSE-KMS](#)).
- Client-side encryption (CSE) with a AWS KMS customer managed key ([CSE-KMS](#))

Note

With SSE-KMS, Athena does not require you to indicate that data is encrypted when creating a table.

For more information about AWS KMS encryption with Amazon S3, see [What is AWS Key Management Service](#) and [How Amazon Simple Storage Service \(Amazon S3\) Uses AWS KMS](#) in the [AWS Key Management Service Developer Guide](#).

Athena does not support SSE with customer-provided keys (SSE-C), nor does it support client-side encryption using a client-side master key. To compare Amazon S3 encryption options, see [Protecting Data Using Encryption](#) in the [Amazon Simple Storage Service Developer Guide](#).

Athena does not support running queries from one Region on encrypted data stored in Amazon S3 in another Region.

Important

The setup for querying an encrypted dataset in Amazon S3 and the options in Athena to encrypt query results are independent. Each option is enabled and configured separately. You can use different encryption methods or keys for each. This means that reading encrypted data in Amazon S3 doesn't automatically encrypt Athena query results in Amazon S3. The opposite is also true. Encrypting Athena query results in Amazon S3 doesn't encrypt the underlying dataset in Amazon S3.

Regardless of whether you use options for encrypting data at rest in Amazon S3, transport layer security (TLS) encrypts objects in-transit between Athena resources and between Athena and Amazon S3. Query results that stream to JDBC or ODBC clients are encrypted using TLS.

Permissions to Encrypted Data in Amazon S3

Depending on the type of encryption you use in Amazon S3, you may need to add permissions, also known as "Allow" actions, to your policies used in Athena:

- **SSE-S3** – If you use SSE-S3 for encryption, Athena users require no additional permissions in their policies. It is sufficient to have the appropriate Amazon S3 permissions for the appropriate Amazon S3 location and for Athena actions. For more information about policies that allow appropriate Athena and Amazon S3 permissions, see [IAM Policies for User Access \(p. 203\)](#) and [Amazon S3 Permissions \(p. 207\)](#).
- **AWS KMS** – If you use AWS KMS for encryption, Athena users must be allowed to perform particular AWS KMS actions in addition to Athena and Amazon S3 permissions. You allow these actions by editing the key policy for the AWS KMS customer managed keys (CMKs) that are used to encrypt data in Amazon S3. The easiest way to do this is to use the IAM console to add key users to the appropriate AWS KMS key policies. For information about how to add a user to a AWS KMS key policy, see [How to Modify a Key Policy](#) in the [AWS Key Management Service Developer Guide](#).

Note

Advanced key policy administrators can adjust key policies. `kms:Decrypt` is the minimum allowed action for an Athena user to work with an encrypted dataset. To work with encrypted query results, the minimum allowed actions are `kms:GenerateDataKey` and `kms:Decrypt`.

When using Athena to query datasets in Amazon S3 with a large number of objects that are encrypted with AWS KMS, AWS KMS may throttle query results. This is more likely when there are a large number of small objects. Athena backs off retry requests, but a throttling error might still occur. In this case, visit the [AWS Support Center](#) and create a case to increase your limit. For more information about limits and AWS KMS throttling, see [Limits](#) in the [AWS Key Management Service Developer Guide](#).

Encrypting Query Results Stored in Amazon S3

You set up query result encryption using the Athena console. Workgroups allow you to enforce the encryption of query results.

If you connect using the JDBC or ODBC driver, you configure driver options to specify the type of encryption to use and the Amazon S3 staging directory location. To configure the JDBC or ODBC

driver to encrypt your query results using any of the encryption protocols that Athena supports, see [Connecting to Amazon Athena with ODBC and JDBC Drivers \(p. 71\)](#).

You can configure the setting for encryption of query results in two ways:

- **Client-side settings** – When you use **Settings** in the console or the API operations to indicate that you want to encrypt query results, this is known as using client-side settings. Client-side settings include query results location and encryption. If you specify them, they are used, unless they are overridden by the workgroup settings.
- **Workgroup settings** – When you [create or edit a workgroup \(p. 249\)](#) and select the **Override client-side settings** field, then all queries that run in this workgroup use the workgroup settings. For more information, see [Workgroup Settings Override Client-Side Settings \(p. 247\)](#). Workgroup settings include query results location and encryption.

To encrypt query results stored in Amazon S3 using the console

Important

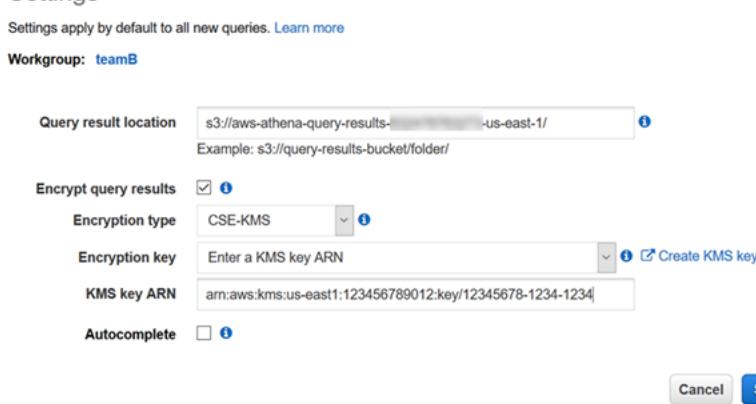
If your workgroup has the **Override client-side settings** field selected, then the queries use the workgroup settings. The encryption configuration and the query results location listed in **Settings**, the API operations, and the drivers are not used. For more information, see [Workgroup Settings Override Client-Side Settings \(p. 247\)](#).

1. In the Athena console, choose **Settings**.



Athena **Query Editor** Saved Queries History AWS Glue Data Catalog Workgroup : teamA

2. For **Query result location**, enter a custom value or leave the default. This is the Amazon S3 staging directory where query results are stored.
3. Choose **Encrypt query results**.



Settings

Settings apply by default to all new queries. [Learn more](#)

Workgroup: [teamB](#)

Query result location	s3://aws-athena-query-results- -us-east-1/
Example: s3://query-results-bucket/folder/	
Encrypt query results	<input checked="" type="checkbox"/>
Encryption type	CSE-KMS
Encryption key	Enter a KMS key ARN
KMS key ARN	arn:aws:kms:us-east1:123456789012:key/12345678-1234-1234
Autocomplete	<input type="checkbox"/>

[Cancel](#) [Save](#)

4. For **Encryption type**, choose **CSE-KMS**, **SSE-KMS**, or **SSE-S3**.
5. If you chose **SSE-KMS** or **CSE-KMS**, specify the **Encryption key**.
 - If your account has access to an existing AWS KMS customer managed key (CMK), choose its alias or choose **Enter a KMS key ARN** and then enter an ARN.
 - If your account does not have access to an existing AWS KMS customer managed key (CMK), choose **Create KMS key**, and then open the [AWS KMS console](#). In the navigation pane, choose **AWS managed keys**. For more information, see [Creating Keys](#) in the [AWS Key Management Service Developer Guide](#).
6. Return to the Athena console to specify the key by alias or ARN as described in the previous step.
7. Choose **Save**.

Creating Tables Based on Encrypted Datasets in Amazon S3

When you create a table, indicate to Athena that a dataset is encrypted in Amazon S3. This is not required when using SSE-KMS. For both SSE-S3 and AWS KMS encryption, Athena determines the proper materials to use to decrypt the dataset and create the table, so you don't need to provide key information.

Users that run queries, including the user who creates the table, must have the appropriate permissions as described earlier in this topic.

Important

If you use Amazon EMR along with EMRFS to upload encrypted Parquet files, you must disable multipart uploads by setting `fs.s3n.multipart.uploads.enabled` to `false`. If you don't do this, Athena is unable to determine the Parquet file length and a **HIVE_CANNOT_OPEN_SPLIT** error occurs. For more information, see [Configure Multipart Upload for Amazon S3](#) in the *Amazon EMR Management Guide*.

Indicate that the dataset is encrypted in Amazon S3 in one of the following ways. This step is not required if SSE-KMS is used.

- Use the [CREATE TABLE](#) (p. 313) statement with a `TBLPROPERTIES` clause that specifies `'has_encrypted_data'='true'`.

```
1 CREATE EXTERNAL TABLE `MyEncryptedTable` (
2   `n_nationkey` int,
3   `n_name` string,
4   `n_regionkey` int,
5   `n_comment` string)
6 ROW FORMAT SERDE
7   'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
8 STORED AS INPUTFORMAT
9   'org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat'
10 OUTPUTFORMAT
11   'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
12 LOCATION
13   's3://path/to/my/encrypted/data'
14 TBLPROPERTIES {
15   'has_encrypted_data': 'true'}
```

- Use the [JDBC driver](#) (p. 71) and set the `TBLPROPERTIES` value as shown in the previous example, when you execute [CREATE TABLE](#) (p. 313) using `statement.executeQuery()`.
- Use the **Add table** wizard in the Athena console, and then choose **Encrypted data set** when you specify a value for **Location of input data set**.

Catalog Manager

Databases > Add table

Step 1: Name & Location Step 2: Data Format Step 3: Columns Step 4: Partitions

Database Choose an existing database or create a new one by selecting "Create new database".
MyDatabase
Name of the new database

Table Name
Name of the new table. Table names must be globally unique. Table names tend to correspond to the directory

Location of Input Data Set Encrypted data set
Input the path to the data set you want to process on Amazon S3. For example, if your data is stored at s3://input-data-set/logs/year=2004/month=12/day=11/ just input the base path s3://input-data-set/logs/

External
Note: Amazon Athena only allows you to create tables with the EXTERNAL keyword. Dropping a table created

Tables based on encrypted data in Amazon S3 appear in the **Database** list with an encryption icon.

Services Resource Groups

Athena Query Editor Saved Queries History Catalog

DATABASE

TABLES Filter Tables...

1 -- Run an
2 -- ANSI SQL
3 -- SELECT
4 -- Hive DDL
5 -- CREATE
6 -- Date Dimension
7 -- Time Dimension
8 -- Location
9 -- Bytes
10 -- Request
11 -- Method
12 -- Host
13 -- Uri
14 -- Status
15 -- Content
16 -- Headers
17 -- Headers

Permissions to Encrypted Metadata in the AWS Glue Data Catalog

If you [encrypt metadata in the AWS Glue Data Catalog](#), you must add "kms:GenerateDataKey", "kms:Decrypt", and "kms:Encrypt" actions to the policies you use for accessing Athena. For information, see [Access to Encrypted Metadata in the AWS Glue Data Catalog \(p. 214\)](#).

Encryption in Transit

In addition to encrypting data at rest in Amazon S3, Amazon Athena uses Transport Layer Security (TLS) encryption for data in-transit between Athena and Amazon S3, and between Athena and customer applications accessing it.

You should allow only encrypted connections over HTTPS (TLS) using the [aws:SecureTransport condition](#) on Amazon S3 bucket IAM policies.

Query results that stream to JDBC or ODBC clients are encrypted using TLS. For information about the latest versions of the JDBC and ODBC drivers and their documentation, see [Connect with the JDBC Driver \(p. 71\)](#) and [Connect with the ODBC Driver \(p. 73\)](#).

Key Management

Amazon Athena supports AWS Key Management Service (AWS KMS) to encrypt datasets in Amazon S3 and Athena query results. AWS KMS uses customer master keys (CMKs) to encrypt your Amazon S3 objects and relies on [envelope encryption](#).

In AWS KMS, you can perform the following actions:

- [Create keys](#)
- [Import your own key material for new CMKs](#)

For more information, see [What is AWS Key Management Service](#) in the [AWS Key Management Service Developer Guide](#), and [How Amazon Simple Storage Service Uses AWS KMS](#). To view the keys in your account that AWS creates and manages for you, in the navigation pane, choose **AWS managed keys**.

If you are uploading or accessing objects encrypted by SSE-KMS, use AWS Signature Version 4 for added security. For more information, see [Specifying the Signature Version in Request Authentication](#) in the [Amazon Simple Storage Service Developer Guide](#).

Internet Traffic Privacy

Traffic is protected both between Athena and on-premises applications and between Athena and Amazon S3. Traffic between Athena and other services, such as AWS Glue and AWS Key Management Service, uses HTTPS by default.

- **For traffic between Athena and on-premises clients and applications**, query results that stream to JDBC or ODBC clients are encrypted using Transport Layer Security (TLS).

You can use one of the connectivity options between your private network and AWS:

- A Site-to-Site VPN AWS VPN connection. For more information, see [What is Site-to-Site VPN AWS VPN](#) in the [AWS Site-to-Site VPN User Guide](#).
- An AWS Direct Connect connection. For more information, see [What is AWS Direct Connect](#) in the [AWS Direct Connect User Guide](#).
- **For traffic between Athena and Amazon S3 buckets**, Transport Layer Security (TLS) encrypts objects in-transit between Athena and Amazon S3, and between Athena and customer applications accessing it, you should allow only encrypted connections over HTTPS (TLS) using the [aws:SecureTransport condition](#) on Amazon S3 bucket IAM policies.

Identity and Access Management in Athena

Amazon Athena uses AWS Identity and Access Management (IAM) policies to restrict access to Athena operations.

To run queries in Athena, you must have the appropriate permissions for the following:

- Athena API actions including additional actions for Athena [workgroups \(p. 239\)](#).
- Amazon S3 locations where the underlying data to query is stored.
- Metadata and resources that you store in the AWS Glue Data Catalog, such as databases and tables, including additional actions for encrypted metadata.

If you are an administrator for other users, make sure that they have appropriate permissions associated with their user profiles.

Topics

- [Managed Policies for User Access \(p. 203\)](#)
- [Access through JDBC and ODBC Connections \(p. 207\)](#)
- [Access to Amazon S3 \(p. 207\)](#)
- [Fine-Grained Access to Databases and Tables in the AWS Glue Data Catalog \(p. 207\)](#)
- [Access to Encrypted Metadata in the AWS Glue Data Catalog \(p. 214\)](#)
- [Cross-account Access \(p. 214\)](#)
- [Access to Workgroups and Tags \(p. 215\)](#)
- [Allow Access to an Athena Data Connector for External Hive Metastore \(Preview\) \(p. 215\)](#)
- [Example IAM Permissions Policies to Allow Athena Federated Query \(Preview\) \(p. 217\)](#)
- [Example IAM Permissions Policies to Allow Amazon Athena User Defined Functions \(UDF\) \(p. 221\)](#)
- [Allowing Access for ML with Athena \(Preview\) \(p. 225\)](#)
- [Enabling Federated Access to the Athena API \(p. 226\)](#)

Managed Policies for User Access

To allow or deny Amazon Athena service actions for yourself or other users using AWS Identity and Access Management (IAM), you attach identity-based policies to principals, such as users or groups.

Each identity-based policy consists of statements that define the actions that are allowed or denied. For more information and step-by-step instructions for attaching a policy to a user, see [Attaching Managed Policies in the AWS Identity and Access Management User Guide](#). For a list of actions, see the [Amazon Athena API Reference](#).

Managed policies are easy to use and are updated automatically with the required actions as the service evolves.

Athena has these managed policies:

- The `AmazonAthenaFullAccess` managed policy grants full access to Athena. Attach it to users and other principals who need full access to Athena. See [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#).
- The `AWSquicksightAthenaAccess` managed policy grants access to actions that Amazon QuickSight needs to integrate with Athena. Attach this policy to principals who use Amazon QuickSight in conjunction with Athena. See [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#).

Customer-managed and *inline* identity-based policies allow you to specify more detailed Athena actions within a policy to fine-tune access. We recommend that you use the [AmazonAthenaFullAccess](#) policy as a starting point and then allow or deny specific actions listed in the [Amazon Athena API Reference](#). For more information about inline policies, see [Managed Policies and Inline Policies](#) in the *AWS Identity and Access Management User Guide*.

If you also have principals that connect using JDBC, you must provide the JDBC driver credentials to your application. For more information, see [Service Actions for JDBC Connections \(p. 207\)](#).

If you use AWS Glue with Athena, and have encrypted the AWS Glue Data Catalog, you must specify additional actions in the identity-based IAM policies for Athena. For more information, see [Access to Encrypted Metadata in the AWS Glue Data Catalog \(p. 214\)](#).

Important

If you create and use workgroups, make sure your policies include appropriate access to workgroup actions. For detailed information, see [the section called “IAM Policies for Accessing Workgroups” \(p. 242\)](#) and [the section called “Workgroup Example Policies” \(p. 243\)](#).

AmazonAthenaFullAccess Managed Policy

The [AmazonAthenaFullAccess](#) managed policy grants full access to Athena.

Managed policy contents change, so the policy shown here may be out-of-date. Check the IAM console for the most up-to-date policy.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "athena:*"  
            ],  
            "Resource": [  
                "*"  
            ]  
        },  
        {  
            "Effect": "Allow",  
            "Action": [  
                "glue>CreateDatabase",  
                "glue>DeleteDatabase",  
                "glue>GetDatabase",  
                "glue>GetDatabases",  
                "glue>UpdateDatabase",  
                "glue>CreateTable",  
                "glue>DeleteTable",  
                "glue>BatchDeleteTable",  
                "glue>UpdateTable",  
                "glue>GetTable",  
                "glue>GetTables",  
                "glue>BatchCreatePartition",  
                "glue>CreatePartition",  
                "glue>DeletePartition",  
                "glue>BatchDeletePartition",  
                "glue>UpdatePartition",  
                "glue>GetPartition",  
                "glue>GetPartitions",  
                "glue>BatchGetPartition"  
            ],  
            "Resource": [  
                "*"  
            ]  
        }  
    ]  
}
```

```
},
{
    "Effect": "Allow",
    "Action": [
        "s3:GetBucketLocation",
        "s3:GetObject",
        "s3>ListBucket",
        "s3>ListBucketMultipartUploads",
        "s3>ListMultipartUploadParts",
        "s3>AbortMultipartUpload",
        "s3>CreateBucket",
        "s3>PutObject"
    ],
    "Resource": [
        "arn:aws:s3:::aws-athena-query-results-*"
    ]
},
{
    "Effect": "Allow",
    "Action": [
        "s3GetObject",
        "s3>ListBucket"
    ],
    "Resource": [
        "arn:aws:s3:::athena-examples*"
    ]
},
{
    "Effect": "Allow",
    "Action": [
        "s3>ListBucket",
        "s3:GetBucketLocation",
        "s3>ListAllMyBuckets"
    ],
    "Resource": [
        "*"
    ]
},
{
    "Effect": "Allow",
    "Action": [
        "sns>ListTopics",
        "sns>GetTopicAttributes"
    ],
    "Resource": [
        "*"
    ]
},
{
    "Effect": "Allow",
    "Action": [
        "cloudwatch>PutMetricAlarm",
        "cloudwatch>DescribeAlarms",
        "cloudwatch>DeleteAlarms"
    ],
    "Resource": [
        "*"
    ]
}
]
```

AWSQuicksightAthenaAccess Managed Policy

An additional managed policy, `AWSQuicksightAthenaAccess`, grants access to actions that Amazon QuickSight needs to integrate with Athena. This policy includes some actions for Athena that are either deprecated and not included in the current public API, or that are used only with the JDBC and ODBC drivers. Attach this policy only to principals who use Amazon QuickSight with Athena.

Managed policy contents change, so the policy shown here may be out-of-date. Check the IAM console for the most up-to-date policy.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "athena:BatchGetQueryExecution",  
                "athena:CancelQueryExecution",  
                "athena:GetCatalogs",  
                "athena:GetExecutionEngine",  
                "athena:GetExecutionEngines",  
                "athena:GetNamespace",  
                "athena:GetNamespaces",  
                "athena:GetQueryExecution",  
                "athena:GetQueryExecutions",  
                "athena:GetQueryResults",  
                "athena:GetQueryResultsStream",  
                "athena:GetTable",  
                "athena:GetTables",  
                "athena>ListQueryExecutions",  
                "athena:RunQuery",  
                "athena:StartQueryExecution",  
                "athena:StopQueryExecution"  
            ],  
            "Resource": [  
                "*"  
            ]  
        },  
        {  
            "Effect": "Allow",  
            "Action": [  
                "glue>CreateDatabase",  
                "glue>DeleteDatabase",  
                "glue:GetDatabase",  
                "glue:GetDatabases",  
                "glue:UpdateDatabase",  
                "glue>CreateTable",  
                "glue>DeleteTable",  
                "glue:BatchDeleteTable",  
                "glue:UpdateTable",  
                "glue:GetTable",  
                "glue:GetTables",  
                "glue:BatchCreatePartition",  
                "glue>CreatePartition",  
                "glue>DeletePartition",  
                "glue:BatchDeletePartition",  
                "glue:UpdatePartition",  
                "glue:GetPartition",  
                "glue:GetPartitions",  
                "glue:BatchGetPartition"  
            ],  
            "Resource": [  
                "*"  
            ]  
        }  
    ]  
}
```

```
        },
        {
            "Effect": "Allow",
            "Action": [
                "s3:GetBucketLocation",
                "s3:GetObject",
                "s3>ListBucket",
                "s3>ListBucketMultipartUploads",
                "s3>ListMultipartUploadParts",
                "s3:AbortMultipartUpload",
                "s3>CreateBucket",
                "s3:PutObject"
            ],
            "Resource": [
                "arn:aws:s3:::aws-athena-query-results-*"
            ]
        }
    ]
}
```

Access through JDBC and ODBC Connections

To gain access to AWS services and resources, such as Athena and the Amazon S3 buckets, provide the JDBC or ODBC driver credentials to your application. If you are using the JDBC or ODBC driver, ensure that the IAM permissions policy includes all of the actions listed in [AWSQuicksightAthenaAccess Managed Policy \(p. 206\)](#).

For information about the latest versions of the JDBC and ODBC drivers and their documentation, see [Connect with the JDBC Driver \(p. 71\)](#) and [Connect with the ODBC Driver \(p. 73\)](#).

Access to Amazon S3

If you or your users need to create tables and work with underlying data, they must have access to the Amazon S3 location of the data. This access is in addition to the allowed actions for Athena that you define in IAM identity-based policies.

You can grant access to Amazon S3 locations using identity-based policies, bucket resource policies, or both. For detailed information and scenarios about how to grant Amazon S3 access, see [Example Walkthroughs: Managing Access in the Amazon Simple Storage Service Developer Guide](#). For more information and an example of which Amazon S3 actions to allow, see the example bucket policy in [Cross-Account Access \(p. 214\)](#).

Note

Athena does not support restricting or allowing access to Amazon S3 resources based on the `aws:SourceIp` condition key.

Fine-Grained Access to Databases and Tables in the AWS Glue Data Catalog

If you use the AWS Glue Data Catalog with Amazon Athena, you can define resource-level policies for the following Data Catalog objects that are used in Athena: databases and tables.

You define resource-level permissions in IAM identity-based policies.

Important

This section discusses resource-level permissions in IAM identity-based policies. These are different from resource-based policies. For more information about the differences, see [Identity-Based Policies and Resource-Based Policies](#) in the *AWS Identity and Access Management User Guide*.

See the following topics for these tasks:

To perform this task	See the following topic
Create an IAM policy that defines fine-grained access to resources	Creating IAM Policies in the AWS Identity and Access Management User Guide.
Learn about IAM identity-based policies used in AWS Glue	Identity-Based Policies (IAM Policies) in the AWS Glue Developer Guide.

In this section

- [Limitations \(p. 208\)](#)
- [Mandatory: Access Policy to the Default Database and Catalog per AWS Region \(p. 209\)](#)
- [Table Partitions and Versions in AWS Glue \(p. 209\)](#)
- [Fine-Grained Policy Examples \(p. 210\)](#)

Limitations

Consider the following limitations when using fine-grained access control with the AWS Glue Data Catalog and Athena:

- You can limit access only to databases and tables. Fine-grained access controls apply at the table level and you cannot limit access to individual partitions within a table. For more information, see [Table Partitions and Versions in AWS Glue \(p. 209\)](#).
- Athena does not support cross-account access to the AWS Glue Data Catalog.
- The AWS Glue Data Catalog contains the following resources: CATALOG, DATABASE, TABLE, and FUNCTION.

Note

From this list, resources that are common between Athena and the AWS Glue Data Catalog are TABLE, DATABASE, and CATALOG for each account. Function is specific to AWS Glue. For delete actions in Athena, you must include permissions to AWS Glue actions. See [Fine-Grained Policy Examples \(p. 210\)](#).

The hierarchy is as follows: CATALOG is an ancestor of all DATABASES in each account, and each DATABASE is an ancestor for all of its TABLES and FUNCTIONS. For example, for a table named `table_test` that belongs to a database `db` in the catalog in your account, its ancestors are `db` and the catalog in your account. For the `db` database, its ancestor is the catalog in your account, and its descendants are tables and functions. For more information about the hierarchical structure of resources, see [List of ARNs in Data Catalog](#) in the *AWS Glue Developer Guide*.

- For any non-delete Athena action on a resource, such as CREATE DATABASE, CREATE TABLE, SHOW DATABASE, SHOW TABLE, or ALTER TABLE, you need permissions to call this action on the resource (table or database) and all ancestors of the resource in the Data Catalog. For example, for a table, its ancestors are the database to which it belongs, and the catalog for the account. For a database, its ancestor is the catalog for the account. See [Fine-Grained Policy Examples \(p. 210\)](#).
- For a delete action in Athena, such as DROP DATABASE or DROP TABLE, you also need permissions to call the delete action on all ancestors and descendants of the resource in the Data Catalog. For example, to delete a database you need permissions on the database, the catalog, which is its ancestor, and all the tables and user defined functions, which are its descendants. A table does not have descendants. To run DROP TABLE, you need permissions to this action on the table, the database to which it belongs, and the catalog. See [Fine-Grained Policy Examples \(p. 210\)](#).

- When limiting access to a specific database in the Data Catalog, you must also specify the access policy to the default database and catalog for each AWS Region for `GetDatabase` and `CreateDatabase` actions. If you use Athena in more than one Region, add a separate line to the policy for the resource ARN for each default database and catalog in each Region.

For example, to allow `GetDatabase` access to `example_db` in the `us-east-1` (N.Virginia) Region, also include the default database and catalog in the policy for that Region for two actions: `GetDatabase` and `CreateDatabase`:

```
{
    "Effect": "Allow",
    "Action": [
        "glue:GetDatabase",
        "glue>CreateDatabase"
    ],
    "Resource": [
        "arn:aws:glue:us-east-1:123456789012:catalog",
        "arn:aws:glue:us-east-1:123456789012:database/default",
        "arn:aws:glue:us-east-1:123456789012:database/example_db"
    ]
}
```

Mandatory: Access Policy to the Default Database and Catalog per AWS Region

For Athena to work with the AWS Glue Data Catalog, the following access policy to the default database and to the AWS Glue Data Catalog per AWS Region for `GetDatabase` and `CreateDatabase` must be present :

```
{
    "Effect": "Allow",
    "Action": [
        "glue:GetDatabase",
        "glue>CreateDatabase"
    ],
    "Resource": [
        "arn:aws:glue:us-east-1:123456789012:catalog",
        "arn:aws:glue:us-east-1:123456789012:database/default"
    ]
}
```

Table Partitions and Versions in AWS Glue

In AWS Glue, tables can have partitions and versions. Table versions and partitions are not considered to be independent resources in AWS Glue. Access to table versions and partitions is given by granting access on the table and ancestor resources for the table.

For the purposes of fine-grained access control, the following access permissions apply:

- Fine-grained access controls apply at the table level. You can limit access only to databases and tables. For example, if you allow access to a partitioned table, this access applies to all partitions in the table. You cannot limit access to individual partitions within a table.

Important

Having access to all partitions within a table is not sufficient if you need to run actions in AWS Glue on partitions. To run actions on partitions, you need permissions for those actions. For example, to run `GetPartitions` on table `myTable` in the database `myDB`, you need

permissions for the action `glue:GetPartitions` in the Data Catalog, the `myDB` database, and `myTable`.

- Fine-grained access controls do not apply to table versions. As with partitions, access to previous versions of a table is granted through access to the table version APIs in AWS Glue on the table, and to the table ancestors.

For information about permissions on AWS Glue actions, see [AWS Glue API Permissions: Actions and Resources Reference](#) in the *AWS Glue Developer Guide*.

Examples of Fine-Grained Permissions to Tables and Databases

The following table lists examples of IAM identity-based policies that allow fine-grained access to databases and tables in Athena. We recommend that you start with these examples and, depending on your needs, adjust them to allow or deny specific actions to particular databases and tables.

These examples include the access policy to the `default` database and catalog, for `GetDatabase` and `CreateDatabase` actions. This policy is required for Athena and the AWS Glue Data Catalog to work together. For multiple AWS Regions, include this policy for each of the default databases and their catalogs, one line for each Region.

In addition, replace the `example_db` database and `test` table names with the names for your databases and tables.

DDL Statement	Example of an IAM access policy granting access to the resource
CREATE DATABASE	<p>Allows you to create the database named <code>example_db</code>.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default", "arn:aws:glue:us-east-1:123456789012:database/example_db"] }</pre>
ALTER DATABASE	<p>Allows you to modify the properties for the <code>example_db</code> database.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"], { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue:UpdateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:database/example_db"] } }</pre>

DDL Statement	Example of an IAM access policy granting access to the resource
	<pre> "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/example_db"] } </pre>
DROP DATABASE	<p>Allows you to drop the example_db database, including all tables in it.</p> <pre> { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"] }, { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>DeleteDatabase", "glue:GetTables", "glue:GetTable", "glue>DeleteTable"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/example_db", "arn:aws:glue:us-east-1:123456789012:table/example_db/*", "arn:aws:glue:us-east-1:123456789012:userDefinedFunction/ example_db/*"] } </pre>

DDL Statement	Example of an IAM access policy granting access to the resource
SHOW DATABASES	<p>Allows you to list all databases in the AWS Glue Data Catalog.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"] }, { "Effect": "Allow", "Action": ["glue:GetDatabases"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/*"] }</pre>
CREATE TABLE	<p>Allows you to create a table named <code>test</code> in the <code>example_db</code> database.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"] }, { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue:GetTable", "glue>CreateTable"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/example_db", "arn:aws:glue:us-east-1:123456789012:table/example_db/test"] }</pre>

DDL Statement	Example of an IAM access policy granting access to the resource
SHOW TABLES	<p>Allows you to list all tables in the <code>example_db</code> database.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"] }, { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue:GetTables"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/example_db", "arn:aws:glue:us-east-1:123456789012:table/example_db/*"] }</pre>
DROP TABLE	<p>Allows you to drop a partitioned table named <code>test</code> in the <code>example_db</code> database. If your table does not have partitions, do not include partition actions.</p> <pre>{ "Effect": "Allow", "Action": ["glue:GetDatabase", "glue>CreateDatabase"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/default"] }, { "Effect": "Allow", "Action": ["glue:GetDatabase", "glue:GetTable", "glue>DeleteTable", "glue:GetPartitions", "glue:GetPartition", "glue>DeletePartition"], "Resource": ["arn:aws:glue:us-east-1:123456789012:catalog", "arn:aws:glue:us-east-1:123456789012:database/example_db", "arn:aws:glue:us-east-1:123456789012:table/example_db/test"] }</pre>

Access to Encrypted Metadata in the AWS Glue Data Catalog

If you use the AWS Glue Data Catalog with Amazon Athena, you can enable encryption in the AWS Glue Data Catalog using the AWS Glue console or the API. For information, see [Encrypting Your Data Catalog](#) in the [AWS Glue Developer Guide](#).

If the AWS Glue Data Catalog is encrypted, you must add the following actions to all policies that are used to access Athena:

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "kms:GenerateDataKey",  
                "kms:Decrypt",  
                "kms:Encrypt"  
            ],  
            "Resource": "(arn of key being used to encrypt the catalog)"  
        }  
    ]  
}
```

Cross-account Access

A common Amazon Athena scenario is granting access to users in an account different from the bucket owner so that they can perform queries. In this case, use a bucket policy to grant access.

The following example bucket policy, created and applied to bucket `s3://my-athena-data-bucket` by the bucket owner, grants access to all users in account `123456789123`, which is a different account.

```
{  
    "Version": "2012-10-17",  
    "Id": "MyPolicyID",  
    "Statement": [  
        {  
            "Sid": "MyStatementsId",  
            "Effect": "Allow",  
            "Principal": {  
                "AWS": "arn:aws:iam::123456789123:root"  
            },  
            "Action": [  
                "s3:GetBucketLocation",  
                "s3:GetObject",  
                "s3>ListBucket",  
                "s3>ListBucketMultipartUploads",  
                "s3>ListMultipartUploadParts",  
                "s3:AbortMultipartUpload",  
                "s3:PutObject"  
            ],  
            "Resource": [  
                "arn:aws:s3:::my-athena-data-bucket",  
                "arn:aws:s3:::my-athena-data-bucket/*"  
            ]  
        }  
    ]  
}
```

To grant access to a particular user in an account, replace the `Principal` key with a key that specifies the user instead of `root`. For example, for user profile `Dave`, use `arn:aws:iam::123456789123:user/Dave`.

Access to Workgroups and Tags

A workgroup is a resource managed by Athena. Therefore, if your workgroup policy uses actions that take `workgroup` as an input, you must specify the workgroup's ARN as follows, where `workgroup-name` is the name of your workgroup:

```
"Resource": [arn:aws:athena:region:AWSAcctID:workgroup/workgroup-name]
```

For example, for a workgroup named `test_workgroup` in the `us-west-2` region for AWS account `123456789012`, specify the workgroup as a resource using the following ARN:

```
"Resource": ["arn:aws:athena:us-east-1:123456789012:workgroup/test_workgroup"]
```

- For a list of workgroup policies, see [the section called “Workgroup Example Policies” \(p. 243\)](#).
- For a list of tag-based policies for workgroups, see [Tag-Based IAM Access Control Policies \(p. 266\)](#).
- For more information about creating IAM policies for workgroups, see [Workgroup IAM Policies \(p. 242\)](#).
- For a complete list of Amazon Athena actions, see the API action names in the [Amazon Athena API Reference](#).
- For more information about IAM policies, see [Creating Policies with the Visual Editor](#) in the [IAM User Guide](#).

Allow Access to an Athena Data Connector for External Hive Metastore (Preview)

The permission policy examples in this topic demonstrate required allowed actions and the resources for which they are allowed. Examine these policies carefully and modify them according to your requirements before you attach similar permissions policies to IAM identities.

- [Example Policy to Allow an IAM Principal to Query Data Using Athena Data Connector for External Hive Metastore \(Preview\) \(p. 215\)](#)
- [Example Policy to Allow an IAM Principal to Create an Athena Data Connector for External Hive Metastore \(Preview\) \(p. 216\)](#)

Example – Allow an IAM Principal to Query Data Using Athena Data Connector for External Hive Metastore (Preview)

The following policy is attached to IAM principals in addition to the [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#), which grants full access to Athena actions.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "VisualEditor1",  
            "Effect": "Allow",  
            "Action": [  
                "lambda:GetFunction",  
                "lambda:GetLayerVersion",  
                "lambda:InvokeFunction",  
                "lambda:ListFunctions*",  
                "lambda:ListLayerVersions*",  
                "lambda:UpdateFunction",  
                "lambda:UpdateLayerVersion"  
            ]  
        }  
    ]  
}
```

```

        "lambda:InvokeFunction"
    ],
    "Resource": [
        "arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunction",
        "arn:aws:lambda:*:MyAWSAcctId:function:AnotherAthenaLambdaFunction",
        "arn:aws:lambda:*:MyAWSAcctId:layer:MyAthenaLambdaLayer:*"
    ]
},
{
    "Sid": "VisualEditor2",
    "Effect": "Allow",
    "Action": [
        "s3:GetBucketLocation",
        "s3:GetObject",
        "s3>ListBucket",
        "s3:PutObject",
        "s3>ListMultipartUploadParts",
        "s3:AbortMultipartUpload"
    ],
    "Resource": "arn:aws:s3:::MyLambdaSpillBucket/MyLambdaSpillLocation"
}
]
}

```

Explanation of Permissions

Allowed Actions	Explanation
"s3:GetBucketLocation", "s3:GetObject", "s3>ListBucket", "s3:PutObject", "s3>ListMultipartUploadParts", "s3:AbortMultipartUpload"	s3 actions allow reading from and writing to the resource specified as "arn:aws:s3::: <i>MyLambdaSpillBucket</i> / <i>MyLambdaSpillLocation</i> ", where <i>MyLambdaSpillLocation</i> identifies the spill bucket that is specified in the configuration of the Lambda function or functions being invoked. The <i>arn:aws:lambda:*</i> : <i>MyAWSAcctId</i> :layer: <i>MyAthenaLambdaLayer</i> resource identifier is required only if you use a Lambda layer to create custom runtime dependencies to reduce function artifact size at deployment time. The * in the last position is a wildcard for layer version.
"lambda:GetFunction", "lambda:GetLayerVersion", "lambda:InvokeFunction"	Allows queries to invoke the AWS Lambda functions specified in the Resource block. For example, arn:aws:lambda:*: <i>MyAWSAcctId</i> :function: <i>MyAthenaLambdaFunction</i> where <i>MyAthenaLambdaFunction</i> specifies the name of a Lambda function to be invoked. Multiple functions can be specified as shown in the example.

Example – Allow an IAM Principal to Create an Athena Data Connector for External Hive Metastore (Preview)

The following policy is attached to IAM principals in addition to the [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#), which grants full access to Athena actions.

```
{
    "Version": "2012-10-17",
    "Statement": [

```

```
{
    "Sid": "VisualEditor0",
    "Effect": "Allow",
    "Action": [
        "lambda:GetFunction",
        "lambda>ListFunctions",
        "lambda:GetLayerVersion",
        "lambda:InvokeFunction",
        "lambda>CreateFunction",
        "lambda>DeleteFunction",
        "lambda>PublishLayerVersion",
        "lambda>DeleteLayerVersion",
        "lambda>UpdateFunctionConfiguration",
        "lambda>PutFunctionConcurrency",
        "lambda>DeleteFunctionConcurrency"
    ],
    "Resource": "arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunctionsPrefix*"
}
]
```

Explanation of Permissions

Allows queries to invoke the AWS Lambda functions for the AWS Lambda functions specified in the Resource block. For example, `arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunction`, where `MyAthenaLambdaFunction` specifies the name of a Lambda function to be invoked. Multiple functions can be specified as shown in the example.

