Amazon Athena

User Guide

Amazon Athena: User Guide

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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?

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. 43).

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. 28) 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. 43) andConnecting to Amazon Athena with ODBC (p. 44).
- 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. 28). 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. 29).

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. 135)	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. 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, seeCreating a Table for CloudTrail Logs in the CloudTrail Console (p. 136).
Amazon CloudFront	Querying Amazon CloudFront Logs (p. 139)	Use Athena to query Amazon CloudFront.
Elastic Load Balancing	• Querying Application Load Balancer Logs (p. 143) • Querying Classic Load Balancer Logs (p. 140)	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. 143) 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,

AWS Service	Topic	Description
		latency, and bytes transferred. See Creating the Table for ELB Logs (p. 141).
Amazon Virtual Private Cloud	Querying Amazon VPC Flow Logs (p. 145)	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 *AWS CloudFormation User Guide*.	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 *Amazon Athena API Reference*, and AWS::Athena::NamedQuery in the *AWS CloudFormation User Guide*.
AWS Glue Data Catalog	Integration with AWS Glue (p. 28)	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. 28) and What is AWS Glue in the *AWS Glue Developer Guide*.

AWS Service	Topic	Description
Amazon QuickSight	Connecting to Amazon Athena with ODBC and JDBC Drivers (p. 43)	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. 43).
IAM	Actions for Amazon Athena	You can use Athena API actions in IAM permission policies. See Actions for Amazon Athena and Access Control Policies (p. 47).

Release Notes

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

Contents

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. 44). 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. 172) to create and manage workgroups, and Athena API tag actions (p. 183) 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. 158) and Workgroup Example Policies (p. 162).
- Tagging Workgroups (p. 180) and Tag-Based IAM Access Control Policies (p. 184).

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. 43).

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. 180).

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. 180).

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. 184).

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. 43).

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. 158). 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. 158) and Controlling Costs and Monitoring Queries with CloudWatch Metrics (p. 174).

  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. 161), and the **AmazonAthenaFullAccess** Managed Policy (p. 48).

  You can start using workgroups in the console, with the workgroup API operations (p. 172), or with the JDBC driver. For a high-level procedure, see Setting up Workgroups (p. 160). To download the JDBC driver with workgroup support, see Using Athena with the JDBC Driver (p. 43).

  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. 172) and Troubleshooting Workgroups (p. 172).

- 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. 204).
- 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. 68) 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. 142).

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 Athena API” (p. 59).

To download the JDBC driver version 2.0.6 and its documentation, see Using Athena with the JDBC Driver (p. 43). 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. 44). 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. 58).
- 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. 51).

  Note
  Data resides in the Amazon S3 buckets, and access to it is governed by the Amazon S3 Permissions (p. 51). 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. 91).

Use CTAS queries to:

- Create a table from query results (p. 91) in one step.
- Create CTAS queries in the Athena console (p. 93), using Examples (p. 97). For information about syntax, see CREATE TABLE AS (p. 226).
- 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. 91) and Columnar Storage Formats (p. 78).

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. 44).

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. 50).

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. 217).

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. 43).

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. 50). 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. 249), 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. 145) and Amazon VPC Flow Logs can now be delivered to S3.

June 5, 2018

Published on *2018-06-05*

Topics

Support for Views

Added support for views. You can now use CREATE VIEW (p. 228), DESCRIBE VIEW (p. 229), DROP VIEW (p. 230), SHOW CREATE VIEW (p. 232), and SHOW VIEWS (p. 234) in Athena. The query that defines the view runs each time you reference the view in your query. For more information, see Views (p. 86).

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. 148).
- 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. 253). 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. 43).

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. 249).

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. 136).

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. 234) in this guide, and Presto 0.172 Functions.

Athena does not support all of Presto's features. For more information, see Limitations (p. 239).

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. 44).

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. 123) 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. 28).

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. 200). 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. 43).

- 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 Configuring Encryption Options (p. 62).

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. 249) for the previous version of the driver, and Connect with the JDBC (p. 43), 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. 196). 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`.