Example IAM Permissions Policies to Allow Athena Federated Query (Preview)

The permission policy examples in this topic demonstrate required allowed actions and the resources for which they are allowed. Examine these policies carefully and modify them according to your requirements before attaching them to IAM identities.

- [Example Policy to Allow an IAM Principal to Run and Return Results Using Athena Federated Query \(Preview\) \(p. 217\)](#)
- [Example Policy to Allow an IAM Principal to Create a Data Source Connector \(p. 219\)](#)

Example – Allow an IAM Principal to Run and Return Results Using Athena Federated Query (Preview)

The following identity-based permissions policy allows actions that a user or other IAM principal requires to use Athena Federated Query (Preview). Principals who are allowed to perform these actions are able to run queries that specify Athena catalogs associated with a federated data source.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "athena:StartQueryExecution",
                "lambda:InvokeFunction",
                "athena:GetQueryResults",
                "s3>ListMultipartUploadParts",
                "s3:AbortMultipartUpload"
            ]
        }
    ]
}
```

```

        "athena:GetWorkGroup",
        "s3:PutObject",
        "s3:GetObject",
        "s3:AbortMultipartUpload",
        "athena:CancelQueryExecution",
        "athena:StopQueryExecution",
        "athena:GetQueryExecution",
        "s3:GetBucketLocation"
    ],
    "Resource": [
        "arn:aws:athena:*:MyAWSAcctId:workgroup/AmazonAthenaPreviewFunctionality",
        "arn:aws:s3:::MyQueryResultsBucket",
        "arn:aws:s3:::MyLambdaSpillBucket/*",
        "arn:aws:lambda:*:MyAWSAcctId:function:OneAthenaLambdaFunction",
        "arn:aws:lambda:*:MyAWSAcctId:function:AnotherAthenaLambdaFunction"
    ]
},
{
    "Sid": "VisualEditor1",
    "Effect": "Allow",
    "Action": "athena>ListWorkGroups",
    "Resource": "*"
},
{
    "Sid": "VisualEditor2",
    "Effect": "Allow",
    "Action": "s3:GetObject",
    "Resource": "arn:aws:s3:::MyLambdaSpillBucket/MyLambdaSpillPrefix*"
}
]
}

```

Explanation of Permissions

Allowed Actions	Explanation
"athena:StartQueryExecution", "athena:GetQueryResults", "athena:GetWorkGroup", "athena:CancelQueryExecution", "athena:StopQueryExecution", "athena:GetQueryExecution",	Athena permissions that are required to run queries in the AmazonAthenaPreviewFunctionality work group.
"s3:PutObject", "s3:GetObject", "s3:AbortMultipartUpload"	s3:PutObject and s3:AbortMultipartUpload allow writing query results to all sub-folders of the query results bucket as specified by the arn:aws:s3::: <i>MyQueryResultsBucket</i> /* resource identifier, where <i>MyQueryResultsBucket</i> is the Athena query results bucket. For more information, see Working with Query Results, Output Files, and Query History (p. 107) .
	s3:GetObject allows reading of query results and query history for the resource specified as arn:aws:s3::: <i>MyQueryResultsBucket</i> , where <i>MyQueryResultsBucket</i> is the Athena query results bucket.

Allowed Actions	Explanation
	s3:GetObject also allows reading from the resource specified as <code>"arn:aws:s3:::MyLambdaSpillBucket/MyLambdaSpillPrefix*</code> , where <code>MyLambdaSpillPrefix</code> is specified in the configuration of the Lambda function or functions being invoked.
<code>"lambda:InvokeFunction"</code>	Allows queries to invoke the AWS Lambda functions for the AWS Lambda functions specified in the Resource block. For example, <code>arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunction</code> where <code>MyAthenaLambdaFunction</code> specifies the name of a Lambda function to be invoked. Multiple functions can be specified as shown in the example.

Example – Allow an IAM Principal to Create a Data Source Connector

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "lambda>CreateFunction",
                "lambda>ListVersionsByFunction",
                "iam>CreateRole",
                "lambda:GetFunctionConfiguration",
                "iam:AttachRolePolicy",
                "iam:PutRolePolicy",
                "lambda:PutFunctionConcurrency",
                "iam:PassRole",
                "iam:DetachRolePolicy",
                "lambda>ListTags",
                "iam>ListAttachedRolePolicies",
                "iam>DeleteRolePolicy",
                "lambda>DeleteFunction",
                "lambda>GetAlias",
                "iam>ListRolePolicies",
                "iam>GetRole",
                "iam>GetPolicy",
                "lambda>InvokeFunction",
                "lambda>GetFunction",
                "lambda>ListAliases",
                "lambda>UpdateFunctionConfiguration",
                "iam>DeleteRole",
                "lambda>UpdateFunctionCode",
                "s3.GetObject",
                "lambda>AddPermission",
                "iam>UpdateRole",
                "lambda>DeleteFunctionConcurrency",
                "lambda>RemovePermission",
                "iam>GetRolePolicy",
                "lambda>GetPolicy"
            ],
            "Resource": [
                "arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunctionsPrefix*",
                "arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunctionsPrefix*"
            ]
        }
    ]
}
```

```

        "arn:aws:s3:::awsserverlessrepo-changesets-1iiv3xa62ln3m/*",
        "arn:aws:iam::*:role/*",
        "arn:aws:iam::MyAWSAcctId:policy/*"
    ],
},
{
    "Sid": "VisualEditor1",
    "Effect": "Allow",
    "Action": [
        "cloudformation>CreateUploadBucket",
        "cloudformation>DescribeStackDriftDetectionStatus",
        "cloudformation>ListExports",
        "cloudformation>ListStacks",
        "cloudformation>ListImports",
        "lambda>ListFunctions",
        "iam>ListRoles",
        "lambda:GetAccountSettings",
        "ec2>DescribeSecurityGroups",
        "cloudformation>EstimateTemplateCost",
        "ec2>DescribeVpcs",
        "lambda>ListEventSourceMappings",
        "cloudformation>DescribeAccountLimits",
        "ec2>DescribeSubnets",
        "cloudformation>CreateStackSet",
        "cloudformation>ValidateTemplate"
    ],
    "Resource": "*"
},
{
    "Sid": "VisualEditor2",
    "Effect": "Allow",
    "Action": "cloudformation:*",
    "Resource": [
        "arn:aws:cloudformation::*:MyAWSAcctId:stack/aws-serverless-
repository-MyCFStackPrefix/*",
        "arn:aws:cloudformation::*:MyAWSAcctId:stack/
serverlessrepo-MyCFStackPrefix/*",
        "arn:aws:cloudformation::*:transform/Serverless-*",
        "arn:aws:cloudformation::*:MyAWSAcctId:stackset/aws-serverless-
repository-MyCFStackPrefix::*",
        "arn:aws:cloudformation::*:MyAWSAcctId:stackset/
serverlessrepo-MyCFStackPrefix::*"
    ]
},
{
    "Sid": "VisualEditor3",
    "Effect": "Allow",
    "Action": "serverlessrepo:*",
    "Resource": "arn:aws:serverlessrepo::*:applications/*"
}
]
}

```

Explanation of Permissions

Allowed Actions	Explanation
"lambda>CreateFunction", "lambda>ListVersionsByFunction", "lambda>GetFunctionConfiguration", "lambda>PutFunctionConcurrency", "lambda>ListTags", "lambda>DeleteFunction", "lambda>GetAlias",	Allow the creation and management of Lambda functions listed as resources. In the example, a name prefix is used in the resource identifier <code>arn:aws:lambda::*:<i>MyAWSAcctId</i>:function:<i>MyAthenaLambdaFunctionName</i></code> where <code><i>MyAthenaLambdaFunctionsPrefix</i></code> is a shared prefix used in the name of a group of Lambda functions so that they don't need to be

Allowed Actions	Explanation
<pre>"lambda:InvokeFunction", "lambda:GetFunction", "lambda>ListAliases", "lambda:UpdateFunctionConfiguration", "lambda:UpdateFunctionCode", "lambda:AddPermission", "lambda>DeleteFunctionConcurrency", "lambda:RemovePermission", "lambda:GetPolicy" "lambda:GetAccountSettings", "lambda>ListFunctions", "lambda>ListEventSourceMappings",</pre>	specified individually as resources. You can specify one or more Lambda function resources.
<pre>"s3:GetObject"</pre>	Allows reading of a bucket that AWS Serverless Application Repository requires as specified by the resource identifier <code>arn:aws:s3:::awsserverlessrepo-changesets-<i>1liv3xa62ln3m</i>/*</code> . This bucket may be specific to your account.
<pre>"cloudformation:*</pre>	Allows the creation and management of AWS CloudFormation stacks specified by the resource <code>MyCFStackPrefix</code> . These stacks and stacksets are how AWS Serverless Application Repository deploys connectors and UDFs.
<pre>"serverlessrepo:*</pre>	Allows searching, viewing, publishing, and updating applications in the AWS Serverless Application Repository, specified by the resource identifier <code>arn:aws:serverlessrepo:*:*:applications/*</code> .

Example IAM Permissions Policies to Allow Amazon Athena User Defined Functions (UDF)

The permission policy examples in this topic demonstrate required allowed actions and the resources for which they are allowed. Examine these policies carefully and modify them according to your requirements before you attach similar permissions policies to IAM identities.

- [Example Policy to Allow an IAM Principal to Run and Return Queries that Contain an Athena UDF Statement \(p. 221\)](#)
- [Example Policy to Allow an IAM Principal to Create an Athena UDF \(p. 223\)](#)

Example – Allow an IAM Principal to Run and Return Queries that Contain an Athena UDF Statement

The following identity-based permissions policy allows actions that a user or other IAM principal requires to run queries that use Athena UDF statements.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:myLambdaFunction"
        }
    ]
}
```

```

    "Sid": "VisualEditor0",
    "Effect": "Allow",
    "Action": [
        "athena:StartQueryExecution",
        "lambda:InvokeFunction",
        "athena:GetQueryResults",
        "s3>ListMultipartUploadParts",
        "athena:GetWorkGroup",
        "s3:PutObject",
        "s3:GetObject",
        "s3:AbortMultipartUpload",
        "athena:CancelQueryExecution",
        "athena:StopQueryExecution",
        "athena:GetQueryExecution",
        "s3:GetBucketLocation"
    ],
    "Resource": [
        "arn:aws:athena:*:MyAWSAcctId:workgroup/AmazonAthenaPreviewFunctionality",
        "arn:aws:s3:::MyQueryResultsBucket",
        "arn:aws:s3:::MyLambdaSpillBucket/*",
        "arn:aws:lambda:*:MyAWSAcctId:function:OneAthenaLambdaFunction",
        "arn:aws:lambda:*:MyAWSAcctId:function:AnotherAthenaLambdaFunction"
    ]
},
{
    "Sid": "VisualEditor1",
    "Effect": "Allow",
    "Action": "athena>ListWorkGroups",
    "Resource": "*"
},
{
    "Sid": "VisualEditor2",
    "Effect": "Allow",
    "Action": "s3:GetObject",
    "Resource": "arn:aws:s3:::MyLambdaSpillBucket/MyLambdaSpillPrefix*"
}
]
}

```

Explanation of Permissions

Allowed Actions	Explanation
"athena:StartQueryExecution", "athena:GetQueryResults", "athena:GetWorkGroup", "athena:CancelQueryExecution", "athena:StopQueryExecution", "athena:GetQueryExecution",	Athena permissions that are required to run queries in the AmazonAthenaPreviewFunctionality work group.
"s3:PutObject", "s3:GetObject", "s3:AbortMultipartUpload"	s3:PutObject and s3:AbortMultipartUpload allow writing query results to all sub-folders of the query results bucket as specified by the arn:aws:s3::: <i>MyQueryResultsBucket</i> /* resource identifier, where <i>MyQueryResultsBucket</i> is the Athena query results bucket. For more information, see Working with Query Results, Output Files, and Query History (p. 107) .

Allowed Actions	Explanation
	<p>s3:GetObject allows reading of query results and query history for the resource specified as <code>arn:aws:s3:::MyQueryResultsBucket</code>, where <code>MyQueryResultsBucket</code> is the Athena query results bucket. For more information, see Working with Query Results, Output Files, and Query History (p. 107).</p> <p>s3:GetObject also allows reading from the resource specified as <code>"arn:aws:s3:::MyLambdaSpillBucket/MyLambdaSpillPrefix*</code>, where <code>MyLambdaSpillPrefix</code> is specified in the configuration of the Lambda function or functions being invoked.</p>
<code>"lambda:InvokeFunction"</code>	Allows queries to invoke the AWS Lambda functions specified in the Resource block. For example, <code>arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunction</code> where <code>MyAthenaLambdaFunction</code> specifies the name of a Lambda function to be invoked. Multiple functions can be specified as shown in the example.

Example – Allow an IAM Principal to Create an Athena UDF

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "lambda>CreateFunction",
                "lambda>ListVersionsByFunction",
                "iam>CreateRole",
                "lambda>GetFunctionConfiguration",
                "iam>AttachRolePolicy",
                "iam>PutRolePolicy",
                "lambda>PutFunctionConcurrency",
                "iam>PassRole",
                "iam>DetachRolePolicy",
                "lambda>ListTags",
                "iam>ListAttachedRolePolicies",
                "iam>DeleteRolePolicy",
                "lambda>DeleteFunction",
                "lambda>GetAlias",
                "iam>ListRolePolicies",
                "iam>GetRole",
                "iam>GetPolicy",
                "lambda>InvokeFunction",
                "lambda>GetFunction",
                "lambda>ListAliases",
                "lambda>UpdateFunctionConfiguration",
                "iam>DeleteRole",
                "lambda>UpdateFunctionCode",
                "s3>GetObject"
            ]
        }
    ]
}
```

```
        "lambda:AddPermission",
        "iam:UpdateRole",
        "lambda:DeleteFunctionConcurrency",
        "lambda:RemovePermission",
        "iam:GetRolePolicy",
        "lambda:GetPolicy"
    ],
    "Resource": [
        "arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunctionsPrefix**",
        "arn:aws:s3:::awsserverlessrepo-changesets-1iiv3xa62ln3m/*",
        "arn:aws:iam::*:role/*",
        "arn:aws:iam::MyAWSAcctId:policy/*"
    ]
},
{
    "Sid": "VisualEditor1",
    "Effect": "Allow",
    "Action": [
        "cloudformation>CreateUploadBucket",
        "cloudformation>DescribeStackDriftDetectionStatus",
        "cloudformation>ListExports",
        "cloudformation>ListStacks",
        "cloudformation>ListImports",
        "lambda>ListFunctions",
        "iam>ListRoles",
        "lambda>GetAccountSettings",
        "ec2>DescribeSecurityGroups",
        "cloudformation>EstimateTemplateCost",
        "ec2>DescribeVpcs",
        "lambda>ListEventSourceMappings",
        "cloudformation>DescribeAccountLimits",
        "ec2>DescribeSubnets",
        "cloudformation>CreateStackSet",
        "cloudformation>ValidateTemplate"
    ],
    "Resource": "*"
},
{
    "Sid": "VisualEditor2",
    "Effect": "Allow",
    "Action": "cloudformation:*",
    "Resource": [
        "arn:aws:cloudformation:*:MyAWSAcctId:stack/aws-serverless-
repository-MyCFStackPrefix/*",
        "arn:aws:cloudformation:*:MyAWSAcctId:stack/
serverlessrepo-MyCFStackPrefix/*",
        "arn:aws:cloudformation:***:transform/Serverless-*",
        "arn:aws:cloudformation:*:MyAWSAcctId:stackset/aws-serverless-
repository-MyCFStackPrefix/*",
        "arn:aws:cloudformation:*:MyAWSAcctId:stackset/
serverlessrepo-MyCFStackPrefix/*"
    ]
},
{
    "Sid": "VisualEditor3",
    "Effect": "Allow",
    "Action": "serverlessrepo:*",
    "Resource": "arn:aws:serverlessrepo:***:applications/*"
}
]
```

Explanation of Permissions

Allowed Actions	Explanation
<pre>"lambda>CreateFunction", "lambda>ListVersionsByFunction", "lambda:GetFunctionConfiguration", "lambda:PutFunctionConcurrency", "lambda>ListTags", "lambda>DeleteFunction", "lambda:GetAlias", "lambda:InvokeFunction", "lambda:GetFunction", "lambda>ListAliases", "lambda:UpdateFunctionConfiguration", "lambda:UpdateFunctionCode", "lambda:AddPermission", "lambda:DeleteFunctionConcurrency", "lambda:RemovePermission", "lambda:GetPolicy", "lambda:GetAccountSettings", "lambda>ListFunctions", "lambda>ListEventSourceMappings",</pre>	Allow the creation and management of Lambda functions listed as resources. In the example, a name prefix is used in the resource identifier <code>arn:aws:lambda:*:MyAWSAcctId:function:MyAthenaLambdaFunction</code> where <code>MyAthenaLambdaFunctionsPrefix</code> is a shared prefix used in the name of a group of Lambda functions so that they don't need to be specified individually as resources. You can specify one or more Lambda function resources.
<code>"s3GetObject"</code>	Allows reading of a bucket that AWS Serverless Application Repository requires as specified by the resource identifier <code>arn:aws:s3:::awsserverlessrepo-changesets-1liv3xa62ln3m/*</code> .
<code>"cloudformation:*</code>	Allows the creation and management of AWS CloudFormation stacks specified by the resource <code>MyCFStackPrefix</code> . These stacks and stacksets are how AWS Serverless Application Repository deploys connectors and UDFs.
<code>"serverlessrepo:*</code>	Allows searching, viewing, publishing, and updating applications in the AWS Serverless Application Repository, specified by the resource identifier <code>arn:aws:serverlessrepo:***:applications/*</code> .

Allowing Access for ML with Athena (Preview)

IAM principals who run Athena ML queries must be allowed to perform the `sagemaker:invokeEndpoint` action for Sagemaker endpoints that they use. Include a policy statement similar to the following in identity-based permissions policies attached to user identities. In addition, attach the [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#), which grants full access to Athena actions, or a modified inline policy that allows a subset of actions.

Replace `arn:aws:sagemaker:region:AWSAcctID:ModelEndpoint` in the example with the ARN or ARNs of model endpoints to be used in queries. For more information, see [Actions, Resources, and Condition Keys for Amazon SageMaker](#) in the *IAM User Guide*.

```
{
    "Effect": "Allow",
    "Action": [
```

```
        "sagemaker:invokeEndpoint"
    ],
    "Resource": "arn:aws:sagemaker:us-west-2:123456789012:workteam/public-crowd/
default"
}
```

Enabling Federated Access to the Athena API

This section discusses federated access that allows a user or client application in your organization to call Amazon Athena API operations. In this case, your organization's users don't have direct access to Athena. Instead, you manage user credentials outside of AWS in Microsoft Active Directory. Active Directory supports [SAML 2.0](#) (Security Assertion Markup Language 2.0).

To authenticate users in this scenario, use the JDBC or ODBC driver with SAML 2.0 support to access Active Directory Federation Services (ADFS) 3.0 and enable a client application to call Athena API operations.

For more information about SAML 2.0 support on AWS, see [About SAML 2.0 Federation](#) in the *IAM User Guide*.

Note

Federated access to the Athena API is supported for a particular type of identity provider (IdP), the Active Directory Federation Service (ADFS 3.0), which is part of Windows Server. Access is established through the versions of JDBC or ODBC drivers that support SAML 2.0. For information, see [Using Athena with the JDBC Driver \(p. 71\)](#) and [Connecting to Amazon Athena with ODBC \(p. 73\)](#).

Topics

- [Before You Begin \(p. 226\)](#)
- [Architecture Diagram \(p. 226\)](#)
- [Procedure: SAML-based Federated Access to the Athena API \(p. 227\)](#)

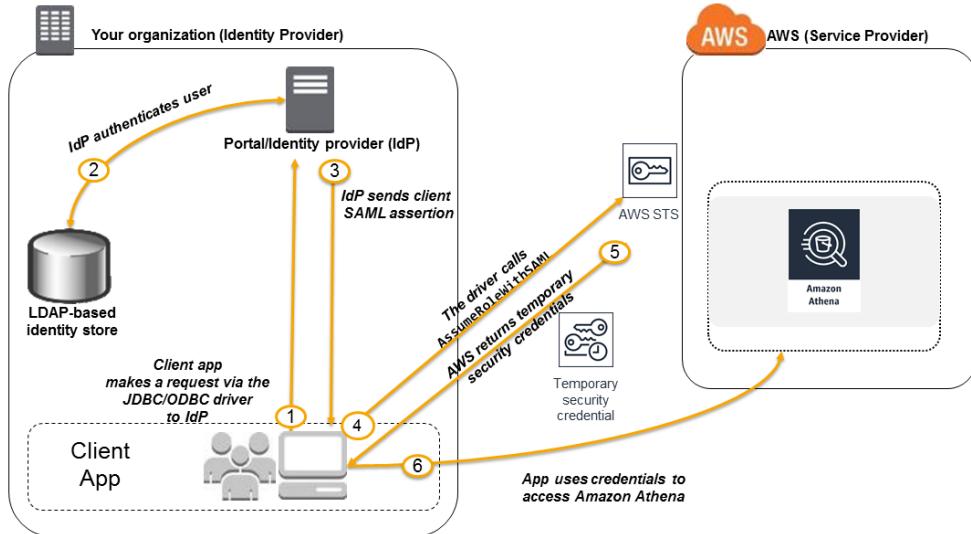
Before You Begin

Before you begin, complete the following prerequisites:

- Inside your organization, install and configure the ADFS 3.0 as your IdP.
- Install and configure the latest available versions of JDBC or ODBC drivers on clients that are used to access Athena. The driver must include support for federated access compatible with SAML 2.0. For information, see [Using Athena with the JDBC Driver \(p. 71\)](#) and [Connecting to Amazon Athena with ODBC \(p. 73\)](#).

Architecture Diagram

The following diagram illustrates this process.



1. A user in your organization uses a client application with the JDBC or ODBC driver to request authentication from your organization's IdP. The IdP is ADFS 3.0.
2. The IdP authenticates the user against Active Directory, which is your organization's Identity Store.
3. The IdP constructs a SAML assertion with information about the user and sends the assertion to the client application via the JDBC or ODBC driver.
4. The JDBC or ODBC driver calls the AWS Security Token Service [AssumeRoleWithSAML](#) API operation, passing it the following parameters:
 - The ARN of the SAML provider
 - The ARN of the role to assume
 - The SAML assertion from the IdP
 For more information, see [AssumeRoleWithSAML](#), in the *AWS Security Token Service API Reference*.
5. The API response to the client application via the JDBC or ODBC driver includes temporary security credentials.
6. The client application uses the temporary security credentials to call Athena API operations, allowing your users to access Athena API operations.

Procedure: SAML-based Federated Access to the Athena API

This procedure establishes trust between your organization's IdP and your AWS account to enable SAML-based federated access to the Amazon Athena API operation.

To enable federated access to the Athena API:

1. In your organization, register AWS as a service provider (SP) in your IdP. This process is known as *relying party trust*. For more information, see [Configuring your SAML 2.0 IdP with Relying Party Trust](#) in the *IAM User Guide*. As part of this task, perform these steps:
 - a. Obtain the sample SAML metadata document from this URL: <https://signin.aws.amazon.com/static/saml-metadata.xml>.

- b. In your organization's IdP (ADFS), generate an equivalent metadata XML file that describes your IdP as an identity provider to AWS. Your metadata file must include the issuer name, creation date, expiration date, and keys that AWS uses to validate authentication responses (assertions) from your organization.
2. In the IAM console, create a SAML identity provider entity. For more information, see [Creating SAML Identity Providers](#) in the *IAM User Guide*. As part of this step, do the following:
 - a. Open the IAM console at <https://console.aws.amazon.com/iam/>.
 - b. Upload the SAML metadata document produced by the IdP (ADFS) in Step 1 in this procedure.
3. In the IAM console, create one or more IAM roles for your IdP. For more information, see [Creating a Role for a Third-Party Identity Provider \(Federation\)](#) in the *IAM User Guide*. As part of this step, do the following:
 - In the role's permission policy, list actions that users from your organization are allowed to do in AWS.
 - In the role's trust policy, set the SAML provider entity that you created in Step 2 of this procedure as the principal.

This establishes a trust relationship between your organization and AWS.

4. In your organization's IdP (ADFS), define assertions that map users or groups in your organization to the IAM roles. The mapping of users and groups to the IAM roles is also known as a *claim rule*. Note that different users and groups in your organization might map to different IAM roles.

For information about configuring the mapping in ADFS, see the blog post: [Enabling Federation to AWS Using Windows Active Directory, ADFS, and SAML 2.0](#).

5. Install and configure the JDBC or ODBC driver with SAML 2.0 support. For information, see [Using Athena with the JDBC Driver \(p. 71\)](#) and [Connecting to Amazon Athena with ODBC \(p. 73\)](#).
6. Specify the connection string from your application to the JDBC or ODBC driver. For information about the connection string that your application should use, see the topic "*Using the Active Directory Federation Services (ADFS) Credentials Provider*" in the [JDBC Driver Installation and Configuration Guide](#), or a similar topic in the [ODBC Driver Installation and Configuration Guide](#).

Following is a high-level summary of configuring the connection string to the drivers:

1. In the `AwsCredentialsProviderClass` configuration, set the `com.simba.athena.iamsupport.plugin.AdfsCredentialsProvider` to indicate that you want to use SAML 2.0 based authentication via ADFS IdP.
2. For `idp_host`, provide the host name of the ADFS IdP server.
3. For `idp_port`, provide the port number that the ADFS IdP listens on for the SAML assertion request.
4. For `UID` and `PWD`, provide the AD domain user credentials. When using the driver on Windows, if `UID` and `PWD` are not provided, the driver attempts to obtain the user credentials of the user logged in to the Windows machine.
5. Optionally, set `ssl_insecure` to `true`. In this case, the driver does not check the authenticity of the SSL certificate for the ADFS IdP server. Setting to `true` is needed if the ADFS IdP's SSL certificate has not been configured to be trusted by the driver.
6. To enable mapping of an Active Directory domain user or group to one or more IAM roles (as mentioned in step 4 of this procedure), in the `preferred_role` for the JDBC or ODBC connection, specify the IAM role (ARN) to assume for the driver connection. Specifying the `preferred_role` is optional, and is useful if the role is not the first role listed in the claim rule.

As a result of this procedure, the following actions occur:

1. The JDBC or ODBC driver calls the AWS STS [AssumeRoleWithSAML](#) API, and passes it the assertions, as shown in step 4 of the [architecture diagram \(p. 226\)](#).
2. AWS makes sure that the request to assume the role comes from the IdP referenced in the SAML provider entity.
3. If the request is successful, the AWS STS [AssumeRoleWithSAML](#) API operation returns a set of temporary security credentials, which your client application uses to make signed requests to Athena.

Your application now has information about the current user and can access Athena programmatically.

Logging and Monitoring in Athena

To detect incidents, receive alerts when incidents occur, and respond to them, use these options with Amazon Athena:

- **Monitor Athena with AWS CloudTrail** – AWS CloudTrail provides a record of actions taken by a user, role, or an AWS service in Athena. It captures calls from the Athena console and code calls to the Athena API operations as events. This allows you to determine the request that was made to Athena, the IP address from which the request was made, who made the request, when it was made, and additional details. You can also use Athena to query CloudTrail log files for insight. For more information, see [Querying AWS CloudTrail Logs \(p. 178\)](#) and [CloudTrail SerDe \(p. 278\)](#).
- **Use CloudWatch Events with Athena** – CloudWatch Events delivers a near real-time stream of system events that describe changes in AWS resources. CloudWatch Events becomes aware of operational changes as they occur, responds to them, and takes corrective action as necessary, by sending messages to respond to the environment, activating functions, making changes, and capturing state information. To use CloudWatch Events with Athena, create a rule that triggers on an Athena API call via CloudTrail. For more information, see [Creating a CloudWatch Events Rule That Triggers on an AWS API Call Using CloudTrail](#) in the [Amazon CloudWatch Events User Guide](#).
- **Use workgroups to separate users, teams, applications, or workloads, and to set query limits and control query costs** – You can view query-related metrics in Amazon CloudWatch, control query costs by configuring limits on the amount of data scanned, create thresholds, and trigger actions, such as Amazon SNS alarms, when these thresholds are breached. For a high-level procedure, see [Setting up Workgroups \(p. 241\)](#). Use resource-level IAM permissions to control access to a specific workgroup. For more information, see [Using Workgroups for Running Queries \(p. 239\)](#) and [Controlling Costs and Monitoring Queries with CloudWatch Metrics \(p. 256\)](#).

Compliance Validation for Amazon Athena

Third-party auditors assess the security and compliance of Amazon Athena as part of multiple AWS compliance programs. These include SOC, PCI, FedRAMP, 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 Athena is determined by the sensitivity of your data, your company'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 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 Athena

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, Athena offers several features to help support your data resiliency and backup needs.

Athena is serverless, so there is no infrastructure to set up or manage. Athena is highly available and executes queries using compute resources across multiple Availability Zones, automatically routing queries appropriately if a particular Availability Zone is unreachable. Athena uses Amazon S3 as its underlying data store, making your data highly available and durable. Amazon S3 provides durable infrastructure to store important data and is designed for durability of 99.999999999% of objects. Your data is redundantly stored across multiple facilities and multiple devices in each facility.

Infrastructure Security in Athena

As a managed service, Amazon Athena 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 Athena through the network. Clients must support TLS (Transport Layer Security) 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.

Use IAM policies to restrict access to Athena operations. Athena [managed policies \(p. 203\)](#) are easy to use, and are automatically updated with the required actions as the service evolves. Customer-managed and inline policies allow you to fine tune policies by specifying more granular Athena actions within the policy. Grant appropriate access to the Amazon S3 location of the data. For detailed information and scenarios about how to grant Amazon S3 access, see [Example Walkthroughs: Managing Access](#) in the

Amazon Simple Storage Service Developer Guide. For more information and an example of which Amazon S3 actions to allow, see the example bucket policy in [Cross-Account Access \(p. 214\)](#).

Topics

- [Connect to Amazon Athena Using an Interface VPC Endpoint \(p. 231\)](#)

Connect to Amazon Athena Using an Interface VPC Endpoint

You can connect directly to Athena using an [interface VPC endpoint \(AWS PrivateLink\)](#) in your Virtual Private Cloud (VPC) instead of connecting over the internet. When you use an interface VPC endpoint, communication between your VPC and Athena is conducted entirely within the AWS network. Each VPC endpoint is represented by one or more [Elastic Network Interfaces \(ENIs\)](#) with private IP addresses in your VPC subnets.

The interface VPC endpoint connects your VPC directly to Athena without an internet gateway, NAT device, VPN connection, or AWS Direct Connect connection. The instances in your VPC don't need public IP addresses to communicate with the Athena API.

To use Athena through your VPC, you must connect from an instance that is inside the VPC or connect your private network to your VPC by using an Amazon Virtual Private Network (VPN) or AWS Direct Connect. For information about Amazon VPN, see [VPN Connections](#) in the *Amazon Virtual Private Cloud User Guide*. For information about AWS Direct Connect, see [Creating a Connection](#) in the *AWS Direct Connect User Guide*.

Note

AWS PrivateLink for Athena is not supported in the EU (Stockholm) Region. Athena supports VPC endpoints in all other AWS Regions where both [Amazon VPC](#) and [Athena](#) are available.

You can create an interface VPC endpoint to connect to Athena using the AWS console or AWS Command Line Interface (AWS CLI) commands. For more information, see [Creating an Interface Endpoint](#).

After you create an interface VPC endpoint, if you enable private DNS hostnames for the endpoint, the default Athena endpoint (<https://athena.Region.amazonaws.com>) resolves to your VPC endpoint.

If you do not enable private DNS hostnames, Amazon VPC provides a DNS endpoint name that you can use in the following format:

`VPCEndpoint_ID.athena.Region.vpce.amazonaws.com`

For more information, see [Interface VPC Endpoints \(AWS PrivateLink\)](#) in the *Amazon VPC User Guide*.

Athena supports making calls to all of its [API Actions](#) inside your VPC.

Create a VPC Endpoint Policy for Athena

You can create a policy for Amazon VPC endpoints for Athena to specify the following:

- The principal that can perform actions.
- The actions that can be performed.
- The resources on which actions can be performed.

For more information, see [Controlling Access to Services with VPC Endpoints](#) in the *Amazon VPC User Guide*.

Example – VPC Endpoint Policy for Athena Actions

The endpoint to which this policy is attached grants access to the listed athena actions to all principals in `workgroupA`.

```
{  
    "Statement": [  
        {  
            "Principal": "*",
            "Effect": "Allow",
            "Action": [  
                "athena:StartQueryExecution",
                "athena:RunQuery",
                "athena:GetQueryExecution",
                "athena:GetQueryResults",
                "athena:CancelQueryExecution",
                "athena>ListWorkGroups",
                "athena:GetWorkGroup",
                "athena:TagResource"
            ],
            "Resource": [  
                "arn:aws:athena:us-west-1:AWSAccountID:workgroup/workgroupA"
            ]
        }
    ]
}
```

Configuration and Vulnerability Analysis in Athena

Athena is serverless, so there is no infrastructure to set up or manage. AWS handles basic security tasks, such as guest operating system (OS) and database patching, firewall configuration, and disaster recovery. These procedures have been reviewed and certified by the appropriate third parties. For more details, see the following resources:

- [Shared Responsibility Model](#)
- [Amazon Web Services: Overview of Security Processes](#) (whitepaper)

Using Athena to Query Data Registered With AWS Lake Formation

[AWS Lake Formation](#) allows you to define and enforce database, table, and column-level access policies when using Athena queries to read data stored in Amazon S3. Lake Formation provides an authorization and governance layer on data stored in Amazon S3. You can use a hierarchy of permissions in Lake Formation to grant or revoke permissions to read data catalog objects such as databases, tables, and columns. Lake Formation simplifies the management of permissions and allows you to implement fine-grained access control (FGAC) for your data.

You can use Athena to query both data that is registered with Lake Formation and data that is not registered with Lake Formation.

Lake Formation permissions apply when using Athena to query source data from Amazon S3 locations that are registered with Lake Formation. Lake Formation permissions also apply when you create databases and tables that point to registered Amazon S3 data locations. To use Athena with data registered using Lake Formation, Athena must be configured to use the AWS Glue Data Catalog.

Lake Formation permissions do not apply when writing objects to Amazon S3, nor do they apply when querying data stored in Amazon S3 or metadata that are not registered with Lake Formation. For source data in Amazon S3 and metadata that is not registered with Lake Formation, access is determined by IAM permissions policies for Amazon S3 and AWS Glue actions. Athena query results locations in Amazon S3 cannot be registered with Lake Formation, and IAM permissions policies for Amazon S3 control access. In addition, Lake Formation permissions do not apply to Athena query history. You can use Athena workgroups to control access to query history.

For more information about Lake Formation, see [Lake Formation FAQs](#) and the [AWS Lake Formation Developer Guide](#).

Topics

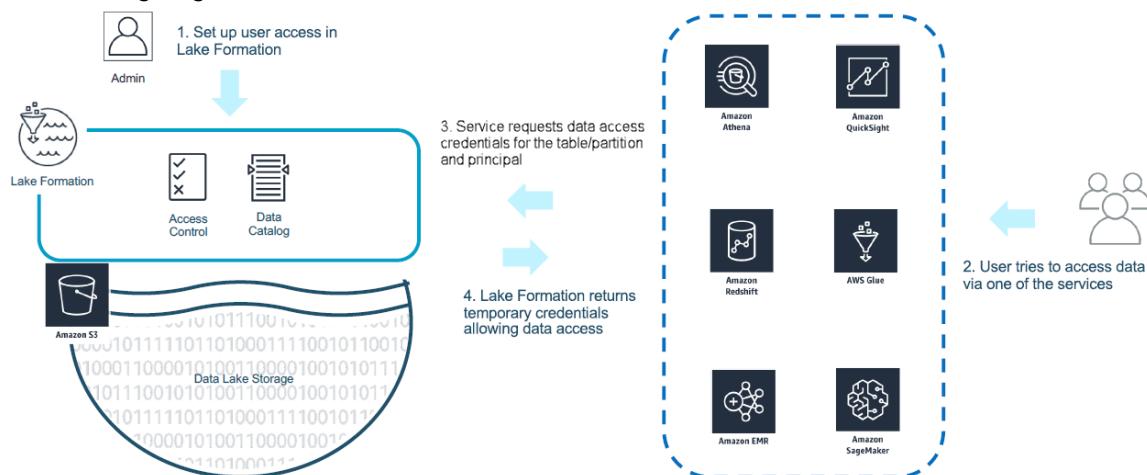
- [How Athena Accesses Data Registered With Lake Formation \(p. 233\)](#)
- [Considerations and Limitations When Using Athena to Query Data Registered With Lake Formation \(p. 234\)](#)
- [Managing Lake Formation and Athena User Permissions \(p. 236\)](#)
- [Applying Lake Formation Permissions to Existing Databases and Tables \(p. 238\)](#)

How Athena Accesses Data Registered With Lake Formation

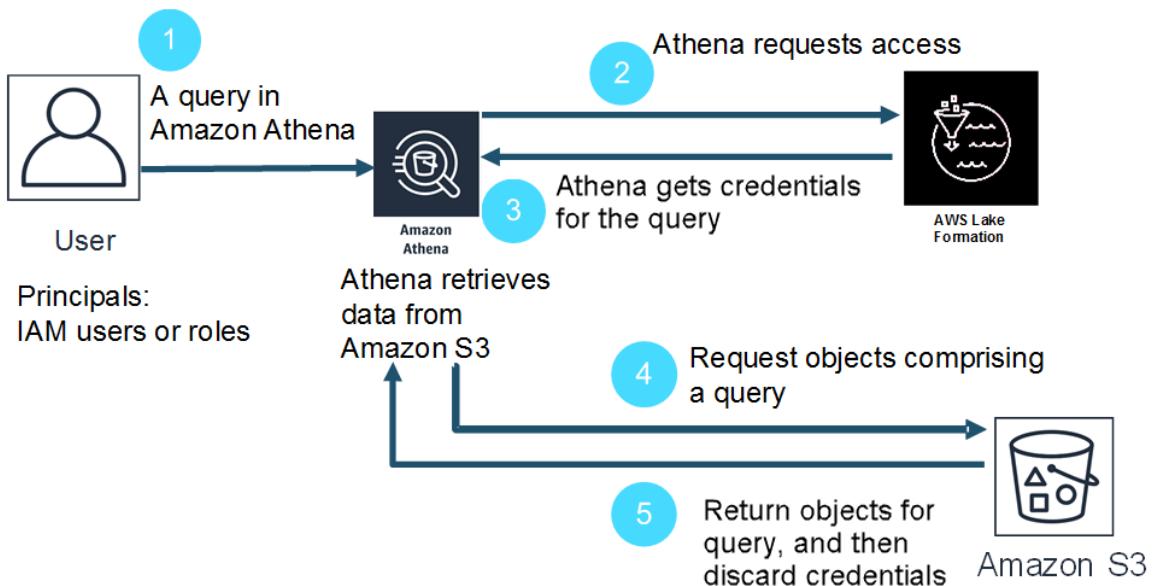
The access workflow described in this section applies only when running Athena queries on Amazon S3 locations and metadata objects that are registered with Lake Formation. For more information, see [Registering a Data Lake](#) in the [AWS Lake Formation Developer Guide](#). In addition to registering data, the Lake Formation administrator applies Lake Formation permissions that grant or revoke access to metadata in the Data Catalog and the data location in Amazon S3. For more information, see [Security and Access Control to Metadata and Data](#) in the [AWS Lake Formation Developer Guide](#).

Each time an Athena principal (user, group, or role) runs a query on data registered using Lake Formation, Lake Formation verifies that the principal has the appropriate Lake Formation permissions to the database, table, and Amazon S3 location as appropriate for the query. If the principal has access, Lake Formation *vends* temporary credentials to Athena, and the query runs.

The following diagram illustrates the flow described above.



The following diagram shows how credential vending works in Athena on a query-by-query basis for a hypothetical `SELECT` query on a table with an Amazon S3 location registered in Lake Formation:



1. A principal runs a `SELECT` query in Athena.
2. Athena analyzes the query and checks Lake Formation permissions to see if the principal has been granted access to the the table, table partitions (if applicable), and table columns.
3. If the principal has access, Athena requests credentials from Lake Formation. If the principal *does not* have access, Athena issues an access denied error.
4. Lake Formation issues credentials to Athena to use when reading data from Amazon S3 and accessing metadata from the Data Catalog.
5. Lake Formation returns query results to Athena. After the query completes, Athena discards the credentials.

Considerations and Limitations When Using Athena to Query Data Registered With Lake Formation

Consider the following when using Athena to query data registered in Lake Formation. For additional information, see [Known Issues for AWS Lake Formation](#) in the [AWS Lake Formation Developer Guide](#).

Considerations and Limitations

- Column Metadata Visible To Unauthorized Users In Some Circumstances With Avro and Custom SerDe (p. 235)
- Working With Lake Formation Permissions To Views (p. 235)
- Athena Query Results Location In Amazon S3 Not Registered With Lake Formation (p. 235)
- Use Athena Workgroups To Limit Access To Query History (p. 235)
- Cross-Account Data Catalogs Not Supported (p. 235)
- SSE-KMS Encrypted Amazon S3 Locations Registered With Lake Formation Cannot Be Queried in Athena (p. 236)
- Partitioned Data Locations Registered with Lake Formation Must Be In Table Sub-Directories (p. 236)
- Create Table As Select (CTAS) Queries Require Amazon S3 Write Permissions (p. 236)

Column Metadata Visible To Unauthorized Users In Some Circumstances With Avro and Custom SerDe

Lake Formation column-level authorization prevents users from accessing data in columns for which the user does not have Lake Formation permissions. However, in certain situations, users are able to access metadata describing all columns in the table, including the columns for which they do not have permissions to the data.

This occurs when column metadata is stored in table properties for tables using either the Avro storage format or using a custom Serializer/Deserializers (SerDe) in which table schema is defined in table properties along with the SerDe definition. When using Athena with Lake Formation, we recommend that you review the contents of table properties that you register with Lake Formation and, where possible, limit the information stored in table properties to prevent any sensitive metadata from being visible to users.

Working With Lake Formation Permissions To Views

For data registered with Lake Formation, an Athena user can create a `VIEW` only if they have Lake Formation permissions to the tables, columns, and source Amazon S3 data locations on which the `VIEW` is based. After a `VIEW` is created in Athena, Lake Formation permissions can be applied to the `VIEW`. Column-level permissions are not available for a `VIEW`. Users who have Lake Formation permissions to a `VIEW` but do not have permissions to the table and columns on which the view was based are not able to use the `VIEW` to query data. However, users with this mix of permissions are able to use statements like `DESCRIBE VIEW`, `SHOW CREATE VIEW`, and `SHOW COLUMNS` to see `VIEW` metadata. For this reason, be sure to align Lake Formation permissions for each `VIEW` with underlying table permissions.

Athena Query Results Location In Amazon S3 Not Registered With Lake Formation

The query results locations in Amazon S3 for Athena cannot be registered with Lake Formation. Lake Formation permissions do not limit access to these locations. Unless you limit access, Athena users can access query result files and metadata when they do not have Lake Formation permissions for the data. To avoid this, we recommend that you use workgroups to specify the location for query results and align workgroup membership with Lake Formation permissions. You can then use IAM permissions policies to limit access to query results locations. For more information about query results, see [Working with Query Results, Output Files, and Query History \(p. 107\)](#).

Use Athena Workgroups To Limit Access To Query History

Athena query history exposes a list of saved queries and complete query strings. Unless you use workgroups to separate access to query histories, Athena users who are not authorized to query data in Lake Formation are able to view query strings run on that data, including column names, selection criteria, and so on. We recommend that you use workgroups to separate query histories, and align Athena workgroup membership with Lake Formation permissions to limit access. For more information, see [Using Workgroups to Control Query Access and Costs \(p. 239\)](#).

Cross-Account Data Catalogs Not Supported

An Athena user from one account can not query databases and tables in the Data Catalog of a different account, even when Lake Formation is used. To query an Amazon S3 data location in a different account, a resource-based IAM policy (bucket policy) must allow access to the location. For more information, see [Cross-account Access \(p. 214\)](#). You can use Lake Formation to register an accessible bucket location in an external account with the Data Catalog in the local account.

SSE-KMS Encrypted Amazon S3 Locations Registered With Lake Formation Cannot Be Queried in Athena

Amazon S3 data locations that are registered with Lake Formation and encrypted using server-side encryption with AWS KMS-managed keys (SSE-KMS) cannot be queried using Athena. You still can use Athena to query SSE-KMS encrypted Amazon S3 data locations that are not registered with Lake Formation and use IAM policies to allow or deny access.

Partitioned Data Locations Registered with Lake Formation Must Be In Table Sub-Directories

Partitioned tables registered with Lake Formation must have partitioned data in directories that are sub-directories of the table in Amazon S3. For example, a table with the location `s3://mydata/mytable` and partitions `s3://mydata/mytable/dt=2019-07-11`, `s3://mydata/mytable/dt=2019-07-12`, and so on can be registered with Lake Formation and queried using Athena. On the other hand, a table with the location `s3://mydata/mytable` and partitions located in `s3://mydata/dt=2019-07-11`, `s3://mydata/dt=2019-07-12`, and so on, cannot be registered with Lake Formation. You can set up access for these tables using IAM permissions outside of Lake Formation to query them in Athena. For more information, see [Partitioning Data \(p. 36\)](#).

Create Table As Select (CTAS) Queries Require Amazon S3 Write Permissions

Create Table As Statements (CTAS) require write access to the Amazon S3 location of tables. To run CTAS queries on data registered with Lake Formation, Athena users must have IAM permissions to write to the table Amazon S3 locations in addition to the appropriate Lake Formation permissions to read the data locations. For more information, see [Creating a Table from Query Results \(CTAS\) \(p. 118\)](#).

Managing Lake Formation and Athena User Permissions

Lake Formation vends credentials to query Amazon S3 data stores that are registered with Lake Formation. If you previously used IAM policies to allow or deny permissions to read data locations in Amazon S3, you can use Lake Formation permissions instead. However, other IAM permissions are still required.

The following sections summarize the permissions required to use Athena to query data registered in Lake Formation. For more information, see [Security in AWS Lake Formation](#) in the *AWS Lake Formation Developer Guide*.

Permissions Summary

- [Identity-Based Permissions For Lake Formation and Athena \(p. 237\)](#)
- [Amazon S3 Permissions For Athena Query Results Locations \(p. 237\)](#)
- [Athena Workgroup Memberships To Query History \(p. 237\)](#)
- [Lake Formation Permissions To Data \(p. 237\)](#)
- [IAM Permissions to Write to Amazon S3 Locations \(p. 237\)](#)
- [Permissions to Encrypted Data, Metadata, and Athena Query Results \(p. 238\)](#)
- [Resource-Based Permissions for Amazon S3 Buckets in External Accounts \(Optional\) \(p. 238\)](#)

Identity-Based Permissions For Lake Formation and Athena

Anyone using Athena to query data registered with Lake Formation must have an IAM permissions policy that allows the `lakeformation:GetDataAccess` action. The [AmazonAthenaFullAccess Managed Policy \(p. 204\)](#) allows this action. If you use inline policies, be sure to update permissions policies to allow this action.

In Lake Formation, a *data lake administrator* has permissions to create metadata objects such as databases and tables, grant Lake Formation permissions to other users, and register new Amazon S3 locations. To register new locations, permissions to the service-linked role for Lake Formation are required. For more information, see [Create a Data Lake Administrator](#) and [Service-Linked Role Permissions for Lake Formation](#) in the *AWS Lake Formation Developer Guide*.

An Lake Formation user can use Athena to query databases, tables, table columns, and underlying Amazon S3 data stores based on Lake Formation permissions granted to them by data lake administrators. Users cannot create databases or tables, or register new Amazon S3 locations with Lake Formation. For more information, see [Create a Data Lake User](#) in the *AWS Lake Formation Developer Guide*.

In Athena, identity-based permissions policies, including those for Athena workgroups, still control access to Athena actions for AWS account users. In addition, federated access might be provided through the SAML-based authentication available with Athena drivers. For more information, see [Using Workgroups to Control Query Access and Costs \(p. 239\)](#), [IAM Policies for Accessing Workgroups \(p. 242\)](#), and [Enabling Federated Access to the Athena API \(p. 226\)](#).

For more information, see [Granting Lake Formation Permissions](#) in the *AWS Lake Formation Developer Guide*.

Amazon S3 Permissions For Athena Query Results Locations

The query results locations in Amazon S3 for Athena cannot be registered with Lake Formation. Lake Formation permissions do not limit access to these locations. Unless you limit access, Athena users can access query result files and metadata when they do not have Lake Formation permissions for the data. To avoid this, we recommend that you use workgroups to specify the location for query results and align workgroup membership with Lake Formation permissions. You can then use IAM permissions policies to limit access to query results locations. For more information about query results, see [Working with Query Results, Output Files, and Query History \(p. 107\)](#).

Athena Workgroup Memberships To Query History

Athena query history exposes a list of saved queries and complete query strings. Unless you use workgroups to separate access to query histories, Athena users who are not authorized to query data in Lake Formation are able to view query strings run on that data, including column names, selection criteria, and so on. We recommend that you use workgroups to separate query histories, and align Athena workgroup membership with Lake Formation permissions to limit access. For more information, see [Using Workgroups to Control Query Access and Costs \(p. 239\)](#).

Lake Formation Permissions To Data

In addition to the baseline permission to use Lake Formation, Athena users must have Lake Formation permissions to access resources that they query. These permissions are granted and managed by a Lake Formation administrator. For more information, see [Security and Access Control to Metadata and Data](#) in the *AWS Lake Formation Developer Guide*.

IAM Permissions to Write to Amazon S3 Locations

Lake Formation permissions to Amazon S3 do not include the ability to write to Amazon S3. Create Table As Statements (CTAS) require write access to the Amazon S3 location of tables. To run CTAS

queries on data registered with Lake Formation, Athena users must have IAM permissions to write to the table Amazon S3 locations in addition to the appropriate Lake Formation permissions to read the data locations. For more information, see [Creating a Table from Query Results \(CTAS\) \(p. 118\)](#).

Permissions to Encrypted Data, Metadata, and Athena Query Results

Underlying source data in Amazon S3 and metadata in the Data Catalog that is registered with Lake Formation can be encrypted. There is no change to the way that Athena handles encryption of query results when using Athena to query data registered with Lake Formation. For more information, see [Encrypting Query Results Stored in Amazon S3 \(p. 198\)](#).

- **Encrypting source data** – SSE-S3 and CSE-KMS encryption of Amazon S3 data locations source data is supported. SSE-KMS encryption is not supported. Athena users who query encrypted Amazon S3 locations that are registered with Lake Formation need permissions to encrypt and decrypt data. For more information about requirements, see [Permissions to Encrypted Data in Amazon S3 \(p. 198\)](#).
- **Encrypting metadata** – Encrypting metadata in the Data Catalog is supported. For principals using Athena, identity-based policies must allow the "kms:GenerateDataKey", "kms:Decrypt", and "kms:Encrypt" actions for the key used to encrypt metadata. For more information, see [Encrypting Your Data Catalog](#) in the *AWS Glue Developer Guide* and [Access to Encrypted Metadata in the AWS Glue Data Catalog \(p. 214\)](#).

Resource-Based Permissions for Amazon S3 Buckets in External Accounts (Optional)

An Athena user from one account can not query databases and tables in the Data Catalog of a different account, even when Lake Formation is used. To query an Amazon S3 data location in a different account, a resource-based IAM policy (bucket policy) must allow access to the location. For more information, see [Cross-account Access \(p. 214\)](#). You can use Lake Formation to register an accessible bucket location in an external account with the Data Catalog in the local account.

Applying Lake Formation Permissions to Existing Databases and Tables

If you are new to Athena and you use Lake Formation to configure access to query data, you do not need to configure IAM policies so that users can read Amazon S3 data and create metadata. You can use Lake Formation to administer permissions.

Registering data with Lake Formation and updating IAM permissions policies is not a requirement. If data is not registered with Lake Formation, Athena users who have appropriate permissions in Amazon S3—and AWS Glue, if applicable—can continue to query data not registered with Lake Formation.

If you have existing Athena users who query data not registered with Lake Formation, you can update IAM permissions for Amazon S3—and the AWS Glue Data Catalog, if applicable—so that you can use Lake Formation permissions to manage user access centrally. For permission to read Amazon S3 data locations, you can update resource-based and identity-based policies to remove Amazon S3 permissions. For access to metadata, if you configured resource-level policies for fine-grained access control with AWS Glue, you can use Lake Formation permissions to manage access instead. For more information, see [Fine-Grained Access to Databases and Tables in the AWS Glue Data Catalog \(p. 207\)](#) and [Upgrading AWS Glue Data Permissions to the AWS Lake Formation Model](#) in the *AWS Lake Formation Developer Guide*.

Using Workgroups to Control Query Access and Costs

Use workgroups to separate users, teams, applications, or workloads, to set limits on amount of data each query or the entire workgroup can process, and to track costs. Because workgroups act as resources, you can use resource-level identity-based policies to control access to a specific workgroup. You can also view query-related metrics in Amazon CloudWatch, control costs by configuring limits on the amount of data scanned, create thresholds, and trigger actions, such as Amazon SNS, when these thresholds are breached.

Workgroups integrate with IAM, CloudWatch, and Amazon Simple Notification Service as follows:

- IAM identity-based policies with resource-level permissions control who can run queries in a workgroup.
- Athena publishes the workgroup query metrics to CloudWatch, if you enable query metrics.
- In Amazon SNS, you can create Amazon SNS topics that issue alarms to specified workgroup users when data usage controls for queries in a workgroup exceed your established thresholds.

Topics

- [Using Workgroups for Running Queries \(p. 239\)](#)
- [Controlling Costs and Monitoring Queries with CloudWatch Metrics \(p. 256\)](#)

Using Workgroups for Running Queries

We recommend using workgroups to isolate queries for teams, applications, or different workloads. For example, you may create separate workgroups for two different teams in your organization. You can also separate workloads. For example, you can create two independent workgroups, one for automated scheduled applications, such as report generation, and another for ad-hoc usage by analysts. You can switch between workgroups.

Topics

- [Benefits of Using Workgroups \(p. 239\)](#)
- [How Workgroups Work \(p. 240\)](#)
- [Setting up Workgroups \(p. 241\)](#)
- [IAM Policies for Accessing Workgroups \(p. 242\)](#)
- [Workgroup Example Policies \(p. 243\)](#)
- [Workgroup Settings \(p. 247\)](#)
- [Managing Workgroups \(p. 248\)](#)
- [Athena Workgroup APIs \(p. 254\)](#)
- [Troubleshooting Workgroups \(p. 254\)](#)

Benefits of Using Workgroups

Workgroups allow you to:

Isolate users, teams, applications, or workloads into groups.	<p>Each workgroup has its own distinct query history and a list of saved queries. For more information, see How Workgroups Work (p. 240).</p> <p>For all queries in the workgroup, you can choose to configure workgroup settings. They include an Amazon S3 location for storing query results, and encryption configuration. You can also enforce workgroup settings. For more information, see Workgroup Settings (p. 247).</p>
Enforce costs constraints.	<p>You can set two types of cost constraints for queries in a workgroup:</p> <ul style="list-style-type: none"> • Per-query limit is a threshold for the amount of data scanned for each query. Athena cancels queries when they exceed the specified threshold. The limit applies to each running query within a workgroup. You can set only one per-query limit and update it if needed. • Per-workgroup limit is a threshold you can set for each workgroup for the amount of data scanned by queries in the workgroup. Breaching a threshold activates an Amazon SNS alarm that triggers an action of your choice, such as sending an email to a specified user. You can set multiple per-workgroup limits for each workgroup. <p>For detailed steps, see Setting Data Usage Control Limits (p. 258).</p>
Track query-related metrics for all workgroup queries in CloudWatch.	<p>For each query that runs in a workgroup, if you configure the workgroup to publish metrics, Athena publishes them to CloudWatch. You can view query metrics (p. 256) for each of your workgroups within the Athena console. In CloudWatch, you can create custom dashboards, and set thresholds and alarms on these metrics.</p>

How Workgroups Work

Workgroups in Athena have the following characteristics:

- By default, each account has a primary workgroup and the default permissions allow all authenticated users access to this workgroup. The primary workgroup cannot be deleted.
- Each workgroup that you create shows saved queries and query history only for queries that ran in it, and not for all queries in the account. This separates your queries from other queries within an account and makes it more efficient for you to locate your own saved queries and queries in history.
- Disabling a workgroup prevents queries from running in it, until you enable it. Queries sent to a disabled workgroup fail, until you enable it again.
- If you have permissions, you can delete an empty workgroup, and a workgroup that contains saved queries. In this case, before deleting a workgroup, Athena warns you that saved queries are deleted. Before deleting a workgroup to which other users have access, make sure its users have access to other workgroups in which they can continue to run queries.
- You can set up workgroup-wide settings and enforce their usage by all queries that run in a workgroup. The settings include query results location in Amazon S3 and encryption configuration.

Important

When you enforce workgroup-wide settings, all queries that run in this workgroup use workgroup settings. This happens even if their client-side settings may differ from workgroup settings. For information, see [Workgroup Settings Override Client-Side Settings \(p. 247\)](#).

Limitations for Workgroups

- You can create up to 1000 workgroups per Region in your account.
- The primary workgroup cannot be deleted.
- You can open up to ten query tabs within each workgroup. When you switch between workgroups, your query tabs remain open for up to three workgroups.

Setting up Workgroups

Setting up workgroups involves creating them and establishing permissions for their usage. First, decide which workgroups your organization needs, and create them. Next, set up IAM workgroup policies that control user access and actions on a workgroup resource. Users with access to these workgroups can now run queries in them.

Note

Use these tasks for setting up workgroups when you begin to use them for the first time. If your Athena account already uses workgroups, each account's user requires permissions to run queries in one or more workgroups in the account. Before you run queries, check your IAM policy to see which workgroups you can access, adjust your policy if needed, and [switch \(p. 252\)](#) to a workgroup you intend to use.

By default, if you have not created any workgroups, all queries in your account run in the primary workgroup:



Workgroups display in the Athena console in the **Workgroup:<workgroup_name>** tab. The console lists the workgroup that you have switched to. When you run queries, they run in this workgroup. You can run queries in the workgroup in the console, or by using the API operations, the command line interface, or a client application through the JDBC or ODBC driver. When you have access to a workgroup, you can view workgroup's settings, metrics, and data usage control limits. Additionally, you can have permissions to edit the settings and data usage control limits.

To Set Up Workgroups

1. Decide which workgroups to create. For example, you can decide the following:
 - Who can run queries in each workgroup, and who owns workgroup configuration. This determines IAM policies you create. For more information, see [IAM Policies for Accessing Workgroups \(p. 242\)](#).
 - Which locations in Amazon S3 to use for the query results for queries that run in each workgroup. A location must exist in Amazon S3 *before* you can specify it for the workgroup query results. All users who use a workgroup must have access to this location. For more information, see [Workgroup Settings \(p. 247\)](#).
 - Which encryption settings are required, and which workgroups have queries that must be encrypted. We recommend that you create separate workgroups for encrypted and non-encrypted queries. That way, you can enforce encryption for a workgroup that applies to all queries that run in it. For more information, see [Encrypting Query Results Stored in Amazon S3 \(p. 198\)](#).
2. Create workgroups as needed, and add tags to them. Open the Athena console, choose the **Workgroup:<workgroup_name>** tab, and then choose **Create workgroup**. For detailed steps, see [Create a Workgroup \(p. 249\)](#).
3. Create IAM policies for your users, groups, or roles to enable their access to workgroups. The policies establish the workgroup membership and access to actions on a workgroup resource. For detailed steps, see [IAM Policies for Accessing Workgroups \(p. 242\)](#). For example JSON policies, see [Workgroup Example Policies \(p. 215\)](#).

4. Set workgroup settings. Specify a location in Amazon S3 for query results and encryption settings, if needed. You can enforce workgroup settings. For more information, see [workgroup settings \(p. 247\)](#).

Important

If you [override client-side settings \(p. 247\)](#), Athena will use the workgroup's settings. This affects queries that you run in the console, by using the drivers, the command line interface, or the API operations.

While queries continue to run, automation built based on availability of results in a certain Amazon S3 bucket may break. We recommend that you inform your users before overriding. After workgroup settings are set to override, you can omit specifying client-side settings in the drivers or the API.

5. Notify users which workgroups to use for running queries. Send an email to inform your account's users about workgroup names that they can use, the required IAM policies, and the workgroup settings.
6. Configure cost control limits, also known as data usage control limits, for queries and workgroups. To notify you when a threshold is breached, create an Amazon SNS topic and configure subscriptions. For detailed steps, see [Setting Data Usage Control Limits \(p. 258\)](#) and [Creating an Amazon SNS Topic](#) in the *Amazon Simple Notification Service Getting Started Guide*.
7. Switch to the workgroup so that you can run queries. To run queries, switch to the appropriate workgroup. For detailed steps, see [the section called "Specify a Workgroup in Which to Run Queries" \(p. 253\)](#).

IAM Policies for Accessing Workgroups

To control access to workgroups, use resource-level IAM permissions or identity-based IAM policies.

The following procedure is specific to Athena.

For IAM-specific information, see the links listed at the end of this section. For information about example JSON workgroup policies, see [Workgroup Example Policies \(p. 243\)](#).

To use the visual editor in the IAM console to create a workgroup policy

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 on the left, choose **Policies**, and then choose **Create policy**.
3. On the **Visual editor** tab, choose **Choose a service**. Then choose Athena to add to the policy.
4. Choose **Select actions**, and then choose the actions to add to the policy. The visual editor shows the actions available in Athena. For more information, see [Actions, Resources, and Condition Keys for Amazon Athena](#) in the *IAM User Guide*.
5. Choose **add actions** to type a specific action or use wildcards (*) to specify multiple actions.

By default, the policy that you are creating allows the actions that you choose. If you chose one or more actions that support resource-level permissions to the `workgroup` resource in Athena, then the editor lists the `workgroup` resource.

6. Choose **Resources** to specify the specific workgroups for your policy. For example JSON workgroup policies, see [Workgroup Example Policies \(p. 243\)](#).
7. Specify the `workgroup` resource as follows:

```
arn:aws:athena:<region>:<user-account>:workgroup/<workgroup-name>
```

8. Choose **Review policy**, and then type a **Name** and a **Description** (optional) for the policy that you are creating. Review the policy summary to make sure that you granted the intended permissions.

9. Choose **Create policy** to save your new policy.
10. Attach this identity-based policy to a user, a group, or role and specify the workgroup resources they can access.

For more information, see the following topics in the *IAM User Guide*:

- [Actions, Resources, and Condition Keys for Amazon Athena](#)
- [Creating Policies with the Visual Editor](#)
- [Adding and Removing IAM Policies](#)
- [Controlling Access to Resources](#)

For example JSON workgroup policies, see [Workgroup Example Policies \(p. 243\)](#).

For a complete list of Amazon Athena actions, see the API action names in the [Amazon Athena API Reference](#).

Workgroup Example Policies

This section includes example policies you can use to enable various actions on workgroups.

A workgroup is an IAM resource managed by Athena. Therefore, if your workgroup policy uses actions that take workgroup as an input, you must specify the workgroup's ARN as follows:

```
"Resource": [arn:aws:athena:<region>:<user-account>:workgroup/<workgroup-name>]
```

Where <workgroup-name> is the name of your workgroup. For example, for workgroup named `test_workgroup`, specify it as a resource as follows:

```
"Resource": [ "arn:aws:athena:us-east-1:123456789012:workgroup/test_workgroup" ]
```

For a complete list of Amazon Athena actions, see the API action names in the [Amazon Athena API Reference](#). For more information about IAM policies, see [Creating Policies with the Visual Editor](#) in the *IAM User Guide*. For more information about creating IAM policies for workgroups, see [Workgroup IAM Policies \(p. 242\)](#).

- [Example Policy for Full Access to All Workgroups \(p. 243\)](#)
- [Example Policy for Full Access to a Specified Workgroup \(p. 244\)](#)
- [Example Policy for Running Queries in a Specified Workgroup \(p. 245\)](#)
- [Example Policy for Running Queries in the Primary Workgroup \(p. 245\)](#)
- [Example Policy for Management Operations on a Specified Workgroup \(p. 246\)](#)
- [Example Policy for Listing Workgroups \(p. 246\)](#)
- [Example Policy for Running and Stopping Queries in a Specific Workgroup \(p. 246\)](#)
- [Example Policy for Working with Named Queries in a Specific Workgroup \(p. 246\)](#)

Example Example Policy for Full Access to All Workgroups

The following policy allows full access to all workgroup resources that might exist in the account. We recommend that you use this policy for those users in your account that must administer and manage workgroups for all other users.

```
{
```

```
"Version": "2012-10-17",
"Statement": [
    {
        "Effect": "Allow",
        "Action": [
            "athena:*"
        ],
        "Resource": [
            "*"
        ]
    }
]
```

Example Example Policy for Full Access to a Specified Workgroup

The following policy allows full access to the single specific workgroup resource, named `workgroupA`. You could use this policy for users with full control over a particular workgroup.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "athena>ListWorkGroups",
                "athena:GetExecutionEngine",
                "athena:GetExecutionEngines",
                "athena:GetNamespace",
                "athena:GetCatalogs",
                "athena:GetNamespaces",
                "athena:GetTables",
                "athena:GetTable"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "athena>StartQueryExecution",
                "athena>GetQueryResults",
                "athena>DeleteNamedQuery",
                "athena>GetNamedQuery",
                "athena>ListQueryExecutions",
                "athena>StopQueryExecution",
                "athena>GetQueryResultsStream",
                "athena>ListNamedQueries",
                "athena>CreateNamedQuery",
                "athena>GetQueryExecution",
                "athena>BatchGetNamedQuery",
                "athena>BatchGetQueryExecution"
            ],
            "Resource": [
                "arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "athena>DeleteWorkGroup",
                "athena>UpdateWorkGroup",
                "athena>GetWorkGroup",
                "athena>CreateWorkGroup"
            ],
            "Resource": [
                "arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA"
            ]
        }
    ]
}
```

```
        "Resource": [
            "arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA"
        ]
    }
}
```

Example Example Policy for Running Queries in a Specified Workgroup

In the following policy, a user is allowed to run queries in the specified workgroupA, and view them. The user is not allowed to perform management tasks for the workgroup itself, such as updating or deleting it.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "athena>ListWorkGroups",
                "athena:GetExecutionEngine",
                "athena:GetExecutionEngines",
                "athena:GetNamespace",
                "athena:GetCatalogs",
                "athena:GetNamespaces",
                "athena:GetTables",
                "athena:GetTable"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "athena:StartQueryExecution",
                "athena:GetQueryResults",
                "athena>DeleteNamedQuery",
                "athena:GetNamedQuery",
                "athena>ListQueryExecutions",
                "athena:StopQueryExecution",
                "athena:GetQueryResultsStream",
                "athena>ListNamedQueries",
                "athena>CreateNamedQuery",
                "athena:GetQueryExecution",
                "athena:BatchGetNamedQuery",
                "athena:BatchGetQueryExecution",
                "athena:GetWorkGroup"
            ],
            "Resource": [
                "arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA"
            ]
        }
    ]
}
```

Example Example Policy for Running Queries in the Primary Workgroup

In the following example, we use the policy that allows a particular user to run queries in the primary workgroup.

Note

We recommend that you add this policy to all users who are otherwise configured to run queries in their designated workgroups. Adding this policy to their workgroup user policies is useful in

case their designated workgroup is deleted or is disabled. In this case, they can continue running queries in the primary workgroup.

To allow users in your account to run queries in the primary workgroup, add the following policy to a resource section of the [Example Policy for Running Queries in a Specified Workgroup \(p. 245\)](#).

```
"arn:aws:athena:us-east-1:123456789012:workgroup/primary"
```

Example Example Policy for Management Operations on a Specified Workgroup

In the following policy, a user is allowed to create, delete, obtain details, and update a workgroup `test_workgroup`.

```
{  
    "Effect": "Allow",  
    "Action": [  
        "athena>CreateWorkGroup",  
        "athena:GetWorkGroup",  
        "athena>DeleteWorkGroup",  
        "athena:UpdateWorkGroup"  
    ],  
    "Resource": [  
        "arn:aws:athena:us-east-1:123456789012:workgroup/test_workgroup"  
    ]  
}
```

Example Example Policy for Listing Workgroups

The following policy allows all users to list all workgroups:

```
{  
    "Effect": "Allow",  
    "Action": [  
        "athena>ListWorkGroups"  
    ],  
    "Resource": "*"  
}
```

Example Example Policy for Running and Stopping Queries in a Specific Workgroup

In this policy, a user is allowed to run queries in the workgroup:

```
{  
    "Effect": "Allow",  
    "Action": [  
        "athena:StartQueryExecution",  
        "athena:StopQueryExecution"  
    ],  
    "Resource": [  
        "arn:aws:athena:us-east-1:123456789012:workgroup/test_workgroup"  
    ]  
}
```

Example Example Policy for Working with Named Queries in a Specific Workgroup

In the following policy, a user has permissions to create, delete, and obtain information about named queries in the specified workgroup:

```
{  
    "Effect": "Allow",  
    "Action": [  
        "athena:CreateNamedQuery",  
        "athena:GetNamedQuery",  
        "athena>DeleteNamedQuery"  
    ],  
    "Resource": [  
        "arn:aws:athena:us-east-1:123456789012:workgroup/test_workgroup"  
    ]  
}
```

Workgroup Settings

Each workgroup has the following settings:

- A unique name. It can contain from 1 to 128 characters, including alphanumeric characters, dashes, and underscores. After you create a workgroup, you cannot change its name. You can, however, create a new workgroup with the same settings and a different name.
- Settings that apply to all queries running in the workgroup. They include:
 - **A location in Amazon S3 for storing query results** for all queries that run in this workgroup. This location must exist before you specify it for the workgroup when you create it.
 - **An encryption setting**, if you use encryption for all workgroup queries. You can encrypt only all queries in a workgroup, not just some of them. It is best to create separate workgroups to contain queries that are either encrypted or not encrypted.

In addition, you can [override client-side settings \(p. 247\)](#). Before the release of workgroups, you could specify results location and encryption options as parameters in the JDBC or ODBC driver, or in the **Properties** tab in the Athena console. These settings could also be specified directly via the API operations. These settings are known as "client-side settings". With workgroups, you can configure these settings at the workgroup level and enforce control over them. This spares your users from setting them individually. If you select the **Override Client-Side Settings**, queries use the workgroup settings and ignore the client-side settings.

If **Override Client-Side Settings** is selected, the user is notified on the console that their settings have changed. If workgroup settings are enforced this way, users can omit corresponding client-side settings. In this case, if you run queries in the console, the workgroup's settings are used for them even if any queries have client-side settings. Also, if you run queries in this workgroup through the command line interface, API operations, or the drivers, any settings that you specified are overwritten by the workgroup's settings. This affects the query results location and encryption. To check which settings are used for the workgroup, [view workgroup's details \(p. 251\)](#).

You can also [set query limits \(p. 256\)](#) for queries in workgroups.

Workgroup Settings Override Client-Side Settings

The **Create workgroup** and **Edit workgroup** dialogs have a field titled **Override client-side settings**. This field is unselected by default. Depending on whether you select it, Athena does the following:

- If **Override client-side settings** is not selected, workgroup settings are not enforced. In this case, for all queries that run in this workgroup, Athena uses the clients-side settings for query results location and encryption. Each user can specify client-side settings in the **Settings** menu on the console. If the client-side settings are not used, the workgroup-wide settings apply, but are not enforced. Also, if you run queries in this workgroup through the API operations, the command line interface, or the JDBC and ODBC drivers, and specify your query results location and encryption there, your queries continue using those settings.

- If **Override client-side settings** is selected, Athena uses the workgroup-wide settings for query results location and encryption. It also overrides any other settings that you specified for the query in the console, by using the API operations, or with the drivers. This affects you only if you run queries in this workgroup. If you do, workgroup settings are used.

If you override client-side settings, then the next time that you or any workgroup user open the Athena console, the notification dialog box displays, as shown in the following example. It notifies you that queries in this workgroup use workgroup's settings, and prompts you to acknowledge this change.



Important

If you run queries through the API operations, the command line interface, or the JDBC and ODBC drivers, and have not updated your settings to match those of the workgroup, your queries run, but use the workgroup's settings. For consistency, we recommend that you omit client-side settings in this case or update your query settings to match the workgroup's settings for the results location and encryption. To check which settings are used for the workgroup, [view workgroup's details \(p. 251\)](#).

Managing Workgroups

In the <https://console.aws.amazon.com/athena/>, you can perform the following tasks:

Statement	Description
Create a Workgroup (p. 249)	Create a new workgroup.
Edit a Workgroup (p. 250)	Edit a workgroup and change its settings. You cannot change a workgroup's name, but you can create a new workgroup with the same settings and a different name.
View the Workgroup's Details (p. 251)	View the workgroup's details, such as its name, description, data usage limits, location of query results, and encryption. You can also verify whether this workgroup enforces its settings, if Override client-side settings is checked.
Delete a Workgroup (p. 252)	Delete a workgroup. If you delete a workgroup, query history, saved queries, the workgroup's settings and per-query data limit controls are deleted. The workgroup-wide data limit controls remain in CloudWatch, and you can delete them individually. The primary workgroup cannot be deleted.
Switch between Workgroups (p. 252)	Switch between workgroups to which you have access.
Enable and Disable a Workgroup (p. 253)	Enable or disable a workgroup. When a workgroup is disabled, its users cannot run queries, or create new named queries. If you have access to it, you can still view metrics, data usage limit controls, workgroup's settings, query history, and saved queries.

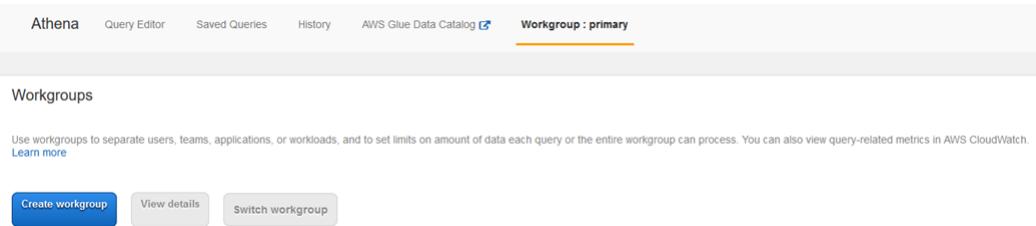
Statement	Description
Specify a Workgroup in Which to Run Queries (p. 253)	Before you can run queries, you must specify to Athena which workgroup to use. You must have permissions to the workgroup.

Create a Workgroup

Creating a workgroup requires permissions to `CreateWorkgroup` API actions. See [Access to Athena Workgroups \(p. 215\)](#) and [IAM Policies for Accessing Workgroups \(p. 242\)](#). If you are adding tags, you also need to add permissions to `TagResource`. See the section called “Tag Policy Examples” (p. 266).