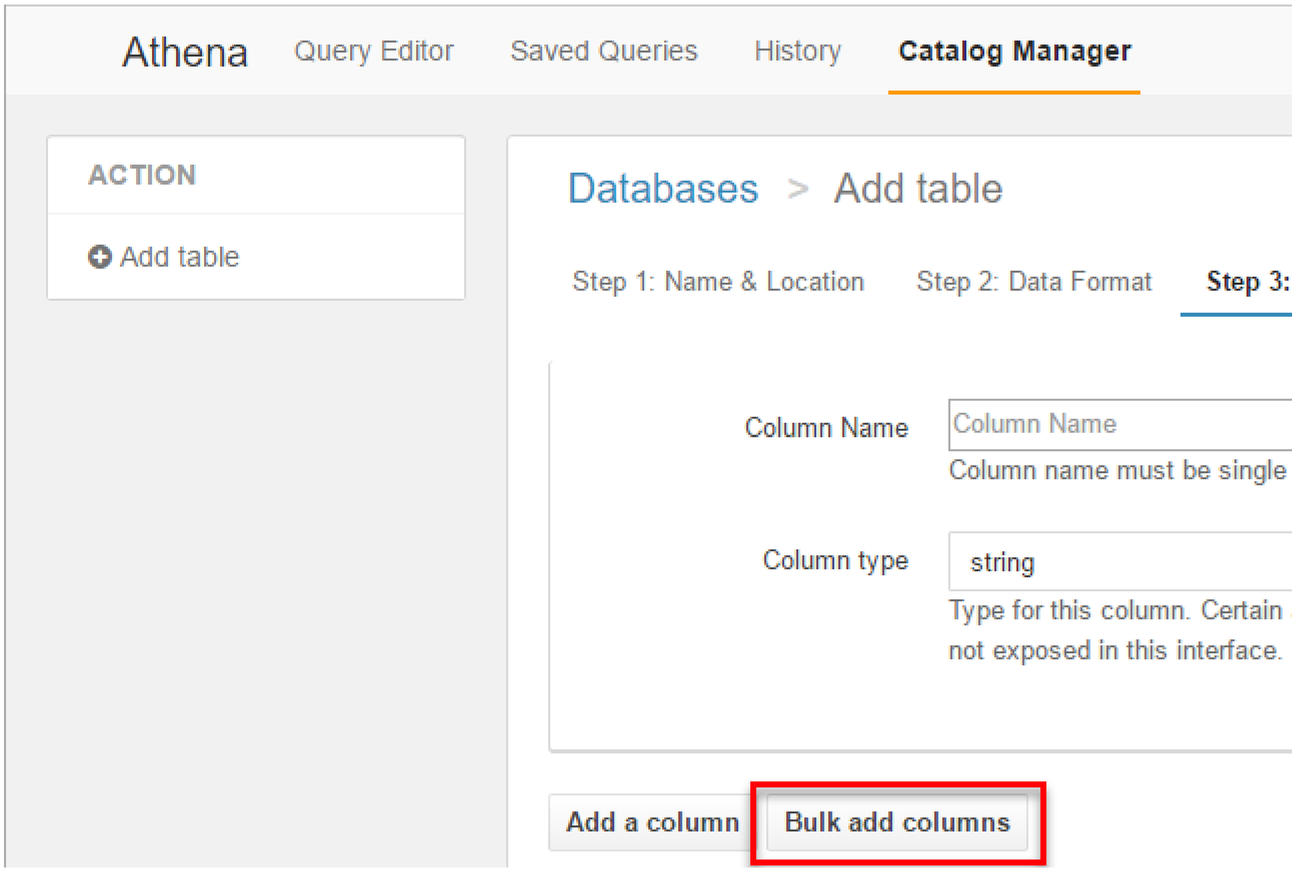
February 20, 2017

Published on *2017-02-20*

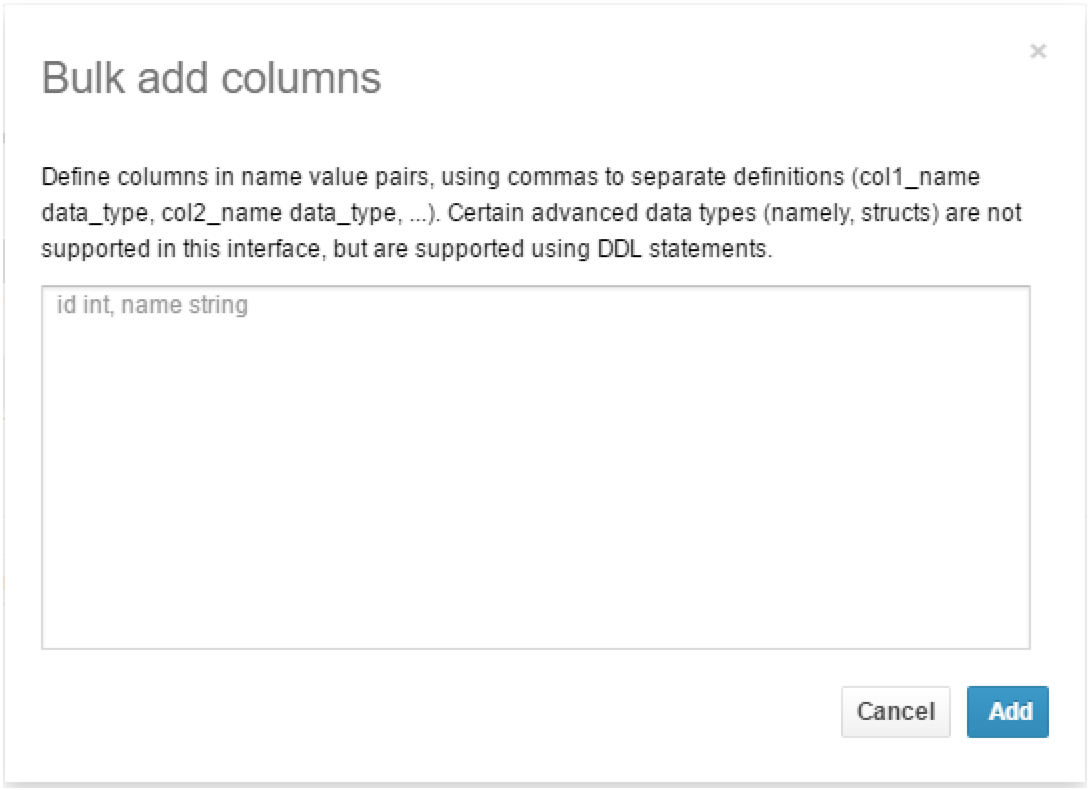
Added support for AvroSerDe and OpenCSVSerDe, US East (Ohio) Region, and bulk editing columns in the console wizard. Improved performance on large Parquet tables.

Features

- **Introduced support for new SerDes:**
  - Avro SerDe (p. 193)
  - OpenCSVSerDe for Processing CSV (p. 198)
- **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.



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



Bulk add columns

Define columns in name value pairs, using commas to separate definitions (col1_name data_type, col2_name data_type, ...). Certain advanced data types (namely, structs) are not supported in this interface, but are supported using DDL statements.