To create a workgroup in the console

1. In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays.
2. In the **Workgroups** panel, choose **Create workgroup**.



3. In the **Create workgroup** dialog box, fill in the fields as follows:

Field	Description
Workgroup name	Required. Enter a unique name for your workgroup. Use 1 - 128 characters. (A-Z,a-z,0-9,_,-,.). This name cannot be changed.
Description	Optional. Enter a description for your workgroup. It can contain up to 1024 characters.
Query result location	Optional. Enter a path to an Amazon S3 bucket or prefix. This bucket and prefix must exist before you specify them. Note If you run queries in the console, specifying the query results location is optional. If you don't specify it for the workgroup or in Settings , Athena uses the default query result location. If you run queries with the API or the drivers, you <i>must</i> specify query results location in at least one of the two places: for individual queries with OutputLocation , or for the workgroup, with WorkGroupConfiguration .
Encrypt query results	Optional. Encrypt results stored in Amazon S3. If selected, all queries in the workgroup are encrypted. If selected, you can select the Encryption type , the Encryption key and enter the KMS Key ARN .

Field	Description
	If you don't have the key, open the AWS KMS console to create it. For more information, see Creating Keys in the <i>AWS Key Management Service Developer Guide</i> .
Publish to CloudWatch	This field is selected by default. Publish query metrics to Amazon CloudWatch. See Viewing Query Metrics (p. 256) .
Override client-side settings	This field is unselected by default. If you select it, workgroup settings apply to all queries in the workgroup and override client-side settings. For more information, see Workgroup Settings Override Client-Side Settings (p. 247) .
Tags	Optional. Add one or more tags to a workgroup. A tag is a label that you assign to an Athena workgroup resource. It consists of a key and a value. Use best practices for AWS tagging strategies to create a consistent set of tags and categorize workgroups by purpose, owner, or environment. You can also use tags in IAM policies, and to control billing costs. Do not use duplicate tag keys the same workgroup. For more information, see Tagging Workgroups (p. 262) .
Requester Pays S3 buckets	Optional. Choose Enable queries on Requester Pays buckets in Amazon S3 if workgroup users will run queries on data stored in Amazon S3 buckets that are configured as Requester Pays. The account of the user running the query is charged for applicable data access and data transfer fees associated with the query. For more information, see Requester Pays Buckets in the <i>Amazon Simple Storage Service Developer Guide</i> .

- Choose **Create workgroup**. The workgroup appears in the list in the **Workgroups** panel.

Alternatively, use the API operations to create a workgroup.

Important

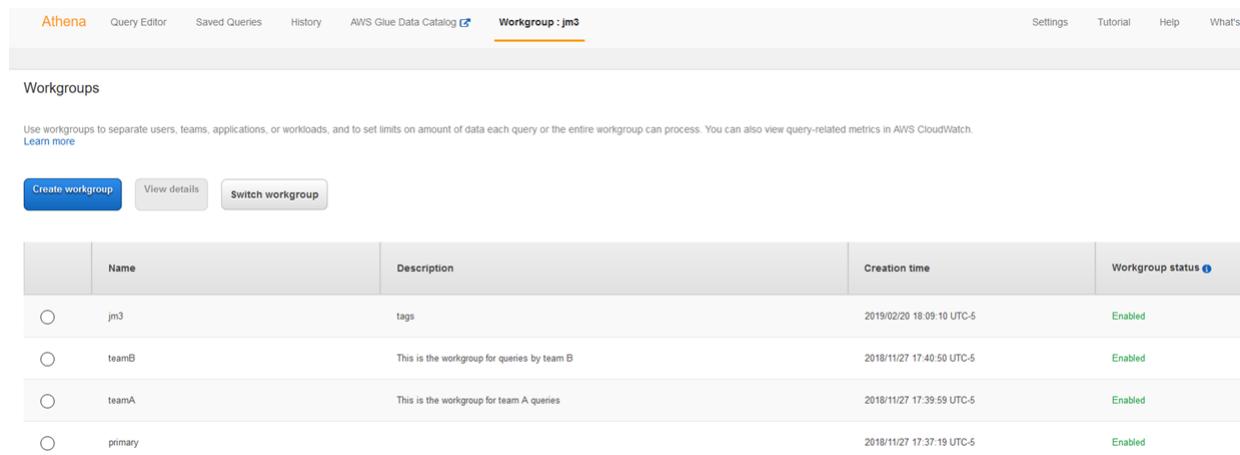
After you create workgroups, create [IAM Policies for Workgroups \(p. 242\)](#) IAM that allow you to run workgroup-related actions.

Edit a Workgroup

Editing a workgroup requires permissions to `UpdateWorkgroup` API operations. See [Access to Athena Workgroups \(p. 215\)](#) and [IAM Policies for Accessing Workgroups \(p. 242\)](#). If you are adding or editing tags, you also need to have permissions to `TagResource`. See [the section called "Tag Policy Examples" \(p. 266\)](#).

To edit a workgroup in the console

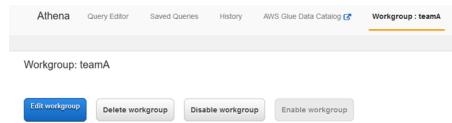
- In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays, listing all of the workgroups in the account.



The screenshot shows the 'Workgroups' section of the Amazon Athena console. At the top, there are tabs for 'Athena', 'Query Editor', 'Saved Queries', 'History', 'AWS Glue Data Catalog', and 'Workgroup : jm3'. Below the tabs, a sub-header reads 'Workgroups' with a note: 'Use workgroups to separate users, teams, applications, or workloads, and to set limits on amount of data each query or the entire workgroup can process. You can also view query-related metrics in AWS CloudWatch.' A 'Learn more' link is provided. Below this, there are three buttons: 'Create workgroup' (blue), 'View details' (gray), and 'Switch workgroup' (gray). The main area displays a table of workgroups:

	Name	Description	Creation time	Workgroup status
<input type="radio"/>	jm3	tags	2019/02/20 18:09:10 UTC-5	Enabled
<input type="radio"/>	teamB	This is the workgroup for queries by team B	2018/11/27 17:40:50 UTC-5	Enabled
<input type="radio"/>	teamA	This is the workgroup for team A queries	2018/11/27 17:39:59 UTC-5	Enabled
<input type="radio"/>	primary		2018/11/27 17:37:19 UTC-5	Enabled

2. In the **Workgroups** panel, choose the workgroup that you want to edit. The **View details** panel for the workgroup displays, with the **Overview** tab selected.
3. Choose **Edit workgroup**.

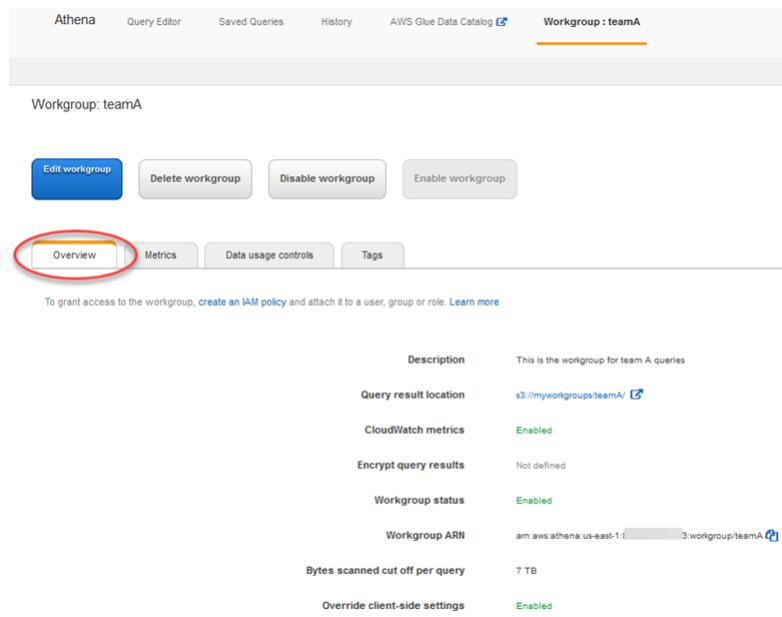
- 
- The screenshot shows the 'Edit workgroup' panel for 'teamA'. At the top, there are tabs for 'Athena', 'Query Editor', 'Saved Queries', 'History', 'AWS Glue Data Catalog', and 'Workgroup : teamA'. Below the tabs, a sub-header reads 'Workgroup: teamA'. There are four buttons at the top: 'Edit workgroup' (blue), 'Delete workgroup' (gray), 'Disable workgroup' (gray), and 'Enable workgroup' (gray). The main area displays the workgroup details:
- | Setting | Value |
|--------------------------|--|
| Name | teamA |
| Description | This is the workgroup for team A queries |
| Location | arn:aws:s3:::athena-workgroup-data |
| Encryption configuration | None |
| Data usage limit (TB) | 0 |
| Created | 2018/11/27 17:39:59 UTC-5 |
| Last modified | 2018/11/27 17:39:59 UTC-5 |
| Enabled | Enabled |
4. Change the fields as needed. For the list of fields, see [Create workgroup \(p. 249\)](#). You can change all fields except for the workgroup's name. If you need to change the name, create another workgroup with the new name and the same settings.
 5. Choose **Save**. The updated workgroup appears in the list in the **Workgroups** panel.

View the Workgroup's Details

For each workgroup, you can view its details. The details include the workgroup's name, description, whether it is enabled or disabled, and the settings used for queries that run in the workgroup, which include the location of the query results and encryption configuration. If a workgroup has data usage limits, they are also displayed.

To view the workgroup's details

- In the **Workgroups** panel, choose the workgroup that you want to edit. The **View details** panel for the workgroup displays, with the **Overview** tab selected. The workgroup details display, as in the following example:



Delete a Workgroup

You can delete a workgroup if you have permissions to do so. The primary workgroup cannot be deleted.

If you have permissions, you can delete an empty workgroup at any time. You can also delete a workgroup that contains saved queries. In this case, before proceeding to delete a workgroup, Athena warns you that saved queries are deleted.

If you delete a workgroup while you are in it, the console switches focus to the primary workgroup. If you have access to it, you can run queries and view its settings.

If you delete a workgroup, its settings and per-query data limit controls are deleted. The workgroup-wide data limit controls remain in CloudWatch, and you can delete them there if needed.

Important

Before deleting a workgroup, ensure that its users also belong to other workgroups where they can continue to run queries. If the users' IAM policies allowed them to run queries *only* in this workgroup, and you delete it, they no longer have permissions to run queries. For more information, see [Example Policy for Running Queries in the Primary Workgroup \(p. 245\)](#).

To delete a workgroup in the console

1. In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays.
2. In the **Workgroups** panel, choose the workgroup that you want to delete. The **View details** panel for the workgroup displays, with the **Overview** tab selected.
3. Choose **Delete workgroup**, and confirm the deletion.

To delete a workgroup with the API operation, use the `DeleteWorkGroup` action.

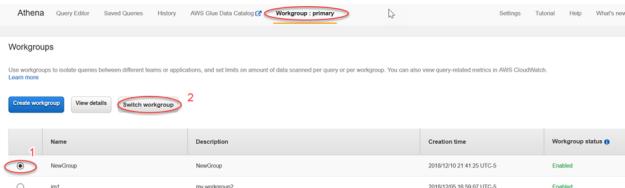
Switch between Workgroups

You can switch from one workgroup to another if you have permissions to both of them.

You can open up to ten query tabs within each workgroup. When you switch between workgroups, your query tabs remain open for up to three workgroups.

To switch between workgroups

1. In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays.
2. In the **Workgroups** panel, choose the workgroup that you want to switch to, and then choose **Switch workgroup**.



3. Choose **Switch**. The console shows the **Workgroup: <workgroup_name>** tab with the name of the workgroup that you switched to. You can now run queries in this workgroup.

Enable and Disable a Workgroup

If you have permissions to do so, you can enable or disable workgroups in the console, by using the API operations, or with the JDBC and ODBC drivers.

To enable or disable a workgroup

1. In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays.
2. In the **Workgroups** panel, choose the workgroup, and then choose **Enable workgroup** or **Disable workgroup**. If you disable a workgroup, its users cannot run queries in it, or create new named queries. If you enable a workgroup, users can use it to run queries.

Specify a Workgroup in Which to Run Queries

Before you can run queries, you must specify to Athena which workgroup to use. You need to have permissions to the workgroup.

To specify a workgroup to Athena

1. Make sure your permissions allow you to run queries in a workgroup that you intend to use. For more information, see [the section called " IAM Policies for Accessing Workgroups" \(p. 242\)](#).
2. To specify the workgroup to Athena, use one of these options:
 - If you are accessing Athena via the console, set the workgroup by [switching workgroups \(p. 252\)](#).
 - If you are using the Athena API operations, specify the workgroup name in the API action. For example, you can set the workgroup name in [StartQueryExecution](#), as follows:

```
StartQueryExecutionRequest startQueryExecutionRequest = new
    StartQueryExecutionRequest()
        .withQueryString(ExampleConstants.ATHENA_SAMPLE_QUERY)
        .withQueryExecutionContext(queryExecutionContext)
        .withWorkgroup(WorkgroupName)
```

- If you are using the JDBC or ODBC driver, set the workgroup name in the connection string using the `Workgroup` configuration parameter. The driver passes the workgroup name to Athena. Specify the `workgroup` parameter in the connection string as in the following example:

```
jdbc:awsathena://AwsRegion=<AWSREGION>;UID=<ACCESSKEY>;  
PWD=<SECRETKEY>;S3OutputLocation=s3://<athena-output>-<AWSREGION>/;  
Workgroup=<WORKGROUPNAME>;
```

For more information, search for "Workgroup" in the driver documentation link included in [JDBC Driver Documentation \(p. 72\)](#).

Athena Workgroup APIs

The following are some of the REST API operations used for Athena workgroups. In all of the following operations except for `ListWorkGroups`, you must specify a workgroup. In other operations, such as `StartQueryExecution`, the workgroup parameter is optional and the operations are not listed here. For the full list of operations, see [Amazon Athena API Reference](#).

- [CreateWorkGroup](#)
- [DeleteWorkGroup](#)
- [GetWorkGroup](#)
- [ListWorkGroups](#)
- [UpdateWorkGroup](#)

Troubleshooting Workgroups

Use the following tips to troubleshoot workgroups.

- Check permissions for individual users in your account. They must have access to the location for query results, and to the workgroup in which they want to run queries. If they want to switch workgroups, they too need permissions to both workgroups. For information, see [IAM Policies for Accessing Workgroups \(p. 242\)](#).
- Pay attention to the context in the Athena console, to see in which workgroup you are going to run queries. If you use the driver, make sure to set the workgroup to the one you need. For information, see the section called ["Specify a Workgroup in Which to Run Queries" \(p. 253\)](#).
- If you use the API or the drivers to run queries, you must specify the query results location using one of the ways: either for individual queries, using `OutputLocation` (client-side), or in the workgroup, using `WorkGroupConfiguration`. If the location is not specified in either way, Athena issues an error at query execution.
- If you override client-side settings with workgroup settings, you may encounter errors with query result location. For example, a workgroup's user may not have permissions to the workgroup's location in Amazon S3 for storing query results. In this case, add the necessary permissions.
- Workgroups introduce changes in the behavior of the API operations. Calls to the following existing API operations require that users in your account have resource-based permissions in IAM to the workgroups in which they make them. If no permissions to the workgroup and to workgroup actions exist, the following API actions throw `AccessDeniedException`: `CreateNamedQuery`, `DeleteNamedQuery`, `GetNamedQuery`, `ListNamedQuerys`, `StartQueryExecution`, `StopQueryExecution`, `ListQueryExecutions`, `GetQueryExecution`, `GetQueryResults`, and `GetQueryResultsStream` (this API action is only available for use with the driver and is not exposed otherwise for public use). For more information, see [Actions, Resources, and Condition Keys for Amazon Athena](#) in the *IAM User Guide*.

Calls to the `BatchGetQueryExecution` and `BatchGetNamedQuery` API operations return information about query executions only for those queries that run in workgroups to which users have access. If the user has no access to the workgroup, these API operations return the unauthorized query IDs as

part of the unprocessed IDs list. For more information, see [the section called “Athena Workgroup APIs” \(p. 254\)](#).

- If the workgroup in which a query will run is configured with an [enforced query results location \(p. 247\)](#), do not specify an `external_location` for the CTAS query. Athena issues an error and fails a query that specifies an `external_location` in this case. For example, this query fails, if you override client-side settings for query results location, enforcing the workgroup to use its own location: `CREATE TABLE <DB>.<TABLE1> WITH (format='Parquet', external_location='s3://my_test/test/') AS SELECT * FROM <DB>.<TABLE2> LIMIT 10;`

You may see the following errors. This table provides a list of some of the errors related to workgroups and suggests solutions.

Workgroup errors

Error	Occurs when...
<code>query state CANCELED. Bytes scanned limit was exceeded.</code>	A query hits a per-query data limit and is canceled. Consider rewriting the query so that it reads less data, or contact your account administrator.
<code>User: arn:aws:iam::123456789012:user/abc is not authorized to perform: athena:StartQueryExecution on resource: arn:aws:athena:us-east-1:123456789012:workgroup/workgroupname</code>	A user runs a query in a workgroup, but does not have access to it. Update your policy to have access to the workgroup.
<code>INVALID_INPUT. WorkGroup <name> is disabled.</code>	A user runs a query in a workgroup, but the workgroup is disabled. Your workgroup could be disabled by your administrator. It is possible also that you don't have access to it. In both cases, contact an administrator who has access to modify workgroups.
<code>INVALID_INPUT. WorkGroup <name> is not found.</code>	A user runs a query in a workgroup, but the workgroup does not exist. This could happen if the workgroup was deleted. Switch to another workgroup to run your query.
<code>InvalidRequestException: when calling the StartQueryExecution operation: No output location provided. An output location is required either through the Workgroup result configuration setting or as an API input.</code>	A user runs a query with the API without specifying the location for query results. You must set the output location for query results using one of the two ways: either for individual queries, using OutputLocation (client-side), or in the workgroup, using WorkGroupConfiguration .
<code>The Create Table As Select query failed because it was submitted with an 'external_location' property to an Athena Workgroup that enforces a centralized output location for all queries. Please remove the 'external_location' property and resubmit the query.</code>	If the workgroup in which a query runs is configured with an enforced query results location (p. 247) , and you specify an <code>external_location</code> for the CTAS query. In this case, remove the <code>external_location</code> and rerun the query.

Controlling Costs and Monitoring Queries with CloudWatch Metrics

Workgroups allow you to set data usage control limits per query or per workgroup, set up alarms when those limits are exceeded, and publish query metrics to CloudWatch.

In each workgroup, you can:

- Configure **Data usage controls** per query and per workgroup, and establish actions that will be taken if queries breach the thresholds.
- View and analyze query metrics, and publish them to CloudWatch. If you create a workgroup in the console, the setting for publishing the metrics to CloudWatch is selected for you. If you use the API operations, you must [enable publishing the metrics \(p. 256\)](#). When metrics are published, they are displayed under the **Metrics** tab in the **Workgroups** panel. Metrics are disabled by default for the primary workgroup.

Topics

- [Enabling CloudWatch Query Metrics \(p. 256\)](#)
- [Monitoring Athena Queries with CloudWatch Metrics \(p. 256\)](#)
- [Setting Data Usage Control Limits \(p. 258\)](#)

Enabling CloudWatch Query Metrics

When you create a workgroup in the console, the setting for publishing query metrics to CloudWatch is selected by default.

If you use API operations, the command line interface, or the client application with the JDBC driver to create workgroups, to enable publishing of query metrics, set `PublishCloudWatchMetricsEnabled` to `true` in [WorkGroupConfiguration](#). The following example shows only the metrics configuration and omits other configuration:

```
"WorkGroupConfiguration": {  
    "PublishCloudWatchMetricsEnabled": "true"  
    ....  
}
```

Monitoring Athena Queries with CloudWatch Metrics

Athena publishes query-related metrics to Amazon CloudWatch, when **Publish to CloudWatch** is selected. You can create custom dashboards, set alarms and triggers on metrics in CloudWatch, or use pre-populated dashboards directly from the Athena console.

When you enable query metrics for queries in workgroups, the metrics are displayed within the **Metrics** tab in the **Workgroups** panel, for each workgroup in the Athena console.

Athena publishes the following metrics to the CloudWatch console:

- `DataScannedInBytes` – the total amount of data scanned per query
- `EngineExecutionTime` – in milliseconds
- `QueryPlanningTime` – in milliseconds
- `QueryQueueTime` – in milliseconds
- `QueryState` – successful, failed, or canceled

- **QueryType** – DDL or DML
- **ServiceProcessingTime** – in milliseconds
- **TotalExecutionTime** – in milliseconds
- **WorkGroup** – name of the workgroup

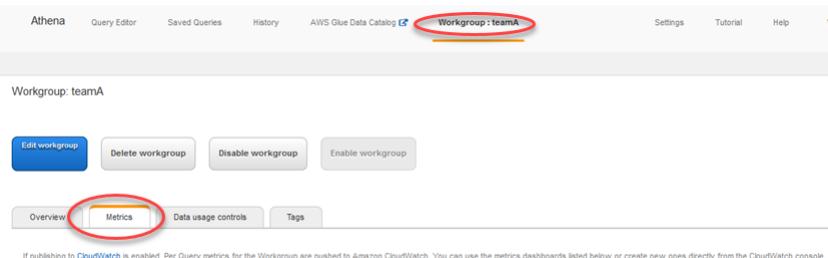
For more information, see the [List of CloudWatch Metrics for Athena \(p. 258\)](#) later in this topic.

To view query metrics for a workgroup in the console

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose the **Workgroup:<name>** tab.

To view a workgroup's metrics, you don't need to switch to it and can remain in another workgroup. You do need to select the workgroup from the list. You also must have permissions to view its metrics.

3. Select the workgroup from the list, and then choose **View details**. If you have permissions, the workgroup's details display in the **Overview** tab.
4. Choose the **Metrics** tab.



As a result, the metrics display.

5. Choose the metrics interval that Athena should use to fetch the query metrics from CloudWatch, or choose the refresh icon to refresh the displayed metrics.



To view metrics in the Amazon CloudWatch console

1. Open the Amazon CloudWatch console at <https://console.aws.amazon.com/cloudwatch/>.
2. In the navigation pane, choose **Metrics**.
3. Select the **AWS/Athena** namespace.

To view metrics with the CLI

- Open a command prompt, and use the following command:

```
aws cloudwatch list-metrics --namespace "AWS/Athena"
```

- To list all available metrics, use the following command:

```
aws cloudwatch list-metrics --namespace "AWS/Athena"
```

List of CloudWatch Metrics for Athena

If you've enabled CloudWatch metrics in Athena, it sends the following metrics to CloudWatch per workgroup. The metrics use the AWS/Athena namespace.

Metric Name	Description
DataScannedInBytes	The amount of data in megabytes that Athena scanned per query. For queries that were canceled (either by the users, or automatically, if they reached the limit), this includes the amount of data scanned before the cancellation time.
EngineExecutionTime	The number of milliseconds that the query took to execute.
QueryPlanningTime	The number of milliseconds that Athena took to plan the query processing flow. This includes the time spent retrieving table partitions from the data source. Note that because the query engine performs the query planning, query planning time is a subset of EngineExecutionTime.
QueryQueueTime	The number of milliseconds that the query was in the query queue waiting for resources. Note that if transient errors occur, the query can be automatically added back to the queue.
QueryState	The query state. Valid statistics: Succeeded, Failed, Canceled
QueryType	The query type. Valid statistics: DDL or DML.
ServiceProcessingTime	Number of milliseconds that Athena took to process the query results after the query engine finished query execution.
TotalExecutionTime	The number of milliseconds that Athena took to run the query.
WorkGroup	The name of the workgroup.

Setting Data Usage Control Limits

Athena allows you to set two types of cost controls: per-query limit and per-workgroup limit. For each workgroup, you can set only one per-query limit and multiple per-workgroup limits.

- The **per-query control limit** specifies the total amount of data scanned per query. If any query that runs in the workgroup exceeds the limit, it is canceled. You can create only one per-query control limit in a workgroup and it applies to each query that runs in it. Edit the limit if you need to change it. For detailed steps, see [To create a per-query data usage control \(p. 259\)](#).
- The **workgroup-wide data usage control limit** specifies the total amount of data scanned for all queries that run in this workgroup during the specified time period. You can create multiple limits per workgroup. The workgroup-wide query limit allows you to set multiple thresholds on hourly or daily aggregates on data scanned by queries running in the workgroup.

If the aggregate amount of data scanned exceeds the threshold, you can choose to take one of the following actions:

- Configure an Amazon SNS alarm and an action in the Athena console to notify an administrator when the limit is breached. For detailed steps, see [To create a per-workgroup data usage](#)

control (p. 260). You can also create an alarm and an action on any metric that Athena publishes from the CloudWatch console. For example, you can set an alert on a number of failed queries. This alert can trigger an email to an administrator if the number crosses a certain threshold. If the limit is exceeded, an action sends an Amazon SNS alarm notification to the specified users.

- Invoke a Lambda function. For more information, see [Invoking Lambda functions using Amazon SNS notifications](#) in the *Amazon Simple Notification Service Developer Guide*.
- Disable the workgroup, stopping any further queries from running.

The per-query and per-workgroup limits are independent of each other. A specified action is taken whenever either limit is exceeded. If two or more users run queries at the same time in the same workgroup, it is possible that each query does not exceed any of the specified limits, but the total sum of data scanned exceeds the data usage limit per workgroup. In this case, an Amazon SNS alarm is sent to the user.

To create a per-query data usage control

The per-query control limit specifies the total amount of data scanned per query. If any query that runs in the workgroup exceeds the limit, it is canceled. Canceled queries are charged according to [Amazon Athena pricing](#).

Note

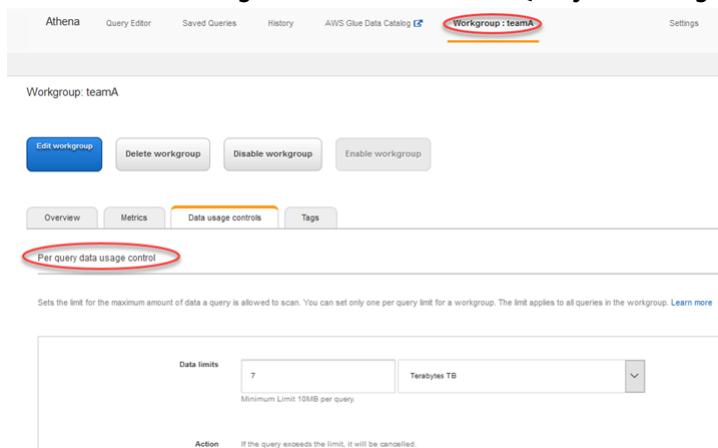
In the case of canceled or failed queries, Athena may have already written partial results to Amazon S3. In such cases, Athena does not delete partial results from the Amazon S3 prefix where results are stored. You must remove the Amazon S3 prefix with partial results. Athena uses Amazon S3 multipart uploads to write data Amazon S3. We recommend that you set the bucket lifecycle policy to abort multipart uploads in cases when queries fail. For more information, see [Aborting Incomplete Multipart Uploads Using a Bucket Lifecycle Policy](#) in the *Amazon Simple Storage Service Developer Guide*.

You can create only one per-query control limit in a workgroup and it applies to each query that runs in it. Edit the limit if you need to change it.

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose the **Workgroup:<name>** tab.

To create a data usage control for a query in a particular workgroup, you don't need to switch to it and can remain in another workgroup. You do need to select the workgroup from the list and have permissions to edit the workgroup.

3. Select the workgroup from the list, and then choose **View details**. If you have permissions, the workgroup's details display in the **Overview** tab.
4. Choose the **Data usage controls** tab. The **Per Query Data Usage Control** dialog displays.



5. Specify (or update) the field values, as follows:

- For **Data limit**, specify a value between 10000 KB (minimum) and 7 EB (maximum).

Note

These are limits imposed by the console for data usage controls within workgroups. They do not represent any query limits in Athena.

- For units, select the unit value from the drop-down list.
- Review the default **Action**. The default **Action** is to cancel the query if it exceeds the limit. This action cannot be changed.

6. Choose **Create** if you are creating a new limit, or **Update** if you are editing an existing limit. If you are editing an existing limit, refresh the **Overview** tab to see the updated limit.

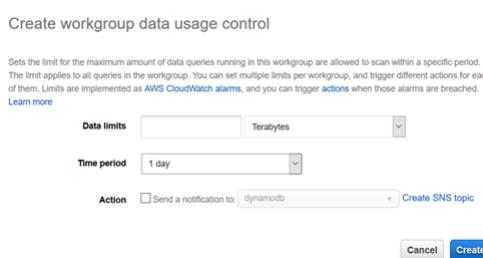
To create a per-workgroup data usage control

The workgroup-wide data usage control limit specifies the total amount of data scanned for all queries that run in this workgroup during the specified time period. You can create multiple control limits per workgroup. If the limit is exceeded, you can choose to take action, such as send an Amazon SNS alarm notification to the specified users.

1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. Choose the **Workgroup:<name>** tab.

To create a data usage control for a particular workgroup, you don't need to switch to it and can remain in another workgroup. You do need to select the workgroup from the list and have permissions to edit the workgroup.

3. Select the workgroup from the list, and then choose **View details**. If you have edit permissions, the workgroup's details display in the **Overview** tab.
4. Choose the **Data usage controls** tab, and scroll down. Then choose **Workgroup Data Usage Control** to create a new limit or edit an existing limit. The **Create workgroup data usage control** dialog displays.



5. Specify field values as follows:

- For **Data limits**, specify a value between 10000 KB (minimum) and 7 EB (maximum).

Note

These are limits imposed by the console for data usage controls within workgroups. They do not represent any query limits in Athena.

- For units, select the unit value from the drop-down list.
- For time period, choose a time period from the drop-down list.
- For **Action**, choose the Amazon SNS topic from the drop-down list, if you have it configured. Or, choose **Create an Amazon SNS topic** to go directly to the [Amazon SNS console](#), create the Amazon SNS topic, and set up a subscription for it for one of the users in your Athena account. For more information, see [Creating an Amazon SNS Topic](#) in the [Amazon Simple Notification Service Getting Started Guide](#).

6. Choose **Create** if you are creating a new limit, or **Save** if you are editing an existing limit. If you are editing an existing limit, refresh the **Overview** tab for the workgroup to see the updated limit.

Tagging Workgroups

A tag consists of a key and a value, both of which you define. When you tag a workgroup, you assign custom metadata to it. You can use tags to categorize your AWS resources in different ways; for example, by purpose, owner, or environment. For Athena, the workgroup is the resource that you can tag. For example, you can create a set of tags for workgroups in your account that helps you track workgroup owners, or identify workgroups by their purpose. We recommend that you use [AWS tagging best practices](#) to create a consistent set of tags to meet your organization requirements.

You can work with tags using the Athena console or the API operations.

Topics

- [Tag Basics \(p. 262\)](#)
- [Tag Restrictions \(p. 263\)](#)
- [Working with Tags Using the Console \(p. 263\)](#)
- [Working with Tags Using the API Actions \(p. 265\)](#)
- [Tag-Based IAM Access Control Policies \(p. 266\)](#)

Tag Basics

A tag is a label that you assign to an Athena resource. Each tag consists of a key and an optional value, both of which you define.

Tags enable you to categorize your AWS resources in different ways. For example, you can define a set of tags for your account's workgroups that helps you track each workgroup owner or purpose.

You can add tags when creating a new Athena workgroup, or you can add, edit, or remove tags from an existing workgroup. You can edit a tag in the console. If you use the API operations, to edit a tag, remove the old tag and add a new one. If you delete a workgroup, any tags for it are also deleted. Other workgroups in your account continue using the same tags.

Athena does not automatically assign tags to your resources, such as your workgroups. You can edit tag keys and values, and you can remove tags from a workgroup at any time. You can set the value of a tag to an empty string, but you can't set the value of a tag to null. Do not add duplicate tag keys at the same time to the same workgroup. If you do, Athena issues an error message. If you tag a workgroup using an existing tag key in a separate **TagResource** action, the new tag value overwrites the old value.

In IAM, you can control which users in your AWS account have permission to create, edit, remove, or list tags. For more information, see [the section called "Tag Policy Examples" \(p. 266\)](#).

For a complete list of Amazon Athena tag actions, see the API action names in the [Amazon Athena API Reference](#).

You can use the same tags for billing. For more information, see [Using Tags for Billing](#) in the *AWS Billing and Cost Management User Guide*.

For more information, see [Tag Restrictions \(p. 263\)](#).

Tag Restrictions

Tags have the following restrictions:

- In Athena, you can tag workgroups. You cannot tag queries.
- Maximum number of tags per workgroup is 50. To stay within the limit, review and delete unused tags.
- For each workgroup, each tag key must be unique, and each tag key can have only one value. Do not add duplicate tag keys at the same time to the same workgroup. If you do, Athena issues an error message. If you tag a workgroup using an existing tag key in a separate TagResource action, the new tag value overwrites the old value.
- Tag key length is 1-128 Unicode characters in UTF-8.
- Tag value length is 0-256 Unicode characters in UTF-8.

Tagging operations, such as adding, editing, removing, or listing tags, require that you specify an ARN for the workgroup resource.

- Athena allows you to use letters, numbers, spaces represented in UTF-8, and the following characters: + - = . _ : / @.
- Tag keys and values are case-sensitive.
- Don't use the "aws :" prefix in tag keys; it's reserved for AWS use. You can't edit or delete tag keys with this prefix. Tags with this prefix do not count against your per-resource tags limit.
- The tags you assign are available only to your AWS account.

Working with Tags Using the Console

Using the Athena console, you can see which tags are in use by each workgroup in your account. You can view tags by workgroup only. You can also use the Athena console to apply, edit, or remove tags from one workgroup at a time.

You can search workgroups using the tags you created.

Topics

- [Displaying Tags for Individual Workgroups \(p. 263\)](#)
- [Adding and Deleting Tags on an Individual Workgroup \(p. 263\)](#)

Displaying Tags for Individual Workgroups

You can display tags for an individual workgroup in the Athena console.

To view a list of tags for a workgroup, select the workgroup, choose **View Details**, and then choose the **Tags** tab. The list of tags for the workgroup displays. You can also view tags on a workgroup if you choose **Edit Workgroup**.

To search for tags, choose the **Tags** tab, and then choose **Manage Tags**. Then, enter a tag name into the search tool.

Adding and Deleting Tags on an Individual Workgroup

You can manage tags for an individual workgroup directly from the **Workgroups** tab.

To add a tag when creating a new workgroup

Note

Make sure you give a user IAM permissions to the **TagResource** and **CreateWorkGroup** actions if you want to allow them to add tags when creating a workgroup in the console, or pass in tags upon **CreateWorkGroup**.

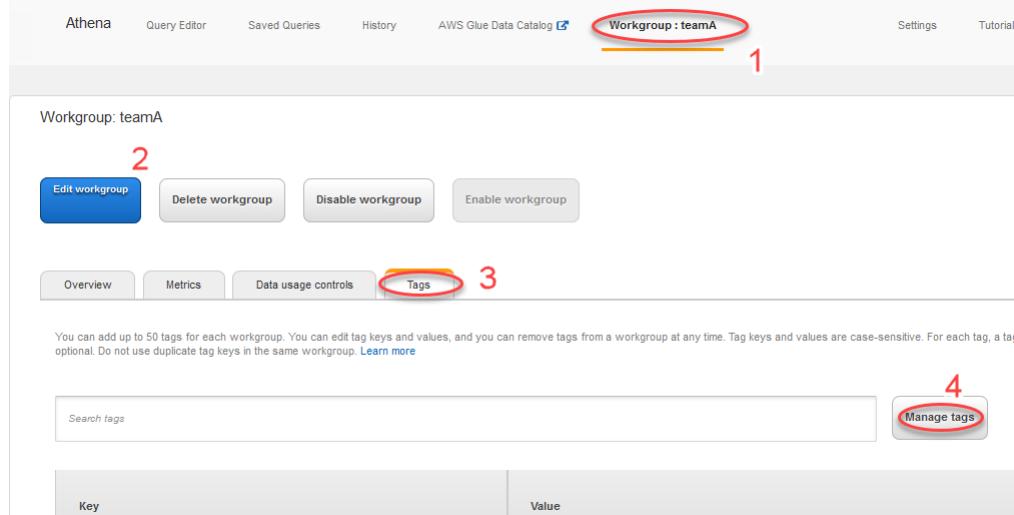
1. Open the Athena console at <https://console.aws.amazon.com/athena/>.
2. On the navigation menu, choose the **Workgroups** tab.
3. Choose **Create workgroup** and fill in the values, as needed. For detailed steps, see [Create a Workgroup \(p. 249\)](#).
4. Add one or more tags, by specifying keys and values. Do not add duplicate tag keys at the same time to the same workgroup. If you do, Athena issues an error message. For more information, see [Tag Restrictions \(p. 263\)](#).
5. When you are done, choose Create Workgroup.

To add or edit a tag to an existing workgroup

Note

Make sure you give a user IAM permissions to the **TagResource** and **CreateWorkGroup** actions if you want to allow them to add tags when creating a workgroup in the console, or pass in tags upon **CreateWorkGroup**.

1. Open the Athena console at <https://console.aws.amazon.com/athena/>, choose the **Workgroups** tab, and select the workgroup.
2. Choose **View details or Edit workgroup**.
3. Choose the **Tags** tab.
4. On the **Tags** tab, choose **Manage tags**, and then specify the key and value for each tag. For more information, see [Tag Restrictions \(p. 263\)](#).



5. When you are done, choose **Save**.

To delete a tag from an individual workgroup

1. Open the Athena console, and then choose the **Workgroups** tab.
2. In the workgroup list, select the workgroup, choose **View details**, and then choose the **Tags** tab.
3. On the **Tags** tab, choose **Manage tags**.

4. In the list of tags, select the **delete** button (a cross) for the tag, and choose **Save**.

Working with Tags Using the API Actions

You can also use the `CreateWorkGroup` API operation with the optional `tag` parameter that you can use to pass in one or more tags for the workgroup. To add, remove, or list tags, you can use the following AWS API operations: `TagResource`, `UntagResource`, and `ListTagsForResource`.

Tags API Actions in Athena

API name	Action description
<code>TagResource</code>	Add or overwrite one or more tags to the workgroup with the specified ARN.
<code>UntagResource</code>	Delete one or more tags from the workgroup with the specified ARN.
<code>ListTagsForResource</code>	List one or more tags for the workgroup resource with the specified ARN.

For more information, see the [Amazon Athena API Reference](#).

Example TagResource

In the following example, we add two tags to `workgroupA`:

```
List<Tag> tags = new ArrayList<>();
tags.add(new Tag().withKey("tagKey1").withValue("tagValue1"));
tags.add(new Tag().withKey("tagKey2").withValue("tagValue2"));

TagResourceRequest request = new TagResourceRequest()
    .withResourceARN("arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA")
    .withTags(tags);

client.tagResource(request);
```

Note

Do not add duplicate tag keys at the same time to the same workgroup. If you do, Athena issues an error message. If you tag a workgroup using an existing tag key in a separate `TagResource` action, the new tag value overwrites the old value.

Example UntagResource

In the following example, we remove `tagKey2` from `workgroupA`:

```
List<String> tagKeys = new ArrayList<>();
tagKeys.add("tagKey2");

UntagResourceRequest request = new UntagResourceRequest()
    .withResourceARN("arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA")
    .withTagKeys(tagKeys);

client.untagResource(request);
```

Example ListTagsForResource

In the following example, we list tags for `workgroupA`:

```
ListTagsForResourceRequest request = new ListTagsForResourceRequest()
    .withResourceARN("arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA");

ListTagsForResourceResult result = client.listTagsForResource(request);

List<Tag> resultTags = result.getTags();
```

Tag-Based IAM Access Control Policies

Having tags allows you to write an IAM policy that includes the Condition block to control access to workgroups based on their tags.

Tag Policy Examples

Example 1. Basic Tagging Policy

The following IAM policy allows you to run queries and interact with tags for the workgroup named `workgroupA`:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "athena>ListWorkGroups",
                "athena:GetExecutionEngine",
                "athena:GetExecutionEngines",
                "athena:GetNamespace",
                "athena:GetCatalogs",
                "athena:GetNamespaces",
                "athena:GetTables",
                "athena:GetTable"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "athena>StartQueryExecution",
                "athena>GetQueryResults",
                "athena>DeleteNamedQuery",
                "athena>GetNamedQuery",
                "athena>ListQueryExecutions",
                "athena>StopQueryExecution",
                "athena>GetQueryResultsStream",
                "athena>GetQueryExecutions",
                "athena>ListNamedQueries",
                "athena>CreateNamedQuery",
                "athena>GetQueryExecution",
                "athena>BatchGetNamedQuery",
                "athena>BatchGetQueryExecution",
                "athena>GetWorkGroup",
                "athena>TagResource",
                "athena>UntagResource",
                "athena>ListTagsForResource"
            ],
            "Resource": "arn:aws:athena:us-east-1:123456789012:workgroup/workgroupA"
        }
    ]
}
```

```
        ]  
    }
```

Example 2: Policy Block that Denies Actions on a Workgroup Based on a Tag Key and Tag Value Pair

Tags that are associated with an existing workgroup are referred to as resource tags. Resource tags let you write policy blocks, such as the following, which deny the listed actions on any workgroup tagged with tag key and tag value pair, such as: `stack`, `production`.

```
{  
    "Effect": "Deny",  
    "Action": [  
        "athena:StartQueryExecution",  
        "athena:GetQueryResults",  
        "athena>DeleteNamedQuery",  
        "athena:UpdateWorkGroup",  
        "athena:GetNamedQuery",  
        "athena>ListQueryExecutions",  
        "athena:GetWorkGroup",  
        "athena:StopQueryExecution",  
        "athena:GetQueryResultsStream",  
        "athena:GetQueryExecutions",  
        "athena>ListNamedQueries",  
        "athena>CreateNamedQuery",  
        "athena:GetQueryExecution",  
        "athena:BatchGetNamedQuery",  
        "athena:BatchGetQueryExecution",  
        "athena:TagResource",  
        "athena:UntagResource",  
        "athena>ListTagsForResource"  
    ],  
    "Resource": "arn:aws:athena:us-east-1:123456789012:workgroup/\*",  
    "Condition": {  
        "StringEquals": {  
            "aws:ResourceTag/stack": "production"  
        }  
    }  
}
```

Example 3. Policy Block that Restricts Tag-Changing Action Requests to Specified Tags

Tags passed in as parameters to a tag-mutating API action, such as `CreateWorkGroup` with tags, `TagResource`, and `UntagResource`, are referred to as request tags. Use these tags, as shown in the following example policy block. This allows `CreateWorkGroup` only if one of the tags included when you create a workgroup is a tag with the `costcenter` key with one of the allowed tag values: `1`, `2`, or `3`.

Note: Make sure that you give a user IAM permissions to the `TagResource` and `CreateWorkGroup` API operations, if you want to allow them to pass in tags upon `CreateWorkGroup`.

```
{  
    "Effect": "Allow",  
    "Action": [  
        "athena:CreateWorkGroup",  
        "athena:TagResource"  
    ],  
    "Resource": "arn:aws:athena:us-east-1:123456789012:workgroup/\*",  
    "Condition": {  
        "StringEquals": {  
            "aws:RequestTag/costcenter": [  
                "1",  
                "2",  
                "3"  
            ]  
        }  
    }  
}
```

```
        } ] "3"  
    } }
```

Monitoring Logs and Troubleshooting

Examine Athena requests using CloudTrail logs and troubleshoot queries.

Topics

- [Logging Amazon Athena API Calls with AWS CloudTrail \(p. 269\)](#)
- [Troubleshooting \(p. 272\)](#)

Logging Amazon Athena API Calls with AWS CloudTrail

Athena is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Athena.

CloudTrail captures all API calls for Athena as events. The calls captured include calls from the Athena console and code calls to the Athena API operations. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for Athena. 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 Athena, 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](#).

You can also use Athena to query CloudTrail log files for insight. For more information, see [Querying AWS CloudTrail Logs \(p. 178\)](#) and [CloudTrail SerDe \(p. 278\)](#).

Athena Information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in Athena, 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 Athena, 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 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:

- [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 Athena actions are logged by CloudTrail and are documented in the [Amazon Athena API Reference](#). For example, calls to the [StartQueryExecution](#) and [GetQueryResults](#) 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 AWS Identity and Access Management (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 Athena 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 aren't an ordered stack trace of the public API calls, so they don't appear in any specific order.

The following examples demonstrate CloudTrail log entries for:

- [StartQueryExecution \(Successful\)](#) (p. 270)
- [StartQueryExecution \(Failed\)](#) (p. 271)
- [CreateNamedQuery](#) (p. 271)

StartQueryExecution (Successful)

```
{  
    "eventVersion": "1.05",  
    "userIdentity": {  
        "type": "IAMUser",  
        "principalId": "EXAMPLE_PRINCIPAL_ID",  
        "arn": "arn:aws:iam::123456789012:user/johndoe",  
        "accountId": "123456789012",  
        "accessKeyId": "EXAMPLE_KEY_ID",  
        "userName": "johndoe"  
    },  
    "eventTime": "2017-05-04T00:23:55Z",  
    "eventSource": "athena.amazonaws.com",  
    "eventName": "StartQueryExecution",  
    "awsRegion": "us-east-1",  
    "sourceIPAddress": "77.88.999.69",  
    "userAgent": "aws-internal/3",  
    "requestParameters": {  
        "clientRequestToken": "16bc6e70-f972-4260-b18a-db1b623cb35c",  
        "resultConfiguration": {  
            "outputLocation": "s3://athena-johndoe-test/test/"  
        },  
        "query": "Select 10"  
    },  
    "responseElements": {  
        "queryExecutionId": "b621c254-74e0-48e3-9630-78ed857782f9"  
    },  
    "requestID": "f5039b01-305f-11e7-b146-c3fc56a7dc7a",  
    "eventID": "c97cf8c8-6112-467a-8777-53bb38f83fd5",  
}
```

```
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
}
```

StartQueryExecution (Failed)

```
{
  "eventVersion": "1.05",
  "userIdentity": {
    "type": "IAMUser",
    "principalId": "EXAMPLE_PRINCIPAL_ID",
    "arn": "arn:aws:iam::123456789012:user/johndoe",
    "accountId": "123456789012",
    "accessKeyId": "EXAMPLE_KEY_ID",
    "userName": "johndoe"
  },
  "eventTime": "2017-05-04T00:21:57Z",
  "eventSource": "athena.amazonaws.com",
  "eventName": "StartQueryExecution",
  "awsRegion": "us-east-1",
  "sourceIPAddress": "77.88.999.69",
  "userAgent": "aws-internal/3",
  "errorCode": "InvalidRequestException",
  "errorMessage": "Invalid result configuration. Should specify either output location or result configuration",
  "requestParameters": {
    "clientRequestToken": "ca0e965f-d6d8-4277-8257-814a57f57446",
    "query": "Select 10"
  },
  "responseElements": null,
  "requestID": "aefbc057-305f-11e7-9f39-bbc56d5d161e",
  "eventID": "6e1fc69b-d076-477e-8dec-024ee51488c4",
  "eventType": "AwsApiCall",
  "recipientAccountId": "123456789012"
}
```

CreateNamedQuery

```
{
  "eventVersion": "1.05",
  "userIdentity": {
    "type": "IAMUser",
    "principalId": "EXAMPLE_PRINCIPAL_ID",
    "arn": "arn:aws:iam::123456789012:user/johndoe",
    "accountId": "123456789012",
    "accessKeyId": "EXAMPLE_KEY_ID",
    "userName": "johndoe"
  },
  "eventTime": "2017-05-16T22:00:58Z",
  "eventSource": "athena.amazonaws.com",
  "eventName": "CreateNamedQuery",
  "awsRegion": "us-west-2",
  "sourceIPAddress": "77.88.999.69",
  "userAgent": "aws-cli/1.11.85 Python/2.7.10 Darwin/16.6.0 botocore/1.5.48",
  "requestParameters": {
    "name": "johndoetest",
    "queryString": "select 10",
    "database": "default",
    "clientRequestToken": "fc1ad880-69ee-4df0-bb0f-1770d9a539b1"
  },
  "responseElements": {
    "namedQueryId": "cdd0fe29-4787-4263-9188-a9c8db29f2d6"
  }
}
```

```
    },
    "requestID": "2487dd96-3a83-11e7-8f67-c9de5ac76512",
    "eventID": "15e3d3b5-6c3b-4c7c-bc0b-36a8dd95227b",
    "eventType": "AwsApiCall",
    "recipientAccountId": "123456789012"
},
```

Troubleshooting

Use these documentation topics to troubleshoot problems with Amazon Athena.

- [Service Limits \(p. 339\)](#)
- [Limitations \(p. 324\)](#)
- [Unsupported DDL \(p. 307\)](#)
- [Names for Tables, Databases, and Columns \(p. 32\)](#)
- [Data Types \(p. 299\)](#)
- [Supported SerDes and Data Formats \(p. 274\)](#)
- [Compression Formats \(p. 298\)](#)
- [Reserved Words \(p. 33\)](#)
- [Troubleshooting Workgroups \(p. 254\)](#)

In addition, use the following AWS resources:

- [Athena topics in the AWS Knowledge Center](#)
- [Athena discussion forum](#)
- [Athena posts in the AWS Big Data Blog](#)

SerDe Reference

Athena supports several SerDe libraries for parsing data from different data formats, such as CSV, JSON, Parquet, and ORC. Athena does not support custom SerDes.

Topics

- [Using a SerDe \(p. 273\)](#)
- [Supported SerDes and Data Formats \(p. 274\)](#)
- [Compression Formats \(p. 298\)](#)

Using a SerDe

A SerDe (Serializer/Deserializer) is a way in which Athena interacts with data in various formats.

It is the SerDe you specify, and not the DDL, that defines the table schema. In other words, the SerDe can override the DDL configuration that you specify in Athena when you create your table.

To Use a SerDe in Queries

To use a SerDe when creating a table in Athena, use one of the following methods:

- Use DDL statements to describe how to read and write data to the table and do not specify a `ROW FORMAT`, as in this example. This omits listing the actual SerDe type and the native `LazySimpleSerDe` is used by default.

In general, Athena uses the `LazySimpleSerDe` if you do not specify a `ROW FORMAT`, or if you specify `ROW FORMAT DELIMITED`.

```
ROW FORMAT
DELIMITED FIELDS TERMINATED BY ','
ESCAPED BY '\\'
COLLECTION ITEMS TERMINATED BY '|'
MAP KEYS TERMINATED BY ':'
```

- Explicitly specify the type of SerDe Athena should use when it reads and writes data to the table. Also, specify additional properties in `SERDEPROPERTIES`, as in this example.

```
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe'
WITH SERDEPROPERTIES (
'serialization.format' = ',',
'field.delim' = ',',
'collection.delim' = '|',
'mapkey.delim' = ':',
'escape.delim' = '\\'
)
```

Supported SerDes and Data Formats

Athena supports creating tables and querying data from CSV, TSV, custom-delimited, and JSON formats; data from Hadoop-related formats: ORC, Apache Avro and Parquet; logs from Logstash, AWS CloudTrail logs, and Apache WebServer logs.

Note

The formats listed in this section are used by Athena for reading data. For information about formats that Athena uses for writing data when it runs CTAS queries, see [Creating a Table from Query Results \(CTAS\) \(p. 118\)](#).

To create tables and query data in these formats in Athena, specify a serializer-deserializer class (SerDe) so that Athena knows which format is used and how to parse the data.

This table lists the data formats supported in Athena and their corresponding SerDe libraries.

A SerDe is a custom library that tells the data catalog used by Athena how to handle the data. You specify a SerDe type by listing it explicitly in the `ROW FORMAT` part of your `CREATE TABLE` statement in Athena. In some cases, you can omit the SerDe name because Athena uses some SerDe types by default for certain types of data formats.

Supported Data Formats and SerDes

Data Format	Description	SerDe types supported in Athena
CSV (Comma-Separated Values)	For data in CSV, each line represents a data record, and each record consists of one or more fields, separated by commas.	<ul style="list-style-type: none"> Use the LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files (p. 288) if your data does not include values enclosed in quotes. Use the OpenCSVSerDe for Processing CSV (p. 280) when your data includes quotes in values, or different separator or escape characters.
TSV (Tab-Separated Values)	For data in TSV, each line represents a data record, and each record consists of one or more fields, separated by tabs.	Use the LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files (p. 288) and specify the separator character as <code>FIELDS TERMINATED BY '\t'</code> .
Custom-Delimited	For data in this format, each line represents a data record, and records are separated by custom delimiters.	Use the LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files (p. 288) and specify custom delimiters.
JSON (JavaScript Object Notation)	For JSON data, each line represents a data record, and each record consists of attribute-value pairs and arrays, separated by commas.	<ul style="list-style-type: none"> Use the Hive JSON SerDe (p. 285). Use the OpenX JSON SerDe (p. 286).
Apache Avro	A format for storing data in Hadoop that uses JSON-based schemas for record values.	Use the Avro SerDe (p. 275) .

Data Format	Description	SerDe types supported in Athena
ORC (Optimized Row Columnar)	A format for optimized columnar storage of Hive data.	Use the ORC SerDe (p. 293) and ZLIB compression.
Apache Parquet	A format for columnar storage of data in Hadoop.	Use the Parquet SerDe (p. 296) and SNAPPY compression.
Logstash logs	A format for storing logs in Logstash.	Use the Grok SerDe (p. 282) .
Apache WebServer logs	A format for storing logs in Apache WebServer.	Use the RegexSerDe for Processing Apache Web Server Logs (p. 277) .
CloudTrail logs	A format for storing logs in CloudTrail.	<ul style="list-style-type: none"> • Use the CloudTrail SerDe (p. 278) to query most fields in CloudTrail logs. • Use the OpenX JSON SerDe (p. 286) for a few fields where their format depends on the service. For more information, see CloudTrail SerDe (p. 278).

Topics

- [Avro SerDe \(p. 275\)](#)
- [RegexSerDe for Processing Apache Web Server Logs \(p. 277\)](#)
- [CloudTrail SerDe \(p. 278\)](#)
- [OpenCSVSerDe for Processing CSV \(p. 280\)](#)
- [Grok SerDe \(p. 282\)](#)
- [JSON SerDe Libraries \(p. 285\)](#)
- [LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files \(p. 288\)](#)
- [ORC SerDe \(p. 293\)](#)
- [Parquet SerDe \(p. 296\)](#)

Avro SerDe

SerDe Name

[Avro SerDe](#)

Library Name

`org.apache.hadoop.hive.serde2.avro.AvroSerDe`

Examples

Athena does not support using `avro.schema.url` to specify table schema for security reasons. Use `avro.schema.literal`. To extract schema from data in the Avro format, use the Apache `avro-`

tools-<version>.jar with the `getschema` parameter. This returns a schema that you can use in your `WITH SERDEPROPERTIES` statement. For example:

```
java -jar avro-tools-1.8.2.jar getschema my_data.avro
```

The `avro-tools-<version>.jar` file is located in the `java` subdirectory of your installed Avro release. To download Avro, see [Apache Avro Releases](#). To download Apache Avro Tools directly, see the [Apache Avro Tools Maven Repository](#).

After you obtain the schema, use a `CREATE TABLE` statement to create an Athena table based on underlying Avro data stored in Amazon S3. In `ROW FORMAT`, you must specify the Avro SerDe as follows: `ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.avro.AvroSerDe'`. As demonstrated in the following example, you must specify the schema using the `WITH SERDEPROPERTIES` clause in addition to specifying the column names and corresponding data types for the table.

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace `myregion` in `s3://athena-examples-myregion/path/to/data/` with the region identifier where you run Athena, for example, `s3://athena-examples-us-east-1/path/to/data/`.

```
CREATE EXTERNAL TABLE flights_avro_example (
    yr INT,
    flightdate STRING,
    uniquecarrier STRING,
    airlineid INT,
    carrier STRING,
    flightnum STRING,
    origin STRING,
    dest STRING,
    depdelay INT,
    carrierdelay INT,
    weatherdelay INT
)
PARTITIONED BY (year STRING)
ROW FORMAT
SERDE 'org.apache.hadoop.hive.serde2.avro.AvroSerDe'
WITH SERDEPROPERTIES ('avro.schema.literal='
{
    "type" : "record",
    "name" : "flights_avro_subset",
    "namespace" : "default",
    "fields" : [ {
        "name" : "yr",
        "type" : [ "null", "int" ],
        "default" : null
    }, {
        "name" : "flightdate",
        "type" : [ "null", "string" ],
        "default" : null
    }, {
        "name" : "uniquecarrier",
        "type" : [ "null", "string" ],
        "default" : null
    }, {
        "name" : "airlineid",
        "type" : [ "null", "int" ],
        "default" : null
    }, {
        "name" : "carrier",
        "type" : [ "null", "string" ],
        "default" : null
    }, {
```

```
        "name" : "flightnum",
        "type" : [ "null", "string" ],
        "default" : null
    },
    {
        "name" : "origin",
        "type" : [ "null", "string" ],
        "default" : null
    },
    {
        "name" : "dest",
        "type" : [ "null", "string" ],
        "default" : null
    },
    {
        "name" : "depdelay",
        "type" : [ "null", "int" ],
        "default" : null
    },
    {
        "name" : "carrierdelay",
        "type" : [ "null", "int" ],
        "default" : null
    },
    {
        "name" : "weatherdelay",
        "type" : [ "null", "int" ],
        "default" : null
    }
]
}
')
STORED AS AVRO
LOCATION 's3://athena-examples-myregion/flight/avro/';
```

Run the `MSCK REPAIR TABLE` statement on the table to refresh partition metadata.

```
MSCK REPAIR TABLE flights_avro_example;
```

Query the top 10 departure cities by number of total departures.

```
SELECT origin, count(*) AS total_departures
FROM flights_avro_example
WHERE year >= '2000'
GROUP BY origin
ORDER BY total_departures DESC
LIMIT 10;
```

Note

The flight table data comes from [Flights](#) provided by US Department of Transportation, [Bureau of Transportation Statistics](#). Desaturated from original.

RegexSerDe for Processing Apache Web Server Logs

SerDe Name

RegexSerDe

Library Name

RegexSerDe

Examples

The following example creates a table from CloudFront logs using the RegExSerDe from the Athena Getting Started tutorial.

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace *myregion* in s3://athena-examples-*myregion*/path/to/data/ with the region identifier where you run Athena, for example, s3://athena-examples-us-east-1/path/to/data/.

CloudTrail SerDe

AWS CloudTrail is a service that records AWS API calls and events for AWS accounts. CloudTrail generates encrypted logs and stores them in Amazon S3. You can use Athena to query these logs directly from Amazon S3, specifying the LOCATION of logs.

To query CloudTrail logs in Athena, create table from the logs and use the CloudTrail SerDe to deserialize the logs data.

In addition to using the CloudTrail SerDe, instances exist where you need to use a different SerDe or to extract data from JSON. Certain fields in CloudTrail logs are STRING values that may have a variable data format, which depends on the service. As a result, the CloudTrail SerDe is unable to predictably deserialize them. To query the following fields, identify the data pattern and then use a different SerDe, such as the [OpenX JSON SerDe \(p. 286\)](#). Alternatively, to get data out of these fields, use `JSON_EXTRACT` functions. For more information, see [Extracting Data From JSON \(p. 153\)](#).

- `requestParameters`
 - `responseElements`
 - `additionalEventData`
 - `serviceEventDetails`

SerDe Name

CloudTrail SerDe

Library Name

com.amazon.emr.hive.serde.CloudTrailSerde

Examples

The following example uses the CloudTrail SerDe on a fictional set of logs to create a table based on them.

In this example, the fields `requestParameters`, `responseElements`, and `additionalEventData` are included as part of `STRUCT` data type used in JSON. To get data out of these fields, use `JSON_EXTRACT` functions. For more information, see [Extracting Data From JSON \(p. 153\)](#).

```
CREATE EXTERNAL TABLE cloudtrail_logs (
    eventversion STRING,
    userIdentity STRUCT<
        type:STRING,
        principalId:STRING,
        arn:STRING,
        accountId:STRING,
        invokedBy:STRING,
        accessKeyId:STRING,
        userName:STRING,
    sessioncontext:STRUCT<
        attributes:STRUCT<
            mfaAuthenticated:STRING,
            creationDate:STRING>,
    sessionIssuer:STRUCT<
        type:STRING,
        principalId:STRING,
        arn:STRING,
        accountId:STRING,
        userName:STRING>>>,
    eventTime STRING,
    eventSource STRING,
    eventName STRING,
    awsRegion STRING,
    sourceIpAddress STRING,
    userAgent STRING,
    errorCode STRING,
    errorMessage STRING,
    requestParameters STRING,
    responseElements STRING,
    additionalEventData STRING,
    requestId STRING,
    eventId STRING,
    resources ARRAY<STRUCT<
        ARN:STRING,
        accountId:STRING,
        type:STRING>>,
    eventType STRING,
    apiVersion STRING,
    readOnly STRING,
    recipientAccountId STRING,
    serviceEventDetails STRING,
    sharedEventId STRING,
    vpcEndpointId STRING
)
ROW FORMAT SERDE 'com.amazon.emr.hive.serde.CloudTrailSerde'
STORED AS INPUTFORMAT 'com.amazon.emr.cloudtrail.CloudTrailInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://cloudtrail_bucket_name/AWSLogs/Account_ID/';
```

The following query returns the logins that occurred over a 24-hour period:

```
SELECT
    userIdentity.username,
```

```
sourceipaddress,  
eventtime,  
additionaleventdata  
FROM default.cloudtrail_logs  
WHERE eventname = 'ConsoleLogin'  
    AND eventtime >= '2017-02-17T00:00:00Z'  
    AND eventtime < '2017-02-18T00:00:00Z';
```

For more information, see [Querying AWS CloudTrail Logs \(p. 178\)](#).

OpenCSVSerDe for Processing CSV

When you create a table from CSV data in Athena, determine what types of values it contains:

- If data contains values enclosed in double quotes ("), you can use the [OpenCSV SerDe](#) to deserialize the values in Athena. In the following sections, note the behavior of this SerDe with STRING data types.
- If data does not contain values enclosed in double quotes ("), you can omit specifying any SerDe. In this case, Athena uses the default [LazySimpleSerDe](#). For information, see [LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files \(p. 288\)](#).

CSV SerDe (OpenCSVSerDe)

The [OpenCSV SerDe](#) behaves as follows:

- Converts all column type values to STRING.
- To recognize data types other than STRING, relies on the Presto parser and converts the values from STRING into those data types if it can recognize them.
- Uses double quotes ("") as the default quote character, and allows you to specify separator, quote, and escape characters, such as:

```
WITH SERDEPROPERTIES ("separatorChar" = ",", "quoteChar" = "^", "escapeChar" = "\\")
```

- Cannot escape \t or \n directly. To escape them, use "escapeChar" = "\\\". See the example in this topic.
- Does not support embedded line breaks in CSV files.
- Does not support empty fields in columns defined as a numeric data type.

Note

When you use Athena with OpenCSVSerDe, the SerDe converts all column types to STRING. Next, the parser in Athena parses the values from STRING into actual types based on what it finds. For example, it parses the values into BOOLEAN, BIGINT, INT, and DOUBLE data types when it can discern them. If the values are in TIMESTAMP in the UNIX format, Athena parses them as TIMESTAMP. If the values are in TIMESTAMP in Hive format, Athena parses them as INT. DATE type values are also parsed as INT.

To further convert columns to the desired type in a table, you can [create a view \(p. 113\)](#) over the table and use CAST to convert to the desired type.

For data types *other* than STRING, when the parser in Athena can recognize them, this SerDe behaves as follows:

- Recognizes BOOLEAN, BIGINT, INT, and DOUBLE data types and parses them without changes.
- Recognizes the TIMESTAMP type if it is specified in the UNIX format, such as yyyy-mm-dd hh:mm:ss[.f...], as the type LONG.

- Does not support **TIMESTAMP** in the JDBC-compliant `java.sql.Timestamp` format, such as "YYYY-MM-DD HH:MM:SS.fffffffff" (9 decimal place precision). If you are processing CSV data from Hive, use the UNIX format for **TIMESTAMP**.
- Recognizes the **DATE** type if it is specified in the UNIX format, such as YYYY-MM-DD, as the type **LONG**.
- Does not support **DATE** in another format. If you are processing CSV data from Hive, use the UNIX format for **DATE**.

Example Example: Escaping \t or \n

Consider the following test data:

```
" \\\t\\\t\\\n 123 \\\t\\\t\\\n ",abc
" 456 ",xyz
```

The following statement creates a table in Athena, specifying that "escapeChar" = "\\".

```
CREATE EXTERNAL TABLE test1 (
f1 string,
s2 string)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.OpenCSVSerde'
WITH SERDEPROPERTIES ("separatorChar" = ",", "escapeChar" = "\\")
LOCATION 's3://user-test-region/dataset/test1/'
```

Next, run the following query:

```
select * from test1;
```

It returns this result, correctly escaping \t or \n:

```
f1          s2
\t\t\\n 123 \t\t\\n      abc
456          xyz
```

SerDe Name

[CSV SerDe](#)

Library Name

To use this SerDe, specify its fully qualified class name in `ROW FORMAT`. Also specify the delimiters inside `SERDEPROPERTIES`, as follows:

```
...
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.OpenCSVSerde'
WITH SERDEPROPERTIES (
  "separatorChar" = ",",
  "quoteChar"     = "`",
  "escapeChar"    = "\\"
)
```

Example

This example presumes data in CSV saved in `s3://mybucket/mycsv/` with the following contents:

```
"a1","a2","a3","a4"  
"1","2","abc","def"  
"a","a1","abc3","ab4"
```

Use a `CREATE TABLE` statement to create an Athena table based on the data, and reference the `OpenCSVSerDe` class in `ROW FORMAT`, also specifying SerDe properties for character separator, quote character, and escape character, as follows:

```
CREATE EXTERNAL TABLE myopencsvtable (  
    col1 string,  
    col2 string,  
    col3 string,  
    col4 string  
)  
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.OpenCSVSerde'  
WITH SERDEPROPERTIES (  
    'separatorChar' = ',',  
    'quoteChar' = '\"',  
    'escapeChar' = '\\\'  
)  
STORED AS TEXTFILE  
LOCATION 's3://location/of/csv/';
```

Query all values in the table:

```
SELECT * FROM myopencsvtable;
```

The query returns the following values:

col1	col2	col3	col4
a1	a2	a3	a4
1	2	abc	def
a	a1	abc3	ab4

Note

The flight table data comes from [Flights](#) provided by US Department of Transportation, [Bureau of Transportation Statistics](#). Desaturated from original.

Grok SerDe

The Logstash Grok SerDe is a library with a set of specialized patterns for deserialization of unstructured text data, usually logs. Each Grok pattern is a named regular expression. You can identify and re-use these deserialization patterns as needed. This makes it easier to use Grok compared with using regular expressions. Grok provides a set of [pre-defined patterns](#). You can also create custom patterns.

To specify the Grok SerDe when creating a table in Athena, use the `ROW FORMAT SERDE 'com.amazonaws.glue.serde.GrokSerDe'` clause, followed by the `WITH SERDEPROPERTIES` clause that specifies the patterns to match in your data, where:

- The `input.format` expression defines the patterns to match in the data. It is required.
- The `input.grokCustomPatterns` expression defines a named custom pattern, which you can subsequently use within the `input.format` expression. It is optional. To include multiple pattern entries into the `input.grokCustomPatterns` expression, use the newline escape character (`\n`) to separate them, as follows: `'input.grokCustomPatterns='INSIDE_QS ([^"]*)\nINSIDE_BRACKETS ([^\]]*)'`.

- The `STORED AS INPUTFORMAT` and `OUTPUTFORMAT` clauses are required.
- The `LOCATION` clause specifies an Amazon S3 bucket, which can contain multiple data objects. All data objects in the bucket are deserialized to create the table.

Examples

These examples rely on the list of predefined Grok patterns. See [pre-defined patterns](#).

Example 1

This example uses source data from Postfix maillog entries saved in `s3://mybucket/groksample/`.

```
Feb  9 07:15:00 m4eastmail postfix/smtpd[19305]: B88C4120838: connect from
unknown[192.168.55.4]
Feb  9 07:15:00 m4eastmail postfix/smtpd[20444]: B58C4330038: client=unknown[192.168.55.4]
Feb  9 07:15:03 m4eastmail postfix/cleanup[22835]: BDC22A77854: message-
id=<31221401257553.5004389LCBF@m4eastmail.example.com>
```

The following statement creates a table in Athena called `mygroktable` from the source data, using a custom pattern and the predefined patterns that you specify:

```
CREATE EXTERNAL TABLE `mygroktable`(
    syslogbase string,
    queue_id string,
    syslog_message string
)
ROW FORMAT SERDE
    'com.amazonaws.glue.serde.GrokSerDe'
WITH SERDEPROPERTIES (
    'input.grokCustomPatterns' = 'POSTFIX_QUEUEID [0-9A-F]{7,12}',
    'input.format'=' %{SYSLOGBASE} %{POSTFIX_QUEUEID:queue_id}: %{GREEDYDATA:syslog_message}'
)
STORED AS INPUTFORMAT
    'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT
    'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION
    's3://mybucket/groksample/';
```

Start with a simple pattern, such as `%{NOTSPACE:column}`, to get the columns mapped first and then specialize the columns if needed.

Example 2

In the following example, you create a query for Log4j logs. The example logs have the entries in this format:

```
2017-09-12 12:10:34,972 INFO - processType=AZ, processId=ABCDEFG614B6F5E49, status=RUN,
threadId=123:amqListenerContainerPool23[P:AJ|ABCDE9614B6F5E49|||
2017-09-12T12:10:11.172-0700],
executionTime=7290, tenantId=12456, userId=123123f8535f8d76015374e7a1d87c3c,
shard=testapp1,
jobId=12312345e5e7df0015e777fb2e03f3c, messageType=REAL_TIME_SYNC,
action=receive, hostname=1.abc.def.com
```

To query this logs data:

- Add the Grok pattern to the `input.format` for each column. For example, for `timestamp`, add `%{TIMESTAMP_ISO8601:timestamp}`. For `loglevel`, add `%{LOGLEVEL:loglevel}`.
- Make sure the pattern in `input.format` matches the format of the log exactly, by mapping the dashes (-) and the commas that separate the entries in the log format.

```
CREATE EXTERNAL TABLE bltest (
    timestamp STRING,
    loglevel STRING,
    processstype STRING,
    processid STRING,
    status STRING,
    threadid STRING,
    executiontime INT,
    tenantid INT,
    userid STRING,
    shard STRING,
    jobid STRING,
    messagetype STRING,
    action STRING,
    hostname STRING
)
ROW FORMAT SERDE 'com.amazonaws.glue.serde.GrokSerDe'
WITH SERDEPROPERTIES (
    "input.grokCustomPatterns" = 'C_ACTION receive|send',
    "input.format" = "%{TIMESTAMP_ISO8601:timestamp} %{LOGLEVEL:loglevel} - processType=%{NOTSPACE:processstype}, processId=%{NOTSPACE:processid}, status=%{NOTSPACE:status}, threadId=%{NOTSPACE:threadid}, executionTime=%{POSINT:executiontime}, tenantId=%{POSINT:tenantid}, userId=%{NOTSPACE:userid}, shard=%{NOTSPACE:shard}, jobId=%{NOTSPACE:jobid}, messageType=%{NOTSPACE:messagetype}, action=%{C_ACTION:action}, hostname=%{HOST:hostname}""
) STORED AS INPUTFORMAT 'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://mybucket/samples/';
```

Example 3

The following example of querying Amazon S3 logs shows the '`input.grokCustomPatterns`' expression that contains two pattern entries, separated by the newline escape character (`\n`), as shown in this snippet from the example query: '`input.grokCustomPatterns='INSIDE_QS ([^"]*)\nINSIDE_BRACKETS ([^\n])*)'`'.

```
CREATE EXTERNAL TABLE `s3_access_auto_raw_02`(
    `bucket_owner` string COMMENT 'from deserializer',
    `bucket` string COMMENT 'from deserializer',
    `time` string COMMENT 'from deserializer',
    `remote_ip` string COMMENT 'from deserializer',
    `requester` string COMMENT 'from deserializer',
    `request_id` string COMMENT 'from deserializer',
    `operation` string COMMENT 'from deserializer',
    `key` string COMMENT 'from deserializer',
    `request_uri` string COMMENT 'from deserializer',
    `http_status` string COMMENT 'from deserializer',
    `error_code` string COMMENT 'from deserializer',
    `bytes_sent` string COMMENT 'from deserializer',
    `object_size` string COMMENT 'from deserializer',
    `total_time` string COMMENT 'from deserializer',
    `turnaround_time` string COMMENT 'from deserializer',
    `referrer` string COMMENT 'from deserializer',
    `user_agent` string COMMENT 'from deserializer',
    `version_id` string COMMENT 'from deserializer')
ROW FORMAT SERDE
```

```
'com.amazonaws.glue.serde.GrokSerDe'
WITH SERDEPROPERTIES (
    'input.format'=''{NOTSPACE:bucket_owner} {NOTSPACE:bucket} \\[{{INSIDE_BRACKETS:time}}\\]
{NOTSPACE:remote_ip} {NOTSPACE:requester} {NOTSPACE:request_id} {NOTSPACE:operation}
{NOTSPACE:key} \"?{INSIDE_QS:request_uri}\"? {NOTSPACE:http_status}
{NOTSPACE:error_code} {NOTSPACE:bytes_sent} {NOTSPACE:object_size}
{NOTSPACE:total_time} {NOTSPACE:turnaround_time} \"?{INSIDE_QS:referrer}\"? \"?
{INSIDE_QS:user_agent}\"? {NOTSPACE:version_id}',
    'input.grokCustomPatterns'='INSIDE_QS ([^"]*)\nINSIDE_BRACKETS ([^\"]*)')
STORED AS INPUTFORMAT
    'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT
    'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION
's3://bucket-for-service-logs/s3_access/'
```

JSON SerDe Libraries

In Athena, you can use two SerDe libraries for processing data in JSON:

- The native [Hive JSON SerDe \(p. 285\)](#)
- The [OpenX JSON SerDe \(p. 286\)](#)

SerDe Names

[Hive-JsonSerDe](#)

[Openx-JsonSerDe](#)

Library Names

Use one of the following:

[org.apache.hive.hcatalog.data.JsonSerDe](#)

[org.openx.data.jsonserde.JsonSerDe](#)

Hive JSON SerDe

The Hive JSON SerDe is used to process JSON data, most commonly events. These events are represented as blocks of JSON-encoded text separated by a new line.

You can also use the Hive JSON SerDe to parse more complex JSON-encoded data with nested structures. However, this requires having a matching DDL representing the complex data types. See [Example: Deserializing Nested JSON \(p. 287\)](#).

With this SerDe, duplicate keys are not allowed in `map` (or `struct`) key names.

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace `myregion` in `s3://athena-examples-myregion/path/to/data/` with the region identifier where you run Athena, for example, `s3://athena-examples-us-east-1/path/to/data/`.

The following DDL statement uses the Hive JSON SerDe:

```

CREATE EXTERNAL TABLE impressions (
    requestbegintime string,
    adid string,
    impressionid string,
    referrer string,
    useragent string,
    usercookie string,
    ip string,
    number string,
    processid string,
    browsercookie string,
    requestendtime string,
    timers struct
        (
            modellookup:string,
            requesttime:string
        ),
    threadid string,
    hostname string,
    sessionid string
)
PARTITIONED BY (dt string)
ROW FORMAT serde 'org.apache.hive.hcatalog.data.JsonSerDe'
with serdeproperties ('paths'='requestbegintime, adid, impressionid, referrer, useragent,
    usercookie, ip' )
LOCATION 's3://myregion.elasticmapreduce/samples/hive-ads/tables/impressions';

```

OpenX JSON SerDe

The OpenX SerDe is used by Athena for deserializing data, which means converting it from the JSON format in preparation for serializing it to the Parquet or ORC format. This is one of two deserializers that you can choose, depending on which one offers the functionality that you need. The other option is the Hive JsonSerDe.

This SerDe has a few useful properties that you can specify when creating tables in Athena, to help address inconsistencies in the data:

ignore.malformed.json

Optional. When set to `TRUE`, lets you skip malformed JSON syntax. The default is `FALSE`.

dots.in.keys

Optional. The default is `FALSE`. When set to `TRUE`, allows the SerDe to replace the dots in key names with underscores. For example, if the JSON dataset contains a key with the name "a.b", you can use this property to define the column name to be "a_b" in Athena. By default (without this SerDe), Athena does not allow dots in column names.

case.insensitive

Optional. By default, Athena requires that all keys in your JSON dataset use lowercase. The default is `TRUE`. When set to `TRUE`, the SerDe converts all uppercase columns to lowercase. Using `WITH SERDE PROPERTIES ("case.insensitive"= FALSE;)` allows you to use case-sensitive key names in your data.

ColumnToJsonKeyMappings

Optional. Maps column names to JSON keys that aren't identical to the column names. This is useful when the JSON data contains keys that are [keywords \(p. 33\)](#). For example, if you have a JSON key named `timestamp`, set this parameter to `{"ts": "timestamp"}` to map this key to a column named `ts`. This parameter takes values of type string. It uses the following key pattern: `^\$+\$` and the following value pattern: `^(?!\\s*\$).+`

With this SerDe, duplicate keys are not allowed in map (or struct) key names.

The following DDL statement uses the OpenX JSON SerDe:

```
CREATE EXTERNAL TABLE impressions (
    requestbegintime string,
    adid string,
    impressionId string,
    referrer string,
    useragent string,
    usercookie string,
    ip string,
    number string,
    processid string,
    browsercokie string,
    requestendtime string,
    timers struct<
        modellookup:string,
        requesttime:string>,
    threadid string,
    hostname string,
    sessionid string
) PARTITIONED BY (dt string)
ROW FORMAT serde 'org.openx.data.jsonserde.JsonSerDe'
with serdeproperties ( 'paths'='requestbegintime, adid, impressionid, referrer, useragent,
usercookie, ip' )
LOCATION 's3://myregion.elasticmapreduce/samples/hive-ads/tables/impressions';
```

Example: Deserializing Nested JSON

JSON data can be challenging to deserialize when creating a table in Athena.

When dealing with complex nested JSON, there are common issues you may encounter. For more information about these issues and troubleshooting practices, see the AWS Knowledge Center Article [I receive errors when I try to read JSON data in Amazon Athena](#).

For more information about common scenarios and query tips, see [Create Tables in Amazon Athena from Nested JSON and Mappings Using JSONSerDe](#).

The following example demonstrates a simple approach to creating an Athena table from data with nested structures in JSON. To parse JSON-encoded data in Athena, each JSON document must be on its own line, separated by a new line.

This example presumes a JSON-encoded data with the following structure:

```
{
"DocId": "AWS",
"User": {
    "Id": 1234,
    "Username": "bob1234",
    "Name": "Bob",
"ShippingAddress": {
"Address1": "123 Main St.",
"Address2": null,
"City": "Seattle",
"State": "WA"
},
"Orders": [
{
    "ItemId": 6789,
    "OrderDate": "11/11/2017"
}
]
```

```

    },
    {
      "ItemId": 4352,
      "OrderDate": "12/12/2017"
    }
  ]
}
}

```

The following `CREATE TABLE` command uses the [Openx-JsonSerDe](#) with collection data types like `struct` and `array` to establish groups of objects. Each JSON document is listed on its own line, separated by a new line. To avoid errors, the data being queried does not include duplicate keys in `struct` and `map` key names. Duplicate keys are not allowed in `map` (or `struct`) key names.

```

CREATE external TABLE complex_json (
  docid string,
  `user` struct<
    id:INT,
    username:string,
    name:string,
    shippingaddress:struct<
      address1:string,
      address2:string,
      city:string,
      state:string
    >,
    orders:array<
      struct<
        itemid:INT,
        orderdate:string
      >
    >
  >
)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
LOCATION 's3://mybucket/myjsondata/';

```

LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files

Specifying this SerDe is optional. This is the SerDe for data in CSV, TSV, and custom-delimited formats that Athena uses by default. This SerDe is used if you don't specify any SerDe and only specify `ROW FORMAT DELIMITED`. Use this SerDe if your data does not have values enclosed in quotes.

Library Name

The Class library name for the LazySimpleSerDe is `org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe`. For more information, see [LazySimpleSerDe](#).

Examples

The following examples show how to create tables in Athena from CSV and TSV, using the `LazySimpleSerDe`. To deserialize custom-delimited file using this SerDe, specify the delimiters similar to the following examples.

- [CSV Example \(p. 289\)](#)

- [TSV Example \(p. 291\)](#)

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace *myregion* in `s3://athena-examples-myregion/path/to/data/` with the region identifier where you run Athena, for example, `s3://athena-examples-us-east-1/path/to/data/`.

Note

The flight table data comes from [Flights](#) provided by US Department of Transportation, [Bureau of Transportation Statistics](#). Desaturated from original.

CSV Example

Use the `CREATE TABLE` statement to create an Athena table from the underlying data in CSV stored in Amazon S3.

```
CREATE EXTERNAL TABLE flight_delays_csv (
    yr INT,
    quarter INT,
    month INT,
    dayofmonth INT,
    dayofweek INT,
    flightdate STRING,
    uniquecarrier STRING,
    airlineid INT,
    carrier STRING,
    tailnum STRING,
    flightnum STRING,
    originairportid INT,
    originairportseqid INT,
    origincitymarketid INT,
    origin STRING,
    origincityname STRING,
    originstate STRING,
    originstatefips STRING,
    originstatename STRING,
    originwac INT,
    destairportid INT,
    destairportseqid INT,
    destcitymarketid INT,
    dest STRING,
    destcityname STRING,
    deststate STRING,
    deststatefips STRING,
    deststatename STRING,
    destwac INT,
    crsdeptime STRING,
    deptime STRING,
    depdelay INT,
    depdelayminutes INT,
    depdel15 INT,
    departuredelaygroups INT,
    deptimeblk STRING,
    taxiout INT,
    wheelsoff STRING,
    wheelson STRING,
    taxiin INT,
    crsarrrtime INT,
    arrttime STRING,
    arrdelay INT,
```

```
arrdelayminutes INT,  
arrdel15 INT,  
arrivaldelaygroups INT,  
arrtimeblk STRING,  
cancelled INT,  
cancellationcode STRING,  
diverted INT,  
crselapsedtime INT,  
actualelapsedtime INT,  
airtime INT,  
flights INT,  
distance INT,  
distancegroup INT,  
carrierdelay INT,  
weatherdelay INT,  
nasdelay INT,  
securitydelay INT,  
lateaircraftdelay INT,  
firstdeptime STRING,  
totaladdgtime INT,  
longestaddgtime INT,  
divairportlandings INT,  
divreacheddest INT,  
divactualelapsedtime INT,  
divarrendelay INT,  
divdistance INT,  
div1airport STRING,  
div1airportid INT,  
div1airportseqid INT,  
div1wheelson STRING,  
div1totalgtime INT,  
div1longestgtime INT,  
div1wheelsoff STRING,  
div1tailnum STRING,  
div2airport STRING,  
div2airportid INT,  
div2airportseqid INT,  
div2wheelson STRING,  
div2totalgtime INT,  
div2longestgtime INT,  
div2wheelsoff STRING,  
div2tailnum STRING,  
div3airport STRING,  
div3airportid INT,  
div3airportseqid INT,  
div3wheelson STRING,  
div3totalgtime INT,  
div3longestgtime INT,  
div3wheelsoff STRING,  
div3tailnum STRING,  
div4airport STRING,  
div4airportid INT,  
div4airportseqid INT,  
div4wheelson STRING,  
div4totalgtime INT,  
div4longestgtime INT,  
div4wheelsoff STRING,  
div4tailnum STRING,  
div5airport STRING,  
div5airportid INT,  
div5airportseqid INT,  
div5wheelson STRING,  
div5totalgtime INT,  
div5longestgtime INT,  
div5wheelsoff STRING,  
div5tailnum STRING
```

```
)  
PARTITIONED BY (year STRING)  
ROW FORMAT DELIMITED  
    FIELDS TERMINATED BY ','  
    ESCAPED BY '\\\'  
    LINES TERMINATED BY '\\n'  
LOCATION 's3://athena-examples-myregion/flight/csv/';
```

Run `MSCK REPAIR TABLE` to refresh partition metadata each time a new partition is added to this table:

```
MSCK REPAIR TABLE flight_delays_csv;
```

Query the top 10 routes delayed by more than 1 hour:

```
SELECT origin, dest, count(*) as delays  
FROM flight_delays_csv  
WHERE depdelayminutes > 60  
GROUP BY origin, dest  
ORDER BY 3 DESC  
LIMIT 10;
```

TSV Example

This example presumes source data in TSV saved in `s3://mybucket/mytsv/`.

Use a `CREATE TABLE` statement to create an Athena table from the TSV data stored in Amazon S3. Notice that this example does not reference any SerDe class in `ROW FORMAT` because it uses the `LazySimpleSerDe`, and it can be omitted. The example specifies SerDe properties for character and line separators, and an escape character:

```
CREATE EXTERNAL TABLE flight_delays_tsv (  
    yr INT,  
    quarter INT,  
    month INT,  
    dayofmonth INT,  
    dayofweek INT,  
    flightdate STRING,  
    uniquecarrier STRING,  
    airlineid INT,  
    carrier STRING,  
    tailnum STRING,  
    flightnum STRING,  
    originairportid INT,  
    originairportseqid INT,  
    origincitymarketid INT,  
    origin STRING,  
    origincityname STRING,  
    originstate STRING,  
    originstatefips STRING,  
    originstatename STRING,  
    originwac INT,  
    destairportid INT,  
    destairportseqid INT,  
    destcitymarketid INT,  
    dest STRING,  
    destcityname STRING,  
    deststate STRING,  
    deststatefips STRING,  
    deststatename STRING,  
    destwac INT,
```

```
crsdeptime STRING,  
deptime STRING,  
depdelay INT,  
depdelayminutes INT,  
depdel15 INT,  
departuredelaygroups INT,  
deptimeblk STRING,  
taxiout INT,  
wheelsoff STRING,  
wheelson STRING,  
taxiin INT,  
crsarrrtime INT,  
arrrtime STRING,  
arrdelay INT,  
arrdelayminutes INT,  
arrdel15 INT,  
arrivaldelaygroups INT,  
arrtimeblk STRING,  
cancelled INT,  
cancellationcode STRING,  
diverted INT,  
crselapsedtime INT,  
actualelapsedtime INT,  
airtime INT,  
flights INT,  
distance INT,  
distancegroup INT,  
carrierdelay INT,  
weatherdelay INT,  
nasdelay INT,  
securitydelay INT,  
lateaircraftdelay INT,  
firstdeptime STRING,  
totaladdgtime INT,  
longestaddgtime INT,  
divairportlandings INT,  
divreacheddest INT,  
divactualelapsedtime INT,  
divarrdelay INT,  
divdistance INT,  
div1airport STRING,  
div1airportid INT,  
div1airportseqid INT,  
div1wheelson STRING,  
div1totalgtime INT,  
div1longestgtime INT,  
div1wheelsoff STRING,  
div1tailnum STRING,  
div2airport STRING,  
div2airportid INT,  
div2airportseqid INT,  
div2wheelson STRING,  
div2totalgtime INT,  
div2longestgtime INT,  
div2wheelsoff STRING,  
div2tailnum STRING,  
div3airport STRING,  
div3airportid INT,  
div3airportseqid INT,  
div3wheelson STRING,  
div3totalgtime INT,  
div3longestgtime INT,  
div3wheelsoff STRING,  
div3tailnum STRING,  
div4airport STRING,  
div4airportid INT,
```

```
div4airportseqid INT,  
div4wheelson STRING,  
div4totalgtime INT,  
div4longestgtime INT,  
div4wheelsoff STRING,  
div4tailnum STRING,  
div5airport STRING,  
div5airportid INT,  
div5airportseqid INT,  
div5wheelson STRING,  
div5totalgtime INT,  
div5longestgtime INT,  
div5wheelsoff STRING,  
div5tailnum STRING  
)  
PARTITIONED BY (year STRING)  
ROW FORMAT DELIMITED  
    FIELDS TERMINATED BY '\t'  
    ESCAPED BY '\\\'  
    LINES TERMINATED BY '\n'  
LOCATION 's3://athena-examples-myregion/flight/tsv/';
```

Run `MSCK REPAIR TABLE` to refresh partition metadata each time a new partition is added to this table:

```
MSCK REPAIR TABLE flight_delays_tsv;
```

Query the top 10 routes delayed by more than 1 hour:

```
SELECT origin, dest, count(*) as delays  
FROM flight_delays_tsv  
WHERE depdelayminutes > 60  
GROUP BY origin, dest  
ORDER BY 3 DESC  
LIMIT 10;
```

Note

The flight table data comes from [Flights](#) provided by US Department of Transportation, [Bureau of Transportation Statistics](#). Desaturated from original.

ORC SerDe

SerDe Name

[OrcSerDe](#)

Library Name

This is the SerDe class for data in the ORC format. It passes the object from ORC to the reader and from ORC to the writer: [OrcSerDe](#)

Examples

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace `myregion` in `s3://athena-examples-myregion/`

path/to/data/ with the region identifier where you run Athena, for example, s3://athena-examples-us-east-1/path/to/data/.

The following example creates a table for the flight delays data in ORC. The table includes partitions:

```
DROP TABLE flight_delays_orc;
CREATE EXTERNAL TABLE flight_delays_orc (
    yr INT,
    quarter INT,
    month INT,
    dayofmonth INT,
    dayofweek INT,
    flightdate STRING,
    uniquecarrier STRING,
    airlineid INT,
    carrier STRING,
    tailnum STRING,
    flightnum STRING,
    originairportid INT,
    originairportseqid INT,
    origincitymarketid INT,
    origin STRING,
    origincityname STRING,
    originstate STRING,
    originstatefips STRING,
    originstatename STRING,
    originwac INT,
    destairportid INT,
    destairportseqid INT,
    destcitymarketid INT,
    dest STRING,
    destcityname STRING,
    deststate STRING,
    deststatefips STRING,
    deststatename STRING,
    destwac INT,
    crsdeptime STRING,
    deptime STRING,
    depdelay INT,
    depdelayminutes INT,
    depdel15 INT,
    departuredelaygroups INT,
    deptimeblk STRING,
    taxiout INT,
    wheelsoff STRING,
    wheelson STRING,
    taxiin INT,
    crsarrrtime INT,
    arrtime STRING,
    arrdelay INT,
    arrdelayminutes INT,
    arrdel15 INT,
    arrivaldelaygroups INT,
    arrtimeblk STRING,
    cancelled INT,
    cancellationcode STRING,
    diverted INT,
    crselapsedtime INT,
    actualelapsedtime INT,
    airtime INT,
    flights INT,
    distance INT,
    distancegroup INT,
    carrierdelay INT,
    weatherdelay INT,
```

```
nasdelay INT,
securitydelay INT,
lateaircraftdelay INT,
firstdeptime STRING,
totaladdgtime INT,
longestaddgtime INT,
divairportlandings INT,
divreacheddest INT,
divactualelapsedtime INT,
divarrdelay INT,
divdistance INT,
div1airport STRING,
div1airportid INT,
div1airportseqid INT,
div1wheelson STRING,
div1totalgtime INT,
div1longestgtime INT,
div1wheelsoff STRING,
div1tailnum STRING,
div2airport STRING,
div2airportid INT,
div2airportseqid INT,
div2wheelson STRING,
div2totalgtime INT,
div2longestgtime INT,
div2wheelsoff STRING,
div2tailnum STRING,
div3airport STRING,
div3airportid INT,
div3airportseqid INT,
div3wheelson STRING,
div3totalgtime INT,
div3longestgtime INT,
div3wheelsoff STRING,
div3tailnum STRING,
div4airport STRING,
div4airportid INT,
div4airportseqid INT,
div4wheelson STRING,
div4totalgtime INT,
div4longestgtime INT,
div4wheelsoff STRING,
div4tailnum STRING,
div5airport STRING,
div5airportid INT,
div5airportseqid INT,
div5wheelson STRING,
div5totalgtime INT,
div5longestgtime INT,
div5wheelsoff STRING,
div5tailnum STRING
)
PARTITIONED BY (year String)
STORED AS ORC
LOCATION 's3://athena-examples-myregion/flight/orc/'
tblproperties ("orc.compress"="ZLIB");
```

Run the `MSCK REPAIR TABLE` statement on the table to refresh partition metadata:

```
MSCK REPAIR TABLE flight_delays_orc;
```

Use this query to obtain the top 10 routes delayed by more than 1 hour:

```
SELECT origin, dest, count(*) as delays
```

```
FROM flight_delays_orc
WHERE depdelayminutes > 60
GROUP BY origin, dest
ORDER BY 3 DESC
LIMIT 10;
```

Parquet SerDe

SerDe Name

ParquetHiveSerDe is used for data stored in [Parquet Format](#).

Library Name

Athena uses this class when it needs to deserialize data stored in Parquet:
[org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe](#).

Example: Querying a File Stored in Parquet

Note

You can query data in regions other than the region where you run Athena. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. To reduce data transfer charges, replace *myregion* in `s3://athena-examples-myregion/path/to/data/` with the region identifier where you run Athena, for example, `s3://athena-examples-us-east-1/path/to/data/`.

Use the following `CREATE TABLE` statement to create an Athena table from the underlying data in CSV stored in Amazon S3 in Parquet:

```
CREATE EXTERNAL TABLE flight_delays_pq (
    yr INT,
    quarter INT,
    month INT,
    dayofmonth INT,
    dayofweek INT,
    flightdate STRING,
    uniquecarrier STRING,
    airlineid INT,
    carrier STRING,
    tailnum STRING,
    flightnum STRING,
    originairportid INT,
    originairportseqid INT,
    origincitymarketid INT,
    origin STRING,
    origincityname STRING,
    originstate STRING,
    originstatefips STRING,
    originstatename STRING,
    originwac INT,
    destairportid INT,
    destairportseqid INT,
    destcitymarketid INT,
    dest STRING,
    destcityname STRING,
    deststate STRING,
    deststatefips STRING,
    deststatename STRING,
    destwac INT,
    crsdeptime STRING,
```

```
deptime STRING,  
depdelay INT,  
depdelayminutes INT,  
depdel15 INT,  
departuredelaygroups INT,  
deptimeblk STRING,  
taxiout INT,  
wheelsoff STRING,  
wheelson STRING,  
taxiin INT,  
crsarrtime INT,  
arrrtime STRING,  
arrdelay INT,  
arrdelayminutes INT,  
arrdel15 INT,  
arrivaldelaygroups INT,  
arrtimeblk STRING,  
cancelled INT,  
cancellationcode STRING,  
diverted INT,  
crselapsedtime INT,  
actualelapsedtime INT,  
airtime INT,  
flights INT,  
distance INT,  
distancegroup INT,  
carrierdelay INT,  
weatherdelay INT,  
nasdelay INT,  
securitydelay INT,  
lateaircraftdelay INT,  
firstdeptime STRING,  
totaladdgtime INT,  
longestaddgtime INT,  
divairportlandings INT,  
divreacheddest INT,  
divactualelapsedtime INT,  
divarrdelay INT,  
divdistance INT,  
div1airport STRING,  
div1airportid INT,  
div1airportseqid INT,  
div1wheelson STRING,  
div1totalgtime INT,  
div1longestgtime INT,  
div1wheelsoff STRING,  
div1tailnum STRING,  
div2airport STRING,  
div2airportid INT,  
div2airportseqid INT,  
div2wheelson STRING,  
div2totalgtime INT,  
div2longestgtime INT,  
div2wheelsoff STRING,  
div2tailnum STRING,  
div3airport STRING,  
div3airportid INT,  
div3airportseqid INT,  
div3wheelson STRING,  
div3totalgtime INT,  
div3longestgtime INT,  
div3wheelsoff STRING,  
div3tailnum STRING,  
div4airport STRING,  
div4airportid INT,  
div4airportseqid INT,
```

```
    div4wheelson STRING,
    div4totalgtime INT,
    div4longestgtime INT,
    div4wheelsoff STRING,
    div4tailnum STRING,
    div5airport STRING,
    div5airportid INT,
    div5airportseqid INT,
    div5wheelson STRING,
    div5totalgtime INT,
    div5longestgtime INT,
    div5wheelsoff STRING,
    div5tailnum STRING
)
PARTITIONED BY (year STRING)
STORED AS PARQUET
LOCATION 's3://athena-examples-myregion/flight/parquet/'
tblproperties ("parquet.compress"="SNAPPY");
```

Run the `MSCK REPAIR TABLE` statement on the table to refresh partition metadata:

```
MSCK REPAIR TABLE flight_delays_pq;
```

Query the top 10 routes delayed by more than 1 hour:

```
SELECT origin, dest, count(*) as delays
FROM flight_delays_pq
WHERE depdelayminutes > 60
GROUP BY origin, dest
ORDER BY 3 DESC
LIMIT 10;
```

Note

The flight table data comes from [Flights](#) provided by US Department of Transportation, [Bureau of Transportation Statistics](#). Desaturated from original.

Compression Formats

Athena supports the following compression formats:

Note

The compression formats listed in this section are used for [CREATE TABLE \(p. 313\)](#) queries. For CTAS queries, Athena supports GZIP and SNAPPY (for data stored in Parquet and ORC). If you omit a format, GZIP is used by default. For more information, see [CREATE TABLE AS \(p. 316\)](#).

- SNAPPY. This is the default compression format for files in the Parquet data storage format.
- ZLIB. This is the default compression format for files in the ORC data storage format.
- LZO
- GZIP.

For data in CSV, TSV, and JSON, Athena determines the compression type from the file extension. If it is not present, the data is not decompressed. If your data is compressed, make sure the file name includes the compression extension, such as `gz`.

Use the GZIP compression in Athena for querying Amazon Kinesis Data Firehose logs. Athena and Amazon Kinesis Data Firehose each support different versions of SNAPPY, so GZIP is the only compatible format.

SQL Reference for Amazon Athena

Amazon Athena supports a subset of Data Definition Language (DDL) and Data Manipulation Language (DML) statements, functions, operators, and data types. With some exceptions, Athena DDL is based on [HiveQL DDL](#) and Athena DML is based on [Presto 0.172](#).

Topics

- [Data Types Supported by Amazon Athena \(p. 299\)](#)
- [DML Queries, Functions, and Operators \(p. 300\)](#)
- [DDL Statements \(p. 306\)](#)
- [Considerations and Limitations for SQL Queries in Amazon Athena \(p. 324\)](#)

Data Types Supported by Amazon Athena

When you run [CREATE TABLE \(p. 313\)](#), you specify column names and the data type that each column can contain. Athena supports the the data types listed below. For information about the data type mappings that the JDBC driver supports between Athena, JDBC, and Java, see [Data Types](#) in the *JDBC Driver Installation and Configuration Guide*. For information about the data type mappings that the ODBC driver supports between Athena and SQL, see [Data Types](#) in the *ODBC Driver Installation and Configuration Guide*.

Supported Data Types

- [BOOLEAN \(p. 299\)](#)
 - [Integer types \(p. 299\)](#)
 - [Floating-point types \(p. 299\)](#)
 - [Fixed precision types \(p. 300\)](#)
 - [String types \(p. 300\)](#)
 - [BINARY \(p. 300\)](#)
 - [Date and time types \(p. 300\)](#)
 - [Structural types \(p. 300\)](#)
-
- **BOOLEAN.** Values are `true` and `false`.
 - **Integer types**
 - **TINYINT.** A 8-bit signed `INTEGER` in two's complement format, with a minimum value of -2^7 and a maximum value of 2^7-1 .
 - **SMALLINT.** A 16-bit signed `INTEGER` in two's complement format, with a minimum value of -2^{15} and a maximum value of $2^{15}-1$.
 - **INT.** Athena combines two different implementations of the `INTEGER` data type. In Data Definition Language (DDL) queries, Athena uses the `INT` data type. In all other queries, Athena uses the `INTEGER` data type, where `INTEGER` is represented as a 32-bit signed value in two's complement format, with a minimum value of -2^{31} and a maximum value of $2^{31}-1$. In the JDBC driver, `INTEGER` is returned, to ensure compatibility with business analytics applications.
 - **BIGINT.** A 64-bit signed `INTEGER` in two's complement format, with a minimum value of -2^{63} and a maximum value of $2^{63}-1$.
 - **Floating-point types**
 - **DOUBLE**

- `FLOAT`
- Fixed precision type
 - `DECIMAL [(precision, scale)]`, where `precision` is the total number of digits, and `scale` (optional) is the number of digits in fractional part, the default is 0. For example, use these type definitions: `DECIMAL(11, 5)`, `DECIMAL(15)`.
- To specify decimal values as literals, such as when selecting rows with a specific decimal value in a query DDL expression, specify the `DECIMAL` type definition, and list the decimal value as a literal (in single quotes) in your query, as in this example: `decimal_value = DECIMAL '0.12'`.
- String types
 - `CHAR`. Fixed length character data, with a specified length between 1 and 255, such as `char(10)`. For more information, see [CHAR Hive Data Type](#).
 - `VARCHAR`. Variable length character data, with a specified length between 1 and 65535, such as `varchar(10)`. For more information, see [VARCHAR Hive Data Type](#).
- `BINARY` (for data in Parquet)
- Date and time types
 - `DATE`, in the UNIX format, such as `YYYY-MM-DD`.
 - `TIMESTAMP`. Instant in time and date in the UNiX format, such as `yyyy-mm-dd hh:mm:ss[.f...]`. For example, `TIMESTAMP '2008-09-15 03:04:05.324'`. This format uses the session time zone.
- Structural types
 - `ARRAY < data_type >`
 - `MAP < primitive_type, data_type >`
 - `STRUCT < col_name : data_type [COMMENT col_comment] [, ...] >`

DML Queries, Functions, and Operators

Athena DML query statements are based on [Presto 0.172](#). For more information about these functions, see [Presto 0.172 Functions and Operators](#) in the open source Presto documentation. We provide links to specific subsections of that documentation in the [Presto Functions \(p. 306\)](#) topic.

Athena does not support all of Presto's features, and there are some significant differences. For more information, see the reference topics for specific statements in this section and [Considerations and Limitations \(p. 324\)](#).

Topics

- [SELECT \(p. 300\)](#)
- [INSERT INTO \(p. 303\)](#)
- [Presto Functions in Amazon Athena \(p. 306\)](#)

SELECT

Retrieves rows from zero or more tables.

Synopsis

```
[ WITH with_query [, ...] ]
SELECT [ ALL | DISTINCT ] select_expression [, ...]
[ FROM from_item [, ...] ]
[ WHERE condition ]
[ GROUP BY [ ALL | DISTINCT ] grouping_element [, ...] ]
```

```
[ HAVING condition ]
[ UNION [ ALL | DISTINCT ] union_query ]
[ ORDER BY expression [ ASC | DESC ] [ NULLS FIRST | NULLS LAST ] [, ...] ]
[ LIMIT [ count | ALL ] ]
```

Parameters

[WITH with_query [,]]

You can use `WITH` to flatten nested queries, or to simplify subqueries.

Using the `WITH` clause to create recursive queries is not supported.

The `WITH` clause precedes the `SELECT` list in a query and defines one or more subqueries for use within the `SELECT` query.

Each subquery defines a temporary table, similar to a view definition, which you can reference in the `FROM` clause. The tables are used only when the query runs.

`with_query` syntax is:

```
subquery_table_name [ ( column_name [, ...] ) ] AS (subquery)
```

Where:

- `subquery_table_name` is a unique name for a temporary table that defines the results of the `WITH` clause subquery. Each `subquery` must have a table name that can be referenced in the `FROM` clause.
- `column_name [, ...]` is an optional list of output column names. The number of column names must be equal to or less than the number of columns defined by `subquery`.
- `subquery` is any query statement.

[ALL | DISTINCT] select_expr

`select_expr` determines the rows to be selected.

`ALL` is the default. Using `ALL` is treated the same as if it were omitted; all rows for all columns are selected and duplicates are kept.

Use `DISTINCT` to return only distinct values when a column contains duplicate values.

FROM from_item [, ...]

Indicates the input to the query, where `from_item` can be a view, a join construct, or a subquery as described below.

The `from_item` can be either:

- `table_name [[AS] alias [(column_alias [, ...])]]`

Where `table_name` is the name of the target table from which to select rows, `alias` is the name to give the output of the `SELECT` statement, and `column_alias` defines the columns for the `alias` specified.

-OR-

- `join_type from_item [ON join_condition | USING (join_column [, ...])]`

Where `join_type` is one of:

- [INNER] JOIN
- LEFT [OUTER] JOIN
- RIGHT [OUTER] JOIN

- FULL [OUTER] JOIN
- CROSS JOIN
- ON *join_condition* | USING (*join_column* [, ...]) Where using *join_condition* allows you to specify column names for join keys in multiple tables, and using *join_column* requires *join_column* to exist in both tables.

[WHERE condition]

Filters results according to the condition you specify.

[GROUP BY [ALL | DISTINCT] *grouping_expressions* [, ...]]

Divides the output of the SELECT statement into rows with matching values.

ALL and DISTINCT determine whether duplicate grouping sets each produce distinct output rows. If omitted, ALL is assumed.

grouping_expressions allow you to perform complex grouping operations.

The *grouping_expressions* element can be any function, such as SUM, AVG, or COUNT, performed on input columns, or be an ordinal number that selects an output column by position, starting at one.

GROUP BY expressions can group output by input column names that don't appear in the output of the SELECT statement.

All output expressions must be either aggregate functions or columns present in the GROUP BY clause.

You can use a single query to perform analysis that requires aggregating multiple column sets.

These complex grouping operations don't support expressions comprising input columns. Only column names or ordinals are allowed.

You can often use UNION ALL to achieve the same results as these GROUP BY operations, but queries that use GROUP BY have the advantage of reading the data one time, whereas UNION ALL reads the underlying data three times and may produce inconsistent results when the data source is subject to change.

GROUP BY CUBE generates all possible grouping sets for a given set of columns. GROUP BY ROLLUP generates all possible subtotals for a given set of columns.

[HAVING condition]

Used with aggregate functions and the GROUP BY clause. Controls which groups are selected, eliminating groups that don't satisfy condition. This filtering occurs after groups and aggregates are computed.

[UNION [ALL | DISTINCT] *union_query*]

Combines the results of more than one SELECT statement into a single query. ALL or DISTINCT control which rows are included in the final result set.

ALL causes all rows to be included, even if the rows are identical.

DISTINCT causes only unique rows to be included in the combined result set. DISTINCT is the default.

Multiple UNION clauses are processed left to right unless you use parentheses to explicitly define the order of processing.

[ORDER BY expression [ASC | DESC] [NULLS FIRST | NULLS LAST] [, ...]]

Sorts a result set by one or more output expression.

When the clause contains multiple expressions, the result set is sorted according to the first expression. Then the second expression is applied to rows that have matching values from the first expression, and so on.

Each expression may specify output columns from `SELECT` or an ordinal number for an output column by position, starting at one.

`ORDER BY` is evaluated as the last step after any `GROUP BY` or `HAVING` clause. `ASC` and `DESC` determine whether results are sorted in ascending or descending order.

The default null ordering is `NULLS LAST`, regardless of ascending or descending sort order.

LIMIT [count | ALL]

Restricts the number of rows in the result set to `count`. `LIMIT ALL` is the same as omitting the `LIMIT` clause. If the query has no `ORDER BY` clause, the results are arbitrary.

TABLESAMPLE BERNoulli | SYSTEM (percentage)

Optional operator to select rows from a table based on a sampling method.

`BERNoulli` selects each row to be in the table sample with a probability of `percentage`. All physical blocks of the table are scanned, and certain rows are skipped based on a comparison between the sample `percentage` and a random value calculated at runtime.

With `SYSTEM`, the table is divided into logical segments of data, and the table is sampled at this granularity.

Either all rows from a particular segment are selected, or the segment is skipped based on a comparison between the sample `percentage` and a random value calculated at runtime. `SYTSTEM` sampling is dependent on the connector. This method does not guarantee independent sampling probabilities.

[UNNEST (array_or_map) [WITH ORDINALITY]]

Expands an array or map into a relation. Arrays are expanded into a single column. Maps are expanded into two columns (`key, value`).

You can use `UNNEST` with multiple arguments, which are expanded into multiple columns with as many rows as the highest cardinality argument.

Other columns are padded with nulls.

The `WITH ORDINALITY` clause adds an ordinality column to the end.

`UNNEST` is usually used with a `JOIN` and can reference columns from relations on the left side of the `JOIN`.

Examples

```
SELECT * FROM table;
```

```
SELECT os, COUNT(*) count FROM cloudfront_logs WHERE date BETWEEN date '2014-07-05' AND date '2014-08-05' GROUP BY os;
```

For more examples, see [Querying Data in Amazon Athena Tables \(p. 76\)](#).

INSERT INTO

Inserts new rows into a destination table based on a `SELECT` query statement that runs on a source table, or based on a set of `VALUES` provided as part of the statement. When the source table is based

on underlying data in one format, such as CSV or JSON, and the destination table is based on another format, such as Parquet or ORC, you can use `INSERT INTO` queries to transform selected data into the destination table's format.

Considerations and Limitations

Consider the following when using `INSERT` queries with Athena.

Important

When running an `INSERT` query on a table with underlying data that is encrypted in Amazon S3, the output files that the `INSERT` query writes are not encrypted by default. We recommend that you encrypt `INSERT` query results if you are inserting into tables with encrypted data. For more information about encrypting query results using the console, see [Encrypting Query Results Stored in Amazon S3 \(p. 198\)](#). To enable encryption using the AWS CLI or Athena API, use the `EncryptionConfiguration` properties of the `StartQueryExecution` action to specify Amazon S3 encryption options according to your requirements.

Supported Formats and SerDes

You can run an `INSERT` query on tables created from data with the following formats and SerDes.

Data format	SerDe
Avro	org.apache.hadoop.hive.serde2.avro.AvroSerDe
JSON	org.apache.hive.hcatalog.data.JsonSerDe
ORC	org.apache.hadoop.hive.ql.io.orc.OrcSerde
Parquet	org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe
Text file	org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe

Note
CSV, TSV, and custom-delimited files are supported.

Bucketed tables not supported

`INSERT INTO` is not supported on bucketed tables. For more information, see [Bucketing vs Partitioning \(p. 122\)](#).

Partition Limits

The `INSERT INTO` statement supports writing a maximum of 100 partitions to the destination table. If you run the `SELECT` clause on a table with more than 100 partitions, the query fails unless the `SELECT` query is limited to 100 partitions or fewer.

Files Written to Amazon S3

Athena writes files to source data locations in Amazon S3 as a result of the `INSERT` command. Each `INSERT` operation creates a new file, rather than appending to an existing file. The file locations depend on the structure of the table and the `SELECT` query, if present. Athena generates a data manifest file for each `INSERT` query. The manifest tracks the files that the query wrote. It is saved to the Athena query result location in Amazon S3. If a query fails, the manifest also tracks files that the query intended to write. The manifest is useful for identifying orphaned files resulting from a failed query. For more information, see [Working with Query Results, Output Files, and Query History \(p. 107\)](#).

INSERT INTO...SELECT

Specifies the query to run on one table, `source_table`, which determines rows to insert into a second table, `destination_table`. If the `SELECT` query specifies columns in the `source_table`, the columns must precisely match those in the `destination_table`.

For more information about `SELECT` queries, see [SELECT \(p. 300\)](#).

Synopsis

```
INSERT INTO destination_table
SELECT select_query
FROM source_table_or_view
```

Examples

Select all rows in the `vancouver_pageviews` table and insert them into the `canada_pageviews` table:

```
INSERT INTO canada_pageviews
SELECT *
FROM vancouver_pageviews;
```

Select only those rows in the `vancouver_pageviews` table where the `date` column has a value between 2019-07-01 and 2019-07-31, and then insert them into `canada_july_pageviews`:

```
INSERT INTO canada_july_pageviews
SELECT *
FROM vancouver_pageviews
WHERE date
    BETWEEN date '2019-07-01'
        AND '2019-07-31';
```

Select the values in the `city` and `state` columns in the `cities_usa` table only from those rows with a value of `usa` in the `country` column and insert them into the `city` and `state` columns in the `cities_world` table:

```
INSERT INTO cities_usa (city,state)
SELECT city,state
FROM cities_world
WHERE country='usa'
```

INSERT INTO...VALUES

Inserts rows into an existing table by specifying columns and values. Specified columns and associated data types must precisely match the columns and data types in the destination table.

Important

We do not recommend inserting rows using `VALUES` because Athena generates files for each `INSERT` operation. This can cause many small files to be created and degrade the table's query performance. To identify files that an `INSERT` query creates, examine the data manifest file. For more information, see [Working with Query Results, Output Files, and Query History \(p. 107\)](#).

Synopsis

```
INSERT INTO destination_table [(col1,col2,...)]
VALUES (col1value,col2value,...)[,
       (col1value,col2value,...)][,
       ...]
```

Examples

In the following examples, the cities table has three columns: `id`, `city`, `state`, `state_motto`. The `id` column is type `INT` and all other columns are type `VARCHAR`.

Insert a single row into the `cities` table, with all column values specified:

```
INSERT INTO cities
VALUES (1,'Lansing','MI','Si quaeris peninsulae amoenam circumspice')
```

Insert two rows into the `cities` table:

```
INSERT INTO cities
VALUES (1,'Lansing','MI','Si quaeris peninsulae amoenam circumspice'),
(3,'Boise','ID','Esto perpetua')
```

Presto Functions in Amazon Athena

The Athena query engine is based on [Presto 0.172](#). For more information about these functions, see [Presto 0.172 Functions and Operators](#) and the specific sections from Presto documentation referenced below.

Athena does not support all of Presto's features. For information, see [Considerations and Limitations \(p. 324\)](#).

- [Logical Operators](#)
- [Comparison Functions and Operators](#)
- [Conditional Expressions](#)
- [Conversion Functions](#)
- [Mathematical Functions and Operators](#)
- [Bitwise Functions](#)
- [Decimal Functions and Operators](#)
- [String Functions and Operators](#)
- [Binary Functions](#)
- [Date and Time Functions and Operators](#)
- [Regular Expression Functions](#)
- [JSON Functions and Operators](#)
- [URL Functions](#)
- [Aggregate Functions](#)
- [Window Functions](#)
- [Color Functions](#)
- [Array Functions and Operators](#)
- [Map Functions and Operators](#)
- [Lambda Expressions and Functions](#)
- [Teradata Functions](#)

DDL Statements

Use the following DDL statements directly in Athena.

The Athena query engine is based on [HiveQL DDL](#).

Athena does not support all DDL statements, and there are some differences between HiveQL DDL and Athena DDL. For more information, see the reference topics in this section and [Unsupported DDL \(p. 307\)](#).

Topics

- [Unsupported DDL \(p. 307\)](#)
- [ALTER DATABASE SET DBPROPERTIES \(p. 308\)](#)
- [ALTER TABLE ADD PARTITION \(p. 309\)](#)
- [ALTER TABLE DROP PARTITION \(p. 310\)](#)
- [ALTER TABLE RENAME PARTITION \(p. 310\)](#)
- [ALTER TABLE SET LOCATION \(p. 311\)](#)
- [ALTER TABLE SET TBLPROPERTIES \(p. 311\)](#)
- [CREATE DATABASE \(p. 312\)](#)
- [CREATE TABLE \(p. 313\)](#)
- [CREATE TABLE AS \(p. 316\)](#)
- [CREATE VIEW \(p. 318\)](#)
- [DESCRIBE TABLE \(p. 318\)](#)
- [DESCRIBE VIEW \(p. 319\)](#)
- [DROP DATABASE \(p. 319\)](#)
- [DROP TABLE \(p. 320\)](#)
- [DROP VIEW \(p. 320\)](#)
- [MSCK REPAIR TABLE \(p. 321\)](#)
- [SHOW COLUMNS \(p. 321\)](#)
- [SHOW CREATE TABLE \(p. 321\)](#)
- [SHOW CREATE VIEW \(p. 322\)](#)
- [SHOW DATABASES \(p. 322\)](#)
- [SHOW PARTITIONS \(p. 322\)](#)
- [SHOW TABLES \(p. 323\)](#)
- [SHOW TBLPROPERTIES \(p. 323\)](#)
- [SHOW VIEWS \(p. 324\)](#)

Unsupported DDL

The following native Hive DDLs are not supported by Athena:

- `ALTER INDEX`
- `ALTER TABLE table_name ARCHIVE PARTITION`
- `ALTER TABLE table_name CLUSTERED BY`
- `ALTER TABLE table_name EXCHANGE PARTITION`
- `ALTER TABLE table_name NOT CLUSTERED`
- `ALTER TABLE table_name NOT SKEWED`
- `ALTER TABLE table_name NOT SORTED`
- `ALTER TABLE table_name NOT STORED AS DIRECTORIES`
- `ALTER TABLE table_name partitionSpec ADD COLUMNS`
- `ALTER TABLE table_name partitionSpec CHANGE COLUMNS`

- ALTER TABLE `table_name` partitionSpec COMPACT
- ALTER TABLE `table_name` partitionSpec CONCATENATE
- ALTER TABLE `table_name` partitionSpec REPLACE COLUMNS
- ALTER TABLE `table_name` partitionSpec SET FILEFORMAT
- ALTER TABLE `table_name` RENAME TO
- ALTER TABLE `table_name` SET SKEWED LOCATION
- ALTER TABLE `table_name` SKEWED BY
- ALTER TABLE `table_name` TOUCH
- ALTER TABLE `table_name` UNARCHIVE PARTITION
- COMMIT
- CREATE INDEX
- CREATE ROLE
- CREATE TABLE `table_name` LIKE `existing_table_name`
- CREATE TEMPORARY MACRO
- DELETE FROM
- DESCRIBE DATABASE
- DFS
- DROP INDEX
- DROP ROLE
- DROP TEMPORARY MACRO
- EXPORT TABLE
- GRANT ROLE
- IMPORT TABLE
- INSERT INTO
- LOCK DATABASE
- LOCK TABLE
- REVOKE ROLE
- ROLLBACK
- SHOW COMPACTIONS
- SHOW CURRENT ROLES
- SHOW GRANT
- SHOW INDEXES
- SHOW LOCKS
- SHOW PRINCIPALS
- SHOW ROLE GRANT
- SHOW ROLES
- SHOW TRANSACTIONS
- START TRANSACTION
- UNLOCK DATABASE
- UNLOCK TABLE

ALTER DATABASE SET DBPROPERTIES

Creates one or more properties for a database. The use of `DATABASE` and `SCHEMA` are interchangeable; they mean the same thing.

Synopsis

```
ALTER (DATABASE|SCHEMA) database_name
    SET DBPROPERTIES ('property_name'='property_value' [, ...] )
```

Parameters

SET DBPROPERTIES ('property_name'='property_value' [, ...])

Specifies a property or properties for the database named `property_name` and establishes the value for each of the properties respectively as `property_value`. If `property_name` already exists, the old value is overwritten with `property_value`.

Examples

```
ALTER DATABASE jd_datasets
    SET DBPROPERTIES ('creator'='John Doe', 'department'='applied mathematics');
```

```
ALTER SCHEMA jd_datasets
    SET DBPROPERTIES ('creator'='Jane Doe');
```

ALTER TABLE ADD PARTITION

Creates one or more partition columns for the table. Each partition consists of one or more distinct column name/value combinations. A separate data directory is created for each specified combination, which can improve query performance in some circumstances. Partitioned columns don't exist within the table data itself, so if you use a column name that has the same name as a column in the table itself, you get an error. For more information, see [Partitioning Data \(p. 36\)](#).

Synopsis

```
ALTER TABLE table_name ADD [IF NOT EXISTS]
    PARTITION
        (partition_col1_name = partition_col1_value
        [,partition_col2_name = partition_col2_value]
        [,...])
        [LOCATION 'location1']
        [PARTITION
            (partition_colA_name = partition_colA_value
            [,partition_colB_name = partition_colB_value]
            [,...])]
        [LOCATION 'location2']
        [,...]
```

Parameters

[IF NOT EXISTS]

Causes the error to be suppressed if a partition with the same definition already exists.

PARTITION (partition_col_name = partition_col_value [,...])

Creates a partition with the column name/value combinations that you specify. Enclose `partition_col_value` in string characters only if the data type of the column is a string.

[LOCATION 'location']

Specifies the directory in which to store the partitions defined by the preceding statement.

Examples

```
ALTER TABLE orders ADD
PARTITION (dt = '2016-05-14', country = 'IN');
```

```
ALTER TABLE orders ADD
PARTITION (dt = '2016-05-14', country = 'IN')
PARTITION (dt = '2016-05-15', country = 'IN');
```

```
ALTER TABLE orders ADD
PARTITION (dt = '2016-05-14', country = 'IN') LOCATION 's3://mystorage/path/to/
INDIA_14_May_2016/'
PARTITION (dt = '2016-05-15', country = 'IN') LOCATION 's3://mystorage/path/to/
INDIA_15_May_2016/';
```

ALTER TABLE DROP PARTITION

Drops one or more specified partitions for the named table.

Synopsis

```
ALTER TABLE table_name DROP [IF EXISTS] PARTITION (partition_spec) [, PARTITION
(partition_spec)]
```

Parameters

[IF EXISTS]

Suppresses the error message if the partition specified does not exist.

PARTITION (partition_spec)

Each `partition_spec` specifies a column name/value combination in the form `partition_col_name = partition_col_value [,...]`.

Examples

```
ALTER TABLE orders
DROP PARTITION (dt = '2014-05-14', country = 'IN');
```

```
ALTER TABLE orders
DROP PARTITION (dt = '2014-05-14', country = 'IN'), PARTITION (dt = '2014-05-15', country =
'IN');
```

ALTER TABLE RENAME PARTITION

Renames a partition column, `partition_spec`, for the table named `table_name`, to `new_partition_spec`.

Synopsis

```
ALTER TABLE table_name PARTITION (partition_spec) RENAME TO PARTITION (new_partition_spec)
```

Parameters

PARTITION (partition_spec)

Each `partition_spec` specifies a column name/value combination in the form `partition_col_name = partition_col_value [,....]`.

Examples

```
ALTER TABLE orders
PARTITION (dt = '2014-05-14', country = 'IN') RENAME TO PARTITION (dt = '2014-05-15',
country = 'IN');
```

ALTER TABLE SET LOCATION

Changes the location for the table named `table_name`, and optionally a partition with `partition_spec`.

Synopsis

```
ALTER TABLE table_name [ PARTITION (partition_spec) ] SET LOCATION 'new location'
```

Parameters

PARTITION (partition_spec)

Specifies the partition with parameters `partition_spec` whose location you want to change. The `partition_spec` specifies a column name/value combination in the form `partition_col_name = partition_col_value`.

SET LOCATION 'new location'

Specifies the new location, which must be an Amazon S3 location. For information about syntax, see [Table Location in Amazon S3 \(p. 34\)](#).

Examples

```
ALTER TABLE customers PARTITION (zip='98040', state='WA') SET LOCATION 's3://mystorage/
custdata/';
```

ALTER TABLE SET TBLPROPERTIES

Adds custom metadata properties to a table and sets their assigned values.

[Managed tables](#) are not supported, so setting '`EXTERNAL`' = 'FALSE' has no effect.

Synopsis

```
ALTER TABLE table_name SET TBLPROPERTIES ('property_name' = 'property_value' [ , ... ])
```

Parameters

SET TBLPROPERTIES ('property_name' = 'property_value' [, ...])

Specifies the metadata properties to add as `property_name` and the value for each as `property_value`. If `property_name` already exists, its value is reset to `property_value`.

Examples

```
ALTER TABLE orders
SET TBLPROPERTIES ('notes'="Please don't drop this table.");
```

CREATE DATABASE

Creates a database. The use of `DATABASE` and `SCHEMA` is interchangeable. They mean the same thing.

Synopsis

```
CREATE (DATABASE|SCHEMA) [IF NOT EXISTS] database_name
[COMMENT 'database_comment']
[LOCATION 'S3_loc']
[WITH DBPROPERTIES ('property_name' = 'property_value') [, ...]]
```

Parameters

[IF NOT EXISTS]

Causes the error to be suppressed if a database named `database_name` already exists.

[COMMENT database_comment]

Establishes the metadata value for the built-in metadata property named `comment` and the value you provide for `database_comment`.

[LOCATION S3_loc]

Specifies the location where database files and metastore will exist as `S3_loc`. The location must be an Amazon S3 location.

[WITH DBPROPERTIES ('property_name' = 'property_value') [, ...]]

Allows you to specify custom metadata properties for the database definition.

Examples

```
CREATE DATABASE clickstreams;
```

```
CREATE DATABASE IF NOT EXISTS clickstreams
```

```
COMMENT 'Site Foo clickstream data aggregates'
LOCATION 's3://myS3location/clickstreams/'
WITH DBPROPERTIES ('creator'='Jane D.', 'Dept.'='Marketing analytics');
```

CREATE TABLE

Creates a table with the name and the parameters that you specify.

Synopsis

```
CREATE [EXTERNAL] TABLE [IF NOT EXISTS]
[db_name.]table_name [(col_name data_type [COMMENT col_comment] [, ...]) ]
[COMMENT table_comment]
[PARTITIONED BY (col_name data_type [COMMENT col_comment], ...)]
[ROW FORMAT row_format]
[STORED AS file_format]
[WITH SERDEPROPERTIES (...)]
[LOCATION 's3_loc']
[TBLPROPERTIES ( ['has_encrypted_data'='true | false', ]
['classification'='aws_glue_classification', ] property_name=property_value [, ...] )]
```

Parameters

[EXTERNAL]

Specifies that the table is based on an underlying data file that exists in Amazon S3, in the LOCATION that you specify. When you create an external table, the data referenced must comply with the default format or the format that you specify with the ROW FORMAT, STORED AS, and WITH SERDEPROPERTIES clauses.

[IF NOT EXISTS]

Causes the error message to be suppressed if a table named table_name already exists.

[db_name.]table_name

Specifies a name for the table to be created. The optional db_name parameter specifies the database where the table exists. If omitted, the current database is assumed. If the table name includes numbers, enclose table_name in quotation marks, for example "table123". If table_name begins with an underscore, use backticks, for example, `_mytable`. Special characters (other than underscore) are not supported.

Athena table names are case-insensitive; however, if you work with Apache Spark, Spark requires lowercase table names.

[(col_name data_type [COMMENT col_comment] [, ...])]

Specifies the name for each column to be created, along with the column's data type. Column names do not allow special characters other than underscore (_). If col_name begins with an underscore, enclose the column name in backticks, for example `_mycolumn`.

The data_type value can be any of the following:

- BOOLEAN. Values are true and false.
- TINYINT. An 8-bit signed INTEGER in two's complement format, with a minimum value of -2^7 and a maximum value of 2^7-1.
- SMALLINT. A 16-bit signed INTEGER in two's complement format, with a minimum value of -2^15 and a maximum value of 2^15-1.

- **INT.** Athena combines two different implementations of the `INTEGER` data type. In Data Definition Language (DDL) queries, Athena uses the `INT` data type. In all other queries, Athena uses the `INTEGER` data type, where `INTEGER` is represented as a 32-bit signed value in two's complement format, with a minimum value of -2^{31} and a maximum value of $2^{31}-1$. In the JDBC driver, `INTEGER` is returned, to ensure compatibility with business analytics applications.
- **BIGINT.** A 64-bit signed `INTEGER` in two's complement format, with a minimum value of -2^{63} and a maximum value of $2^{63}-1$.
- **DOUBLE**
- **FLOAT**
- **DECIMAL [(precision, scale)]**, where `precision` is the total number of digits, and `scale` (optional) is the number of digits in fractional part, the default is 0. For example, use these type definitions: `DECIMAL(11, 5)`, `DECIMAL(15)`.

To specify decimal values as literals, such as when selecting rows with a specific decimal value in a query DDL expression, specify the `DECIMAL` type definition, and list the decimal value as a literal (in single quotes) in your query, as in this example: `decimal_value = DECIMAL '0.12'`.

- **CHAR.** Fixed length character data, with a specified length between 1 and 255, such as `char(10)`. For more information, see [CHAR Hive Data Type](#).
- **VARCHAR.** Variable length character data, with a specified length between 1 and 65535, such as `varchar(10)`. For more information, see [VARCHAR Hive Data Type](#).
- **BINARY** (for data in Parquet)
- Date and time types
- **DATE**, in the UNIX format, such as `YYYY-MM-DD`.
- **TIMESTAMP**. Instant in time and date in the UNiX format, such as `yyyy-mm-dd hh:mm:ss[.f...]`. For example, `TIMESTAMP '2008-09-15 03:04:05.324'`. This format uses the session time zone.
- **ARRAY < data_type >**
- **MAP < primitive_type, data_type >**
- **STRUCT < col_name : data_type [COMMENT col_comment] [, ...] >**

[COMMENT table_comment]

Creates the `comment` table property and populates it with the `table_comment` you specify.

[PARTITIONED BY (col_name data_type [COMMENT col_comment], ...)]

Creates a partitioned table with one or more partition columns that have the `col_name`, `data_type` and `col_comment` specified. A table can have one or more partitions, which consist of a distinct column name and value combination. A separate data directory is created for each specified combination, which can improve query performance in some circumstances. Partitioned columns don't exist within the table data itself. If you use a value for `col_name` that is the same as a table column, you get an error. For more information, see [Partitioning Data \(p. 36\)](#).

Note

After you create a table with partitions, run a subsequent query that consists of the [MSCK REPAIR TABLE \(p. 321\)](#) clause to refresh partition metadata, for example, `MSCK REPAIR TABLE cloudfont_logs;`.

[ROW FORMAT row_format]

Specifies the row format of the table and its underlying source data if applicable. For `row_format`, you can specify one or more delimiters with the `DELIMITED` clause or, alternatively, use the `SERDE` clause as described below. If `ROW FORMAT` is omitted or `ROW FORMAT DELIMITED` is specified, a native SerDe is used.

- [DELIMITED FIELDS TERMINATED BY char [ESCAPED BY char]]
- [DELIMITED COLLECTION ITEMS TERMINATED BY char]
- [MAP KEYS TERMINATED BY char]
- [LINES TERMINATED BY char]
- [NULL DEFINED AS char] -- (Note: Available in Hive 0.13 and later)

--OR--

- SERDE 'serde_name' [WITH SERDEPROPERTIES ("property_name" = "property_value", "property_name" = "property_value" [, ...])]

The `serde_name` indicates the SerDe to use. The `WITH SERDEPROPERTIES` clause allows you to provide one or more custom properties allowed by the SerDe.

[STORED AS file_format]

Specifies the file format for table data. If omitted, `TEXTFILE` is the default. Options for `file_format` are:

- SEQUENCEFILE
- TEXTFILE
- RCFILE
- ORC
- PARQUET
- AVRO
- INPUTFORMAT input_format_classname OUTPUTFORMAT output_format_classname

[LOCATION 'S3_loc']

Specifies the location of the underlying data in Amazon S3 from which the table is created, for example, '`s3://mystorage/`'. For more information about considerations such as data format and permissions, see [Requirements for Tables in Athena and Data in Amazon S3 \(p. 29\)](#).

Use a trailing slash for your folder or bucket. Do not use file names or glob characters.

Use: `s3://mybucket/key/`

Don't use: `s3://path_to_bucket s3://path_to_bucket/* s3://path_to-bucket/mydatafile.dat`

[TBLPROPERTIES (['has_encrypted_data'=‘true | false’], ['classification'=‘aws_glue_classification’], property_name=property_value [, ...])]

Specifies custom metadata key-value pairs for the table definition in addition to predefined table properties, such as "comment".

Athena has a built-in property, `has_encrypted_data`. Set this property to `true` to indicate that the underlying dataset specified by `LOCATION` is encrypted. If omitted and if the workgroup's settings do not override client-side settings, `false` is assumed. If omitted or set to `false` when underlying data is encrypted, the query results in an error. For more information, see [Configuring Encryption Options \(p. 197\)](#).

To run ETL jobs, AWS Glue requires that you create a table with the `classification` property to indicate the data type for AWS Glue as `csv`, `parquet`, `orc`, `avro`, or `json`. For example, `'classification'='csv'`. ETL jobs will fail if you do not specify this property. You can subsequently specify it using the AWS Glue console, API, or CLI. For more information, see [Using AWS Glue Jobs for ETL with Athena \(p. 54\)](#) and [Authoring Jobs in Glue in the AWS Glue Developer Guide](#).

Examples

```
CREATE EXTERNAL TABLE IF NOT EXISTS mydatabase.cloudfront_logs (
    Date DATE,
    Time STRING,
    Location STRING,
    Bytes INT,
    RequestIP STRING,
    Method STRING,
    Host STRING,
    Uri STRING,
    Status INT,
    Referrer STRING,
    os STRING,
    Browser STRING,
    BrowserVersion STRING
    ) ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
    WITH SERDEPROPERTIES (
        "input.regex" = "^(?!#)([^ ]+)\s+([^ ]+)\s+([^ ]+)\s+([^ ]+)\s+([^ ]+)\s+([^\n]+)[\n\r]+([^\n;]+)\.*\%20([^\n;/]+)[\n\r](.*)$"
    ) LOCATION 's3://athena-examples/cloudfront/plaintext/';
```

CREATE TABLE AS

Creates a new table populated with the results of a [SELECT \(p. 300\)](#) query. To create an empty table, use [CREATE TABLE \(p. 313\)](#).

Topics

- [Synopsis \(p. 300\)](#)
- [CTAS Table Properties \(p. 317\)](#)
- [Examples \(p. 318\)](#)

Synopsis

```
CREATE TABLE table_name
[ WITH ( property_name = expression [, ...] ) ]
AS query
[ WITH [ NO ] DATA ]
```

Where:

WITH (*property_name = expression [, ...]*)

A list of optional CTAS table properties, some of which are specific to the data storage format. See [CTAS Table Properties \(p. 317\)](#).

query

A [SELECT \(p. 300\)](#) query that is used to create a new table.

Important

If you plan to create a query with partitions, specify the names of partitioned columns last in the list of columns in the [SELECT](#) statement.

[WITH [NO] DATA]

If `WITH NO DATA` is used, a new empty table with the same schema as the original table is created.

CTAS Table Properties

Each CTAS table in Athena has a list of optional CTAS table properties that you specify using `WITH (property_name = expression [, ...])`. For information about using these parameters, see [Examples of CTAS Queries \(p. 123\)](#).

`WITH (property_name = expression [, ...],)`
`external_location = [location]`

The location where Athena saves your CTAS query in Amazon S3, for example, `WITH (external_location = 's3://my-bucket/tables/parquet_table/')`. This property is optional. When you don't specify any location and your workgroup does not [override client-side settings \(p. 247\)](#), Athena stores the CTAS query results in `external_location = 's3://aws-athena-query-results-<account>-<region>/<query-name-or-unsaved>/<year>/<month>/<date>/<query-id>/'`, and does not use the same path again. If you specify the location manually, make sure that the Amazon S3 location has no data. Athena never attempts to delete your data. If you want to use the same location again, manually clean the data, otherwise your CTAS query will fail.

If the workgroup in which a query will run is configured with an [enforced query results location \(p. 247\)](#), do not specify an `external_location` for the CTAS query. Athena issues an error and fails a query that specifies an `external_location` in this case. For example, this query fails, if you enforce the workgroup to use its own location: `CREATE TABLE <DB>. <TABLE1> WITH (format='Parquet', external_location='s3://my_test/test/') AS SELECT * FROM <DB>. <TABLE2> LIMIT 10;`

To obtain the results location specified for the workgroup, [view workgroup's details \(p. 251\)](#).

`format = [format]`

The data format for the CTAS query results, such as ORC, PARQUET, AVRO, JSON, or TEXTFILE. For example, `WITH (format = 'PARQUET')`. If omitted, PARQUET is used by default. The name of this parameter, `format`, must be listed in lowercase, or your CTAS query will fail.

`partitioned_by = ([col_name,...])`

Optional. An array list of columns by which the CTAS table will be partitioned. Verify that the names of partitioned columns are listed last in the list of columns in the `SELECT` statement.

`bucketed_by([bucket_name,...])`

An array list of buckets to bucket data. If omitted, Athena does not bucket your data in this query.

`bucket_count = [int]`

The number of buckets for bucketing your data. If omitted, Athena does not bucket your data.

`orc_compression = [format]`

The compression type to use for ORC data. For example, `WITH (orc_compression = 'ZLIB')`. If omitted, GZIP compression is used by default for ORC and other data storage formats supported by CTAS.

`parquet_compression = [format]`

The compression type to use for Parquet data. For example, `WITH (parquet_compression = 'SNAPPY')`. If omitted, GZIP compression is used by default for Parquet and other data storage formats supported by CTAS.

`field_delimiter = [delimiter]`

Optional and specific to text-based data storage formats. The field delimiter for files in CSV, TSV, and text files. For example, `WITH (field_delimiter = ',')`. If you don't specify a field delimiter, \001 is used by default.

Examples

See [Examples of CTAS Queries \(p. 123\)](#).

CREATE VIEW

Creates a new view from a specified `SELECT` query. The view is a logical table that can be referenced by future queries. Views do not contain any data and do not write data. Instead, the query specified by the view runs each time you reference the view by another query.

The optional `OR REPLACE` clause lets you update the existing view by replacing it. For more information, see [Creating Views \(p. 116\)](#).

Synopsis

```
CREATE [ OR REPLACE ] VIEW view_name AS query
```

Examples

To create a view `test` from the table `orders`, use a query similar to the following:

```
CREATE VIEW test AS
SELECT
orderkey,
orderstatus,
totalprice / 2 AS half
FROM orders;
```

To create a view `orders_by_date` from the table `orders`, use the following query:

```
CREATE VIEW orders_by_date AS
SELECT orderdate, sum(totalprice) AS price
FROM orders
GROUP BY orderdate;
```

To update an existing view, use an example similar to the following:

```
CREATE OR REPLACE VIEW test AS
SELECT orderkey, orderstatus, totalprice / 4 AS quarter
FROM orders;
```

See also [SHOW COLUMNS \(p. 321\)](#), [SHOW CREATE VIEW \(p. 322\)](#), [DESCRIBE VIEW \(p. 319\)](#), and [DROP VIEW \(p. 320\)](#).

DESCRIBE TABLE

Shows the list of columns, including partition columns, for the named column. This allows you to examine the attributes of a complex column.

Synopsis

```
DESCRIBE [EXTENDED | FORMATTED] [db_name.]table_name [PARTITION partition_spec] [col_name
( [.field_name] | [.'$elem$'] | [.'$key$'] | [.'$value$'] )]
```

Parameters

[EXTENDED | FORMATTED]

Determines the format of the output. If you specify EXTENDED, all metadata for the table is output in Thrift serialized form. This is useful primarily for debugging and not for general use. Use FORMATTED or omit the clause to show the metadata in tabular format.

[PARTITION *partition_spec*]

Lists the metadata for the partition with *partition_spec* if included.

[*col_name* ([.field_name] | ['\$elem\$'] | ['\$key\$'] | ['\$value\$'])*]

Specifies the column and attributes to examine. You can specify .field_name for an element of a struct, '\$elem\$' for array element, '\$key\$' for a map key, and '\$value\$' for map value. You can specify this recursively to further explore the complex column.

Examples

```
DESCRIBE orders;
```

DESCRIBE VIEW

Shows the list of columns for the named view. This allows you to examine the attributes of a complex view.

Synopsis

```
DESCRIBE [view_name]
```

Example

```
DESCRIBE orders;
```

See also [SHOW COLUMNS \(p. 321\)](#), [SHOW CREATE VIEW \(p. 322\)](#), [SHOW VIEWS \(p. 324\)](#), and [DROP VIEW \(p. 320\)](#).

DROP DATABASE

Removes the named database from the catalog. If the database contains tables, you must either drop the tables before executing `DROP DATABASE` or use the `CASCADE` clause. The use of `DATABASE` and `SCHEMA` are interchangeable. They mean the same thing.

Synopsis

```
DROP {DATABASE | SCHEMA} [IF EXISTS] database_name [RESTRICT | CASCADE]
```

Parameters

[IF EXISTS]

Causes the error to be suppressed if `database_name` doesn't exist.

[RESTRICT|CASCADE]

Determines how tables within `database_name` are regarded during the `DROP` operation. If you specify `RESTRICT`, the database is not dropped if it contains tables. This is the default behavior. Specifying `CASCADE` causes the database and all its tables to be dropped.

Examples

```
DROP DATABASE clickstreams;
```

```
DROP SCHEMA IF EXISTS clickstreams CASCADE;
```

DROP TABLE

Removes the metadata table definition for the table named `table_name`. When you drop an external table, the underlying data remains intact because all tables in Athena are `EXTERNAL`.

Synopsis

```
DROP TABLE [ IF EXISTS ] table_name
```

Parameters

[IF EXISTS]

Causes the error to be suppressed if `table_name` doesn't exist.

Examples

```
DROP TABLE fulfilled_orders;
```

```
DROP TABLE IF EXISTS fulfilled_orders;
```

DROP VIEW

Drops (deletes) an existing view. The optional `IF EXISTS` clause causes the error to be suppressed if the view does not exist.

For more information, see [Deleting Views \(p. 118\)](#).

Synopsis

```
DROP VIEW [ IF EXISTS ] view_name
```

Examples

```
DROP VIEW orders_by_date
```

```
DROP VIEW IF EXISTS orders_by_date
```

See also [CREATE VIEW \(p. 318\)](#), [SHOW COLUMNS \(p. 321\)](#), [SHOW CREATE VIEW \(p. 322\)](#), [SHOW VIEWS \(p. 324\)](#), and [DESCRIBE VIEW \(p. 319\)](#).

MSCK REPAIR TABLE

Recovers partitions and data associated with partitions. Use this statement when you add partitions to the catalog. It is possible it will take some time to add all partitions. If this operation times out, it will be in an incomplete state where only a few partitions are added to the catalog. You should run the statement on the same table until all partitions are added. For more information, see [Partitioning Data \(p. 36\)](#).

Synopsis

```
MSCK REPAIR TABLE table_name
```

Examples

```
MSCK REPAIR TABLE orders;
```

SHOW COLUMNS

Lists the columns in the schema for a base table or a view.

Synopsis

```
SHOW COLUMNS IN table_name|view_name
```

Examples

```
SHOW COLUMNS IN clicks;
```

SHOW CREATE TABLE

Analyzes an existing table named `table_name` to generate the query that created it.

Synopsis

```
SHOW CREATE TABLE [db_name.]table_name
```

Parameters

TABLE [db_name.]table_name

The `db_name` parameter is optional. If omitted, the context defaults to the current database.

Note

The table name is required.

Examples

```
SHOW CREATE TABLE orderclickstoday;
```

```
SHOW CREATE TABLE `salesdata.orderclickstoday`;
```

SHOW CREATE VIEW

Shows the SQL statement that creates the specified view.

Synopsis

```
SHOW CREATE VIEW view_name
```

Examples

```
SHOW CREATE VIEW orders_by_date
```

See also [CREATE VIEW \(p. 318\)](#) and [DROP VIEW \(p. 320\)](#).

SHOW DATABASES

Lists all databases defined in the metastore. You can use DATABASES or SCHEMAS. They mean the same thing.

Synopsis

```
SHOW {DATABASES | SCHEMAS} [LIKE 'regular_expression']
```

Parameters

[LIKE 'regular_expression']

Filters the list of databases to those that match the `regular_expression` you specify. Wildcards can only be *, which indicates any character, or |, which indicates a choice between characters.

Examples

```
SHOW SCHEMAS;
```

```
SHOW DATABASES LIKE '*analytics';
```

SHOW PARTITIONS

Lists all the partitions in a table.

Synopsis

```
SHOW PARTITIONS table_name
```

Examples

```
SHOW PARTITIONS clicks;
```

SHOW TABLES

Lists all the base tables and views in a database.

Synopsis

```
SHOW TABLES [IN database_name] ['regular_expression']
```

Parameters

[IN database_name]

Specifies the database_name from which tables will be listed. If omitted, the database from the current context is assumed.

['regular_expression']

Filters the list of tables to those that match the regular_expression you specify. Only the wildcard *, which indicates any character, or |, which indicates a choice between characters, can be used.

Examples

```
SHOW TABLES;
```

```
SHOW TABLES IN marketing_analytics 'orders*';
```

SHOW TBLPROPERTIES

Lists table properties for the named table.

Synopsis

```
SHOW TBLPROPERTIES table_name [('property_name')]
```

Parameters

[('property_name')]

If included, only the value of the property named property_name is listed.

Examples

```
SHOW TBLPROPERTIES orders;
```

```
SHOW TBLPROPERTIES orders('comment');
```

SHOW VIEWS

Lists the views in the specified database, or in the current database if you omit the database name. Use the optional `LIKE` clause with a regular expression to restrict the list of view names.

Athena returns a list of `STRING` type values where each value is a view name.

Synopsis

```
SHOW VIEWS [IN database_name] LIKE ['regular_expression']
```

Parameters

[IN database_name]

Specifies the `database_name` from which views will be listed. If omitted, the database from the current context is assumed.

[LIKE 'regular_expression']

Filters the list of views to those that match the `regular_expression` you specify. Only the wildcard `*`, which indicates any character, or `|`, which indicates a choice between characters, can be used.

Examples

```
SHOW VIEWS;
```

```
SHOW VIEWS IN marketing_analytics LIKE 'orders*';
```

See also [SHOW COLUMNS \(p. 321\)](#), [SHOW CREATE VIEW \(p. 322\)](#), [DESCRIBE VIEW \(p. 319\)](#), and [DROP VIEW \(p. 320\)](#).

Considerations and Limitations for SQL Queries in Amazon Athena

- Stored procedures are not supported.
- The maximum number of partitions you can create with `CREATE TABLE AS SELECT` (CTAS) statements is 100. For information, see [CREATE TABLE AS \(p. 316\)](#).
- `PREPARED` statements are not supported. You cannot run `EXECUTE` with `USING`.
- `CREATE TABLE LIKE` is note supported.
- `DESCRIBE INPUT` and `DESCRIBE OUTPUT` is not supported.

- EXPLAIN statements are not supported.
- [Presto federated connectors](#) are not supported. Use Amazon Athena Federated Query (Preview) to connect data sources. For more information, see [Using Amazon Athena Federated Query \(Preview\) \(p. 62\)](#).
- When you query columns with complex data types (array, map, struct), and are using Parquet for storing data, Athena currently reads an entire row of data, instead of selectively reading only the specified columns as expected. This is a known issue.

Code Samples, Service Limits, and Previous JDBC Driver

Use the following examples to create Athena applications based on AWS SDK for Java.

Use the links in this section to use the previous version of the JDBC driver.

Learn about service limits.

Topics

- [Code Samples \(p. 326\)](#)
- [Using Earlier Version JDBC Drivers \(p. 334\)](#)
- [Service Limits \(p. 339\)](#)

Code Samples

Use examples in this topic as a starting point for writing Athena applications using the SDK for Java 2.x.

- **Java Code Examples**
 - [Constants \(p. 326\)](#)
 - [Create a Client to Access Athena \(p. 327\)](#)
 - **Working with Query Executions**
 - [Start Query Execution \(p. 327\)](#)
 - [Stop Query Execution \(p. 330\)](#)
 - [List Query Executions \(p. 331\)](#)
 - **Working with Named Queries**
 - [Create a Named Query \(p. 332\)](#)
 - [Delete a Named Query \(p. 332\)](#)
 - [List Query Executions \(p. 331\)](#)

Note

These samples use constants (for example, `ATHENA_SAMPLE_QUERY`) for strings, which are defined in an `ExampleConstants.java` class declaration. Replace these constants with your own strings or defined constants.

Constants

The `ExampleConstants.java` class demonstrates how to query a table created by the [Getting Started \(p. 23\)](#) tutorial in Athena.

```
package aws.example.athena;  
  
public class ExampleConstants {
```

```
public static final int CLIENT_EXECUTION_TIMEOUT = 100000;
public static final String ATHENA_OUTPUT_BUCKET = "s3://my-athena-bucket";
// This example demonstrates how to query a table created by the "Getting Started"
tutorial in Athena
public static final String ATHENA_SAMPLE_QUERY = "SELECT elb_name, "
    + " count(1)"
    + " FROM elb_logs"
    + " Where elb_response_code = '200'"
    + " GROUP BY elb_name"
    + " ORDER BY 2 DESC limit 10;";
public static final long SLEEP_AMOUNT_IN_MS = 1000;
public static final String ATHENA_DEFAULT_DATABASE = "default";
}
```

Create a Client to Access Athena

The `AthenaClientFactory.java` class shows how to create and configure an Amazon Athena client.

```
package aws.example.athena;

import software.amazon.awssdk.auth.credentials.InstanceProfileCredentialsProvider;
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.AthenaClientBuilder;

/**
 * AthenaClientFactory
 * -----
 * This code shows how to create and configure an Amazon Athena client.
 */
public class AthenaClientFactory {
    /**
     * AthenaClientClientBuilder to build Athena with the following properties:
     * - Set the region of the client
     * - Use the instance profile from the EC2 instance as the credentials provider
     * - Configure the client to increase the execution timeout.
     */
    private final AthenaClientBuilder builder = AthenaClient.builder()
        .region(Region.US_WEST_2)
        .credentialsProvider(InstanceProfileCredentialsProvider.create());

    public AthenaClient createClient() {
        return builder.build();
    }
}
```

Start Query Execution

The `StartQueryExample` shows how to submit a query to Athena for execution, wait until the results become available, and then process the results.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.*;
import software.amazon.awssdk.services.athena.paginators.GetQueryResultsIterable;

import java.util.List;
```

```
/**  
 * StartQueryExample  
 * -----  
 * This code shows how to submit a query to Athena for execution, wait till results  
 * are available, and then process the results.  
 */  
public class StartQueryExample {  
    public static void main(String[] args) throws InterruptedException {  
        // Build an AthenaClient client  
        AthenaClientFactory factory = new AthenaClientFactory();  
        AthenaClient athenaClient = factory.createClient();  
  
        String queryExecutionId = submitAthenaQuery(athenaClient);  
  
        waitForQueryToComplete(athenaClient, queryExecutionId);  
  
        processResultRows(athenaClient, queryExecutionId);  
    }  
  
    /**  
     * Submits a sample query to Athena and returns the execution ID of the query.  
     */  
    private static String submitAthenaQuery(AthenaClient athenaClient) {  
        // The QueryExecutionContext allows us to set the Database.  
        QueryExecutionContext queryExecutionContext = QueryExecutionContext.builder()  
            .database(ExampleConstants.ATHENA_DEFAULT_DATABASE).build();  
  
        // The result configuration specifies where the results of the query should go in  
        // S3 and encryption options  
        ResultConfiguration resultConfiguration = ResultConfiguration.builder()  
            // You can provide encryption options for the output that is written.  
            // .withEncryptionConfiguration(encryptionConfiguration)  
            .outputLocation(ExampleConstants.ATHENA_OUTPUT_BUCKET).build();  
  
        // Create the StartQueryExecutionRequest to send to Athena which will start the  
        // query.  
        StartQueryExecutionRequest startQueryExecutionRequest =  
        StartQueryExecutionRequest.builder()  
            .queryString(ExampleConstants.ATHENA_SAMPLE_QUERY)  
            .queryExecutionContext(queryExecutionContext)  
            .resultConfiguration(resultConfiguration).build();  
  
        StartQueryExecutionResponse startQueryExecutionResponse =  
        athenaClient.startQueryExecution(startQueryExecutionRequest);  
        return startQueryExecutionResponse.queryExecutionId();  
    }  
  
    /**  
     * Wait for an Athena query to complete, fail or to be cancelled. This is done by  
     * polling Athena over an  
     * interval of time. If a query fails or is cancelled, then it will throw an exception.  
     */  
  
    private static void waitForQueryToComplete(AthenaClient athenaClient, String  
        queryExecutionId) throws InterruptedException {  
        GetQueryExecutionRequest getQueryExecutionRequest =  
        GetQueryExecutionRequest.builder()  
            .queryExecutionId(queryExecutionId).build();  
  
        GetQueryExecutionResponse getQueryExecutionResponse;  
        boolean isQueryStillRunning = true;  
        while (isQueryStillRunning) {  
            getQueryExecutionResponse =  
            athenaClient.getQueryExecution(getQueryExecutionRequest);  
            String queryState =  
            getQueryExecutionResponse.queryExecution().status().state().toString();
```

```
        if (queryState.equals(QueryExecutionState.FAILED.toString())) {
            throw new RuntimeException("Query Failed to run with Error Message: " +
getQueryExecutionResponse
                .queryExecution().status().stateChangeReason());
        } else if (queryState.equals(QueryExecutionState.CANCELLED.toString())) {
            throw new RuntimeException("Query was cancelled.");
        } else if (queryState.equals(QueryExecutionState.SUCCEEDED.toString())) {
            isQueryStillRunning = false;
        } else {
            // Sleep an amount of time before retrying again.
            Thread.sleep(ExampleConstants.SLEEP_AMOUNT_IN_MS);
        }
        System.out.println("Current Status is: " + queryState);
    }

/**
 * This code calls Athena and retrieves the results of a query.
 * The query must be in a completed state before the results can be retrieved and
 * paginated. The first row of results are the column headers.
 */
private static void processResultRows(AthenaClient athenaClient, String
queryExecutionId) {
    GetQueryResultsRequest getQueryResultsRequest = GetQueryResultsRequest.builder()
        // Max Results can be set but if its not set,
        // it will choose the maximum page size
        // As of the writing of this code, the maximum value is 1000
        // .withMaxResults(1000)
        .queryExecutionId(queryExecutionId).build();

    GetQueryResultsIterable getQueryResultsResults =
athenaClient.getQueryResultsPaginator(getQueryResultsRequest);

    for (GetQueryResultsResponse Resultresult : getQueryResultsResults) {
        List<ColumnInfo> columnInfoList =
Resultresult.resultSet().resultSetMetadata().columnInfo();
        List<Row> results = Resultresult.resultSet().rows();
        processRow(results, columnInfoList);
    }
}

private static void processRow(List<Row> row, List<ColumnInfo> columnInfoList) {
    for (ColumnInfo columnInfo : columnInfoList) {
        switch (columnInfo.type()) {
            case "varchar":
                // Convert and Process as String
                break;
            case "tinyint":
                // Convert and Process as tinyint
                break;
            case "smallint":
                // Convert and Process as smallint
                break;
            case "integer":
                // Convert and Process as integer
                break;
            case "bigint":
                // Convert and Process as bigint
                break;
            case "double":
                // Convert and Process as double
                break;
            case "boolean":
                // Convert and Process as boolean
                break;
            case "date":
```

```
// Convert and Process as date
break;
case "timestamp":
    // Convert and Process as timestamp
    break;
default:
    throw new RuntimeException("Unexpected Type is not expected" +
columnInfo.type());
}
}
}
```

Stop Query Execution

The `StopQueryExecutionExample` runs an example query, immediately stops the query, and checks the status of the query to ensure that it was canceled.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.*;

/**
 * StopQueryExecutionExample
 * -----
 * This code runs an example query, immediately stops the query, and checks the status of
 * the query to
 * ensure that it was cancelled.
 */
public class StopQueryExecutionExample {
    public static void main(String[] args) throws Exception {
        // Build an Athena client
        AthenaClientFactory factory = new AthenaClientFactory();
        AthenaClient athenaClient = factory.createClient();

        String sampleQueryExecutionId = submitAthenaQuery(athenaClient);

        // Submit the stop query Request
        StopQueryExecutionRequest stopQueryExecutionRequest =
StopQueryExecutionRequest.builder()
            .queryExecutionId(sampleQueryExecutionId).build();

        StopQueryExecutionResponse stopQueryExecutionResponse =
athenaClient.stopQueryExecution(stopQueryExecutionRequest);

        // Ensure that the query was stopped
        GetQueryExecutionRequest getQueryExecutionRequest =
GetQueryExecutionRequest.builder()
            .queryExecutionId(sampleQueryExecutionId).build();

        GetQueryExecutionResponse getQueryExecutionResponse =
athenaClient.getQueryExecution(getQueryExecutionRequest);
        if (getQueryExecutionResponse.queryExecution()
            .status()
            .state()
            .equals(QueryExecutionState.CANCELLED)) {
            // Query was cancelled.
            System.out.println("Query has been cancelled");
        }
    }
}
```

```
* Submits an example query and returns a query execution ID of a running query to
stop.
*/
public static String submitAthenaQuery(AthenaClient athenaClient) {
    QueryExecutionContext queryExecutionContext = QueryExecutionContext.builder()
        .database(ExampleConstants.ATHENA_DEFAULT_DATABASE).build();

    ResultConfiguration resultConfiguration = ResultConfiguration.builder()
        .outputLocation(ExampleConstants.ATHENA_OUTPUT_BUCKET).build();

    StartQueryExecutionRequest startQueryExecutionRequest =
StartQueryExecutionRequest.builder()
        .queryExecutionContext(queryExecutionContext)
        .queryString(ExampleConstants.ATHENA_SAMPLE_QUERY)
        .resultConfiguration(resultConfiguration).build();

    StartQueryExecutionResponse startQueryExecutionResponse =
athenaClient.startQueryExecution(startQueryExecutionRequest);

    return startQueryExecutionResponse.queryExecutionId();

}
}
```

List Query Executions

The `ListQueryExecutionsExample` shows how to obtain a list of query execution IDs.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.ListQueryExecutionsRequest;
import software.amazon.awssdk.services.athena.model.ListQueryExecutionsResponse;
import software.amazon.awssdk.services.athena.paginators.ListQueryExecutionsIterable;

import java.util.List;

/**
 * ListQueryExecutionsExample
 * -----
 * This code shows how to obtain a list of query execution IDs.
 */
public class ListQueryExecutionsExample {

    public static void main(String[] args) throws Exception {
        // Build an Athena client
        AthenaClientFactory factory = new AthenaClientFactory();
        AthenaClient athenaClient = factory.createClient();

        // Build the request
        ListQueryExecutionsRequest listQueryExecutionsRequest =
ListQueryExecutionsRequest.builder().build();

        // Get the list results.
        ListQueryExecutionsIterable listQueryExecutionResponses =
athenaClient.listQueryExecutionsPaginator(listQueryExecutionsRequest);

        for (ListQueryExecutionsResponse listQueryExecutionResponse :
listQueryExecutionResponses) {
            List<String> queryExecutionIds =
listQueryExecutionResponse.queryExecutionIds();
            // process queryExecutionIds.
        }
    }
}
```

```
        System.out.println(queryExecutionIds);
    }
}
```

Create a Named Query

The `CreateNamedQueryExample` shows how to create a named query.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.CreateNamedQueryRequest;
import software.amazon.awssdk.services.athena.model.CreateNamedQueryResponse;

/**
 * CreateNamedQueryExample
 * -----
 * This code shows how to create a named query.
 */
public class CreateNamedQueryExample {
    public static void main(String[] args) throws Exception {
        // Build an Athena client
        AthenaClientFactory factory = new AthenaClientFactory();
        AthenaClient athenaClient = factory.createClient();

        // Create the named query request.
        CreateNamedQueryRequest createNamedQueryRequest = CreateNamedQueryRequest.builder()
            .database(ExampleConstants.ATHENA_DEFAULT_DATABASE)
            .queryString(ExampleConstants.ATHENA_SAMPLE_QUERY)
            .description("Sample Description")
            .name("SampleQuery2").build();

        // Call Athena to create the named query. If it fails, an exception is thrown.
        CreateNamedQueryResponse createNamedQueryResult =
        athenaClient.createNamedQuery(createNamedQueryRequest);
    }
}
```

Delete a Named Query

The `DeleteNamedQueryExample` shows how to delete a named query by using the named query ID.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.CreateNamedQueryRequest;
import software.amazon.awssdk.services.athena.model.CreateNamedQueryResponse;
import software.amazon.awssdk.services.athena.model.DeleteNamedQueryRequest;
import software.amazon.awssdk.services.athena.model.DeleteNamedQueryResponse;

/**
 * DeleteNamedQueryExample
 * -----
 * This code shows how to delete a named query by using the named query ID.
 */
public class DeleteNamedQueryExample {
    private static String getNamedQueryId(AthenaClient athenaClient) {
        // Create the NameQuery Request.
    }
}
```

```
CreateNamedQueryRequest createNamedQueryRequest = CreateNamedQueryRequest.builder()
    .database(ExampleConstants.ATHENA_DEFAULT_DATABASE)
    .queryString(ExampleConstants.ATHENA_SAMPLE_QUERY)
    .name("SampleQueryName")
    .description("Sample Description").build();

    // Create the named query. If it fails, an exception is thrown.
    CreateNamedQueryResponse createNamedQueryResponse =
athenaClient.createNamedQuery(createNamedQueryRequest);
    return createNamedQueryResponse.namedQueryId();
}

public static void main(String[] args) throws Exception {
    // Build an Athena client
    AthenaClientFactory factory = new AthenaClientFactory();
    AthenaClient athenaClient = factory.createClient();

    String sampleNamedQueryId = getNamedQueryId(athenaClient);

    // Create the delete named query request
    DeleteNamedQueryRequest deleteNamedQueryRequest = DeleteNamedQueryRequest.builder()
        .namedQueryId(sampleNamedQueryId).build();

    // Delete the named query
    DeleteNamedQueryResponse deleteNamedQueryResponse =
athenaClient.deleteNamedQuery(deleteNamedQueryRequest);
}
}
```

List Named Queries

The `ListNamedQueryExample` shows how to obtain a list of named query IDs.

```
package aws.example.athena;

import software.amazon.awssdk.services.athena.AthenaClient;
import software.amazon.awssdk.services.athena.model.ListNamedQueriesRequest;
import software.amazon.awssdk.services.athena.model.ListNamedQueriesResponse;
import software.amazon.awssdk.services.athena.paginators.ListNamedQueriesIterable;

import java.util.List;

/**
 * ListNamedQueryExample
 * -----
 * This code shows how to obtain a list of named query IDs.
 */
public class ListNamedQueryExample {
    public static void main(String[] args) throws Exception {
        // Build an Athena client
        AthenaClientFactory factory = new AthenaClientFactory();
        AthenaClient athenaClient = factory.createClient();

        // Build the request
        ListNamedQueriesRequest listNamedQueriesRequest =
ListNamedQueriesRequest.builder().build();

        // Get the list results.
        ListNamedQueriesIterable listNamedQueriesResponses =
athenaClient.listNamedQueriesPaginator(listNamedQueriesRequest);

        // Process the results.
    }
}
```

```

    {
        for (ListNamedQueriesResponse listNamedQueriesResponse : listNamedQueriesResponses)
        {
            List<String> namedQueryIds = listNamedQueriesResponse.namedQueryIds();
            // process named query IDs

            System.out.println(namedQueryIds);
        }
    }
}

```

Using Earlier Version JDBC Drivers

We recommend that you use the latest version of the JDBC driver. For information, see [Using Athena with the JDBC Driver \(p. 71\)](#). Links to earlier version 2.x drivers and support materials are below if required for your application.

Earlier Version JDBC Drivers

JDBC Driver Version	Downloads					
2.0.8	JDBC 4.2 and JDK 8.0 Compatible – AthenaJDBC42	2.0.8.jar Release Notes	License Agreement	Notices	Installation and Configuration Guide (PDF)	Migration Guide(PDF)
	JDBC 4.1 and JDK 7.0 Compatible – AthenaJDBC41 -2.0.8.jar					
2.0.7	JDBC 4.2 and JDK 8.0 Compatible – AthenaJDBC42	2.0.7.jar Release Notes	License Agreement	Notices	Installation and Configuration Guide (PDF)	Migration Guide(PDF)
	JDBC 4.1 and JDK 7.0 Compatible – AthenaJDBC41 -2.0.7.jar					
2.0.6	JDBC 4.2 and JDK 8.0 Compatible – AthenaJDBC42	2.0.6.jar Release Notes	License Agreement	Notices	Installation and Configuration Guide (PDF)	Migration Guide(PDF)
	JDBC 4.1 and JDK 7.0 Compatible – AthenaJDBC41 -2.0.6.jar					

JDBC Driver Version	Downloads					
2.0.5	JDBC 4.2 and JDK 8.0 Compatible – AthenaJDBC42-2.0.5.jar	Release Notes	License Agreement	Notices	Installation and Configuration Guide (PDF)	Migration Guide(PDF)
	JDBC 4.1 and JDK 7.0 Compatible – AthenaJDBC41-2.0.5.jar					
2.0.2	JDBC 4.2 and JDK 8.0 Compatible – AthenaJDBC42-2.0.2.jar	Release Notes	License Agreement	Notices	Installation and Configuration Guide (PDF)	Migration Guide(PDF)
	JDBC 4.1 and JDK 7.0 Compatible – AthenaJDBC41-2.0.2.jar					

Instructions for JDBC Driver version 1.1.0

This section includes a link to download version 1.1.0 of the JDBC driver. We highly recommend that you migrate to the current version of the driver. For information, see the [JDBC Driver Migration Guide](#).

The JDBC driver version 1.0.1 and earlier versions are deprecated.

JDBC driver version 1.1.0 is compatible with JDBC 4.1 and JDK 7.0. Use the following link to download the driver: [AthenaJDBC41-1.1.0.jar](#). Also, download the [driver license](#), and the [third-party licenses](#) for the driver. Use the AWS CLI with the following command: `aws s3 cp s3://path_to_the_driver [local_directory]`, and then use the remaining instructions in this section.

Note

The following instructions are specific to JDBC version 1.1.0 and earlier.

JDBC Driver Version 1.1.0: Specify the Connection String

To specify the JDBC driver connection URL in your custom application, use the string in this format:

```
jdbc:awsathena://athena.{REGION}.amazonaws.com:443
```

where {REGION} is a region identifier, such as us-west-2. For information on Athena regions see [Regions](#).

JDBC Driver Version 1.1.0: Specify the JDBC Driver Class Name

To use the driver in custom applications, set up your Java class path to the location of the JAR file that you downloaded from Amazon S3 <https://s3.amazonaws.com/athena-downloads/drivers/JDBC/>

[AthenaJDBC_1.1.0/AthenaJDBC41-1.1.0.jar](#). This makes the classes within the JAR available for use. The main JDBC driver class is `com.amazonaws.athena.jdbc.AthenaDriver`.

JDBC Driver Version 1.1.0: Provide the JDBC Driver Credentials

To gain access to AWS services and resources, such as Athena and the Amazon S3 buckets, provide JDBC driver credentials to your application.

To provide credentials in the Java code for your application:

1. Use a class which implements the [AWSCredentialsProvider](#).
2. Set the JDBC property, `aws_credentials_provider_class`, equal to the class name, and include it in your classpath.
3. To include constructor parameters, set the JDBC property `aws_credentials_provider_arguments` as specified in the following section about configuration options.

Another method to supply credentials to BI tools, such as SQL Workbench, is to supply the credentials used for the JDBC as AWS access key and AWS secret key for the JDBC properties for user and password, respectively.

Users who connect through the JDBC driver and have custom access policies attached to their profiles need permissions for policy actions in addition to those in the [Amazon Athena API Reference](#).

Policies for the JDBC Driver Version 1.1.0

You must allow JDBC users to perform a set of policy-specific actions. If the following actions are not allowed, users will be unable to see databases and tables:

- `athena:GetCatalogs`
- `athena:GetExecutionEngine`
- `athena:GetExecutionEngines`
- `athena:GetNamespace`
- `athena:GetNamespaces`
- `athena:GetTable`
- `athena:GetTables`

JDBC Driver Version 1.1.0: Configure the JDBC Driver Options

You can configure the following options for the version of the JDBC driver version 1.1.0.

With this version of the driver, you can also pass parameters using the standard JDBC URL syntax, for example: `jdbc:awsathena://athena.us-west-1.amazonaws.com:443?max_error_retries=20&connection_timeout=20000`.

Options for the JDBC Driver Version 1.0.1

Property Name	Description	Default Value	Is Required
<code>s3_staging_dir</code>	The S3 location to which your query output is written, for example <code>s3://query-results-bucket/folder/</code> , which is established under Settings in the Athena Console, https://	N/A	Yes

Property Name	Description	Default Value	Is Required
	console.aws.amazon.com/athena/ . The JDBC driver then asks Athena to read the results and provide rows of data back to the user.		
query_results_encrypt	The encryption option to use for the directory specified by <code>s3_staging_dir</code> . If not specified, the location is not encrypted. Valid values are <code>SSE_S3</code> , <code>SSE_KMS</code> , and <code>CSE_KMS</code> .	N/A	No
query_results_aws_kms_key_id	The key ID of the AWS customer master key (CMK) to use if <code>query_results_encryption_option</code> specifies <code>SSE-KMS</code> or <code>CSE-KMS</code> . For example, <code>123abcde-4e56-56f7-g890-1234h5678i9j</code> .	N/A	No
aws_credentials_provider	The credentials provider class name, which implements the <code>AWSCredentialsProvider</code> interface.	N/A	No
aws_credentials_provider_arguments	Arguments for the credentials provider constructor as comma-separated values.	N/A	No
max_error_retries	The maximum number of retries that the JDBC client attempts to make a request to Athena.	10	No
connection_timeout	The maximum amount of time, in milliseconds, to make a successful connection to Athena before an attempt is terminated.	10,000	No
socket_timeout	The maximum amount of time, in milliseconds, to wait for a socket in order to send data to Athena.	10,000	No
retry_base_delay	Minimum delay amount, in milliseconds, between retrying attempts to connect Athena.	100	No
retry_max_backoff_time	Maximum delay amount, in milliseconds, between retrying attempts to connect to Athena.	1000	No
log_path	Local path of the Athena JDBC driver logs. If no log path is provided, then no log files are created.	N/A	No
log_level	Log level of the Athena JDBC driver logs. Valid values: <code>INFO</code> , <code>DEBUG</code> , <code>WARN</code> , <code>ERROR</code> , <code>ALL</code> , <code>OFF</code> , <code>FATAL</code> , <code>TRACE</code> .	N/A	No

Examples: Using the 1.1.0 Version of the JDBC Driver with the JDK

The following code examples demonstrate how to use the JDBC driver version 1.1.0 in a Java application. These examples assume that the AWS JAVA SDK is included in your classpath, specifically the `aws-java-sdk-core` module, which includes the authorization packages (`com.amazonaws.auth.*`) referenced in the examples.

Example Example: Creating a Driver Version 1.0.1

```
Properties info = new Properties();
info.put("user", "AWSAccessKey");
info.put("password", "AWSSecretAccessKey");
info.put("s3_staging_dir", "s3://S3 Bucket Location");

info.put("aws_credentials_provider_class", "com.amazonaws.auth.DefaultAWSCredentialsProviderChain");

Class.forName("com.amazonaws.athena.jdbc.AthenaDriver");

Connection connection = DriverManager.getConnection("jdbc:awsathena://athena.us-east-1.amazonaws.com:443/", info);
```

The following examples demonstrate different ways to use a credentials provider that implements the `AWSCredentialsProvider` interface with the previous version of the JDBC driver.

Example Example: Using a Credentials Provider for JDBC Driver 1.0.1

```
Properties myProps = new Properties();

myProps.put("aws_credentials_provider_class", "com.amazonaws.auth.PropertiesFileCredentialsProvider");
myProps.put("aws_credentials_provider_arguments", "/Users/
myUser/.athenaCredentials");
```

In this case, the file `/Users/myUser/.athenaCredentials` should contain the following:

```
accessKey = ACCESSKEY
secretKey = SECRETKEY
```

Replace the right part of the assignments with your account's AWS access and secret keys.

Example Example: Using a Credentials Provider with Multiple Arguments

This example shows an example credentials provider, `CustomSessionsCredentialsProvider`, that uses an access and secret key in addition to a session token. `CustomSessionsCredentialsProvider` is shown for example only and is not included in the driver. The signature of the class looks like the following:

```
public CustomSessionsCredentialsProvider(String accessId, String secretKey, String token)
{
    //...
}
```

You would then set the properties as follows:

```
Properties myProps = new Properties();

myProps.put("aws_credentials_provider_class", "com.amazonaws.athena.jdbc.CustomSessionsCredentialsProvider");
String providerArgs = "My_Access_Key," + "My_Secret_Key," + "My_Token";
myProps.put("aws_credentials_provider_arguments", providerArgs);
```

Note

If you use the `InstanceProfileCredentialsProvider`, you don't need to supply any credential provider arguments because they are provided using the Amazon EC2 instance profile for the instance on which you are running your application. You would still set the `aws_credentials_provider_class` property to this class name, however.

Policies for the JDBC Driver Earlier than Version 1.1.0

Use these deprecated actions in policies **only** with JDBC drivers **earlier than version 1.1.0**. If you are upgrading the JDBC driver, replace policy statements that allow or deny deprecated actions with the appropriate API actions as listed or errors will occur.

Deprecated Policy-Specific Action	Corresponding Athena API Action
athena:RunQuery	athena:StartQueryExecution
athena:CancelQueryExecution	athena:StopQueryExecution
athena:GetQueryExecutions	athena>ListQueryExecutions

Service Limits

Note

You can contact AWS Support to [request a limit increase](#) for the limits listed here.

- By default, limits on your account allow you to submit:
 - 20 DDL queries at the same time. DDL queries include `CREATE TABLE` and `CREATE TABLE ADD PARTITION` queries.
 - 20 DML queries at the same time. DML queries include `SELECT` and `CREATE TABLE AS (CTAS)` queries.

After you submit your queries to Athena, it processes the queries by assigning resources based on the overall service load and the amount of incoming requests. We continuously monitor and make adjustments to the service so that your queries process as fast as possible.

Athena service limits are shared across all workgroups in the account.

These are soft limits and you can [request a limit increase](#). These limits in Athena are defined as the number of queries that can be submitted to the service at the same time. You can submit up to 20 queries of the same type (DDL or DML) at a time. If you submit a query that exceeds the query limit, the Athena API displays an error message: "You have exceeded the limit for the number of queries you can run concurrently. Reduce the number of concurrent queries submitted by this account. Contact customer support to request a concurrent query limit increase."

- If you use Athena in regions where AWS Glue is available, migrate to AWS Glue Data Catalog. See [Upgrading to the AWS Glue Data Catalog Step-by-Step \(p. 56\)](#).
- If you have migrated to AWS Glue Data Catalog, for service limits on tables, databases, and partitions in Athena, see [AWS Glue Limits](#).
- If you have *not* migrated to AWS Glue Data Catalog, the number of partitions per table is 20,000. You can [request a limit increase](#).
- You may encounter a limit for Amazon S3 buckets per account, which is 100. Athena also needs a separate bucket to log results.
- The query timeout is 30 minutes.
- The maximum allowed query string length is 262144 bytes, where the strings are encoded in UTF-8. Use these [tips \(p. 32\)](#) for naming columns, tables, and databases in Athena.
- The maximum number of workgroups you can create per Region in your account is 1000.

- Athena APIs have the following default limits for the number of calls to the API per account (not per query):

API Name	Default Number of Calls per Second	Burst Capacity
<code>BatchGetNamedQuery</code> , <code>ListNamedQueries</code> , <code>ListQueryExecutions</code>	5	up to 10
<code>CreateNamedQuery</code> , <code>DeleteNamedQuery</code> , <code>GetNamedQuery</code>	5	up to 20
<code>BatchGetQueryExecution</code>	20	up to 40
<code>StartQueryExecution</code> , <code>StopQueryExecution</code>	20	up to 80
<code>GetQueryExecution</code> , <code>GetQueryResults</code>	100	up to 200

For example, for `StartQueryExecution`, you can make up to 20 calls per second. In addition, if this API is not called for 4 seconds, your account accumulates a *burst capacity* of up to 80 calls. In this case, your application can make up to 80 calls to this API in burst mode.

If you use any of these APIs and exceed the default limit for the number of calls per second, or the burst capacity in your account, the Athena API issues an error similar to the following: ""ClientError: An error occurred (ThrottlingException) when calling the <API_name> operation: Rate exceeded." Reduce the number of calls per second, or the burst capacity for the API for this account. You can contact AWS Support to [request a limit increase](#).

Document History

Latest documentation update: September 18, 2019.

Change	Description	Release Date
Added section for new INSERT INTO command and updated query result location information for supporting data manifest files.	For more information, see INSERT INTO (p. 303) and Working with Query Results, Output Files, and Query History (p. 107) .	September 18, 2019
Added section for interface VPC endpoints (PrivateLink) support. Updated JDBC drivers. Updated information on enriched VPC flow logs.	For more information, see Connect to Amazon Athena Using an Interface VPC Endpoint (p. 231) , Querying Amazon VPC Flow Logs (p. 191) , and Using Athena with the JDBC Driver (p. 71) .	September 11, 2019
Added section on integrating with AWS Lake Formation.	For more information, see Using Athena to Query Data Registered With AWS Lake Formation (p. 232) .	June 26, 2019
Updated Security section for consistency with other AWS services.	For more information, see Amazon Athena Security (p. 196) .	June 26, 2019
Added section on querying AWS WAF logs.	For more information, see Querying AWS WAF Logs (p. 193) .	May 31, 2019
Released the new version of the ODBC driver with support for Athena workgroups.	<p>To download the ODBC driver version 1.0.5 and its documentation, see Connecting to Amazon Athena with ODBC (p. 73). For information about this version, see the ODBC Driver Release Notes.</p> <p>For more information, search for "workgroup" in the ODBC Driver Installation and Configuration Guide version 1.0.5. There are no changes to the ODBC driver connection string when you use tags on workgroups. To use tags, upgrade to the latest version of the ODBC driver, which is this current version.</p> <p>This driver version lets you use Athena API workgroup actions (p. 254) to create and manage workgroups, and Athena API tag actions (p. 265) to add, list, or remove tags on workgroups. Before you begin, make sure that you have</p>	March 5, 2019

Change	Description	Release Date
	resource-level permissions in IAM for actions on workgroups and tags.	
Added tag support for workgroups in Amazon Athena.	<p>A tag consists of a key and a value, both of which you define. When you tag a workgroup, you assign custom metadata to it. You can add tags to workgroups to help categorize them, using AWS tagging best practices. You can use tags to restrict access to workgroups, and to track costs. For example, create a workgroup for each cost center. Then, by adding tags to these workgroups, you can track your Athena spending for each cost center. For more information, see Using Tags for Billing in the AWS Billing and Cost Management User Guide.</p>	February 22, 2019
Improved the JSON OpenX SerDe used in Athena.	<p>The improvements include, but are not limited to, the following:</p> <ul style="list-style-type: none"> • Support for the <code>ConvertDotsInJsonKeysToUnderscores</code> property. When set to <code>TRUE</code>, it allows the SerDe to replace the dots in key names with underscores. For example, if the JSON dataset contains a key with the name "<code>a.b</code>", you can use this property to define the column name to be "<code>a_b</code>" in Athena. The default is <code>FALSE</code>. By default, Athena does not allow dots in column names. • Support for the <code>case.insensitive</code> property. By default, Athena requires that all keys in your JSON dataset use lowercase. Using <code>WITH SERDE PROPERTIES ("case.insensitive"= FALSE;)</code> allows you to use case-sensitive key names in your data. The default is <code>TRUE</code>. When set to <code>TRUE</code>, the SerDe converts all uppercase columns to lowercase. <p>For more information, see the section called "OpenX JSON SerDe" (p. 286).</p>	February 18, 2019
Added support for workgroups.	<p>Use workgroups to separate users, teams, applications, or workloads, and to set limits on amount of data each query or the entire workgroup can process. Because workgroups act as IAM resources, you can use resource-level permissions to control access to a specific workgroup. You can also view query-related metrics in Amazon CloudWatch, control query costs by configuring limits on the amount of data scanned, create thresholds, and trigger actions, such as Amazon SNS alarms, when these thresholds are breached. For more information, see Using Workgroups for Running Queries (p. 239) and Controlling Costs and Monitoring Queries with CloudWatch Metrics (p. 256).</p>	February 18, 2019

Change	Description	Release Date
Added support for analyzing logs from Network Load Balancer.	Added example Athena queries for analyzing logs from Network Load Balancer. These logs receive detailed information about the Transport Layer Security (TLS) requests sent to the Network Load Balancer. You can use these access logs to analyze traffic patterns and troubleshoot issues. For information, see the section called "Querying Network Load Balancer Logs" (p. 188) .	January 24, 2019
Released the new versions of the JDBC and ODBC driver with support for federated access to Athena API with the AD FS and SAML 2.0 (Security Assertion Markup Language 2.0).	With this release of the drivers, federated access to Athena is supported for the Active Directory Federation Service (AD FS 3.0). Access is established through the versions of JDBC or ODBC drivers that support SAML 2.0. For information about configuring federated access to the Athena API, see the section called "Enabling Federated Access to the Athena API" (p. 226) .	November 10, 2018
Added support for fine-grained access control to databases and tables in Athena. Additionally, added policies in Athena that allow you to encrypt database and table metadata in the Data Catalog.	Added support for creating identity-based (IAM) policies that provide fine-grained access control to resources in the AWS Glue Data Catalog, such as databases and tables used in Athena. Additionally, you can encrypt database and table metadata in the Data Catalog, by adding specific policies to Athena. For details, see Access Control Policies .	October 15, 2018
Added support for CREATE TABLE AS SELECT statements. Made other improvements in the documentation.	Added support for CREATE TABLE AS SELECT statements. See Creating a Table from Query Results (p. 118) , Considerations and Limitations (p. 118) , and Examples (p. 123) .	October 10, 2018
Released the ODBC driver version 1.0.3 with support for streaming results instead of fetching them in pages. Made other improvements in the documentation.	The ODBC driver version 1.0.3 supports streaming results and also includes improvements, bug fixes, and an updated documentation for "Using SSL with a Proxy Server". For details, see the Release Notes for the driver. For downloading the ODBC driver version 1.0.3 and its documentation, see Connecting to Amazon Athena with ODBC (p. 73) .	September 6, 2018

Change	Description	Release Date
<p>Released the JDBC driver version 2.0.5 with default support for streaming results instead of fetching them in pages.</p> <p>Made other improvements in the documentation.</p>	<p>Released the JDBC driver 2.0.5 with default support for streaming results instead of fetching them in pages. For information, see Using Athena with the JDBC Driver (p. 71).</p> <p>For information about streaming results, search for UseResultSetStreaming in the JDBC Driver Installation and Configuration Guide.</p>	August 16, 2018
<p>Updated the documentation for querying Amazon Virtual Private Cloud flow logs, which can be stored directly in Amazon S3 in a GZIP format.</p> <p>Updated examples for querying ALB logs.</p>	<p>Updated the documentation for querying Amazon Virtual Private Cloud flow logs, which can be stored directly in Amazon S3 in a GZIP format. For information, see Querying Amazon VPC Flow Logs (p. 191).</p> <p>Updated examples for querying ALB logs. For information, see Querying Application Load Balancer Logs (p. 189).</p>	August 7, 2018
<p>Added support for views. Added guidelines for schema manipulations for various data storage formats.</p>	<p>Added support for views. For information, see Working with Views (p. 113).</p> <p>Updated this guide with guidance on handling schema updates for various data storage formats. For information, see Handling Schema Updates (p. 126).</p>	June 5, 2018
<p>Increased default query concurrency limits from five to twenty.</p>	<p>You can submit and run up to twenty DDL queries and twenty SELECT queries at a time. For information, see Service Limits (p. 339).</p>	May 17, 2018
<p>Added query tabs, and an ability to configure auto-complete in the Query Editor.</p>	<p>Added query tabs, and an ability to configure auto-complete in the Query Editor. For information, see Using the Console (p. 27).</p>	May 8, 2018
<p>Released the JDBC driver version 2.0.2.</p>	<p>Released the new version of the JDBC driver (version 2.0.2). For information, see Using Athena with the JDBC Driver (p. 71).</p>	April 19, 2018
<p>Added auto-complete for typing queries in the Athena console.</p>	<p>Added auto-complete for typing queries in the Athena console.</p>	April 6, 2018

Change	Description	Release Date
Added an ability to create Athena tables for CloudTrail log files directly from the CloudTrail console.	Added an ability to automatically create Athena tables for CloudTrail log files directly from the CloudTrail console. For information, see Creating a Table for CloudTrail Logs in the CloudTrail Console (p. 180) .	March 15, 2018
Added support for securely offloading intermediate data to disk for queries with GROUP BY.	Added an ability to securely offload intermediate data to disk for memory-intensive queries that use the GROUP BY clause. This improves the reliability of such queries, preventing "Query resource exhausted" errors. For more information, see the release note for February 2, 2018 (p. 14) .	February 2, 2018
Added support for Presto version 0.172.	Upgraded the underlying engine in Amazon Athena to a version based on Presto version 0.172. For more information, see the release note for January 19, 2018 (p. 14) .	January 19, 2018
Added support for the ODBC Driver.	Added support for connecting Athena to the ODBC Driver. For information, see Connecting to Amazon Athena with ODBC .	November 13, 2017
Added support for Asia Pacific (Seoul), Asia Pacific (Mumbai), and EU (London) regions. Added support for querying geospatial data.	Added support for querying geospatial data, and for Asia Pacific (Seoul), Asia Pacific (Mumbai), EU (London) regions. For information, see Querying Geospatial Data and AWS Regions and Endpoints .	November 1, 2017
Added support for EU (Frankfurt).	Added support for EU (Frankfurt). For a list of supported regions, see AWS Regions and Endpoints .	October 19, 2017
Added support for named Athena queries with AWS CloudFormation.	Added support for creating named Athena queries with AWS CloudFormation. For more information, see AWS::Athena::NamedQuery in the AWS CloudFormation User Guide .	October 3, 2017
Added support for Asia Pacific (Sydney).	Added support for Asia Pacific (Sydney). For a list of supported regions, see AWS Regions and Endpoints .	September 25, 2017
Added a section to this guide for querying AWS Service logs and different types of data, including maps, arrays, nested data, and data containing JSON.	Added examples for Querying AWS Service Logs (p. 178) and for querying different types of data in Athena. For information, see Running SQL Queries Using Amazon Athena (p. 76) .	September 5, 2017

Change	Description	Release Date
Added support for AWS Glue Data Catalog.	Added integration with the AWS Glue Data Catalog and a migration wizard for updating from the Athena managed data catalog to the AWS Glue Data Catalog. For more information, see Integration with AWS Glue and AWS Glue .	August 14, 2017
Added support for Grok SerDe.	Added support for Grok SerDe, which provides easier pattern matching for records in unstructured text files such as logs. For more information, see Grok SerDe . Added keyboard shortcuts to scroll through query history using the console (CTRL + ↑/↓ using Windows, CMD + ↑/↓ using Mac).	August 4, 2017
Added support for Asia Pacific (Tokyo).	Added support for Asia Pacific (Tokyo) and Asia Pacific (Singapore). For a list of supported regions, see AWS Regions and Endpoints .	June 22, 2017
Added support for EU (Ireland).	Added support for EU (Ireland). For more information, see AWS Regions and Endpoints .	June 8, 2017
Added an Amazon Athena API and AWS CLI support.	Added an Amazon Athena API and AWS CLI support for Athena. Updated JDBC driver to version 1.1.0.	May 19, 2017
Added support for Amazon S3 data encryption.	Added support for Amazon S3 data encryption and released a JDBC driver update (version 1.0.1) with encryption support, improvements, and bug fixes. For more information, see Encryption at Rest (p. 197) .	April 4, 2017
Added the AWS CloudTrail SerDe.	Added the AWS CloudTrail SerDe, improved performance, fixed partition issues. For more information, see CloudTrail SerDe (p. 278) . <ul style="list-style-type: none"> • Improved performance when scanning a large number of partitions. • Improved performance on <code>MSCK Repair Table</code> operation. • Added ability to query Amazon S3 data stored in regions other than your primary region. Standard inter-region data transfer rates for Amazon S3 apply in addition to standard Athena charges. 	March 24, 2017
Added support for US East (Ohio).	Added support for Avro SerDe (p. 275) and OpenCSVSerDe for Processing CSV (p. 280) , US East (Ohio), and bulk editing columns in the console wizard. Improved performance on large Parquet tables.	February 20, 2017
	The initial release of the <i>Amazon Athena User Guide</i> .	November, 2016

AWS Glossary

For the latest AWS terminology, see the [AWS Glossary](#) in the *AWS General Reference*.