id int, name string

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. 47).

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. 51). If the dataset or Athena query results are encrypted, you may need additional permissions. For more information, see Configuring Encryption Options (p. 62).

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

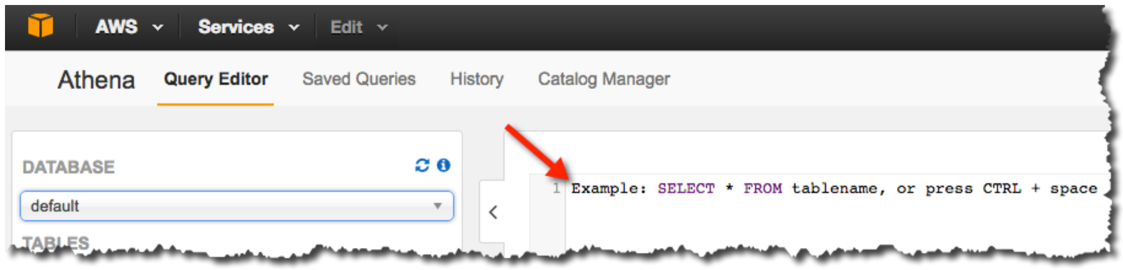
If you have not already done so, sign up for an account in Setting Up (p. 21).

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.

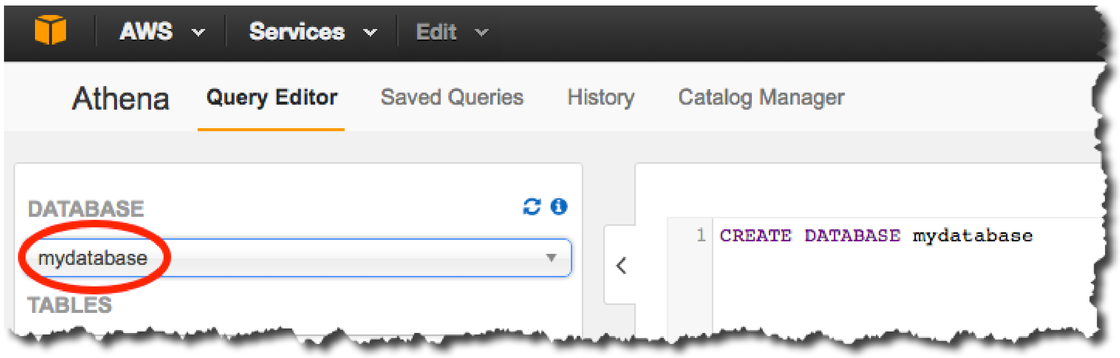


```
Example: SELECT * FROM tablename, or press CTRL + space
```

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.



```
CREATE DATABASE mydatabase
```

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.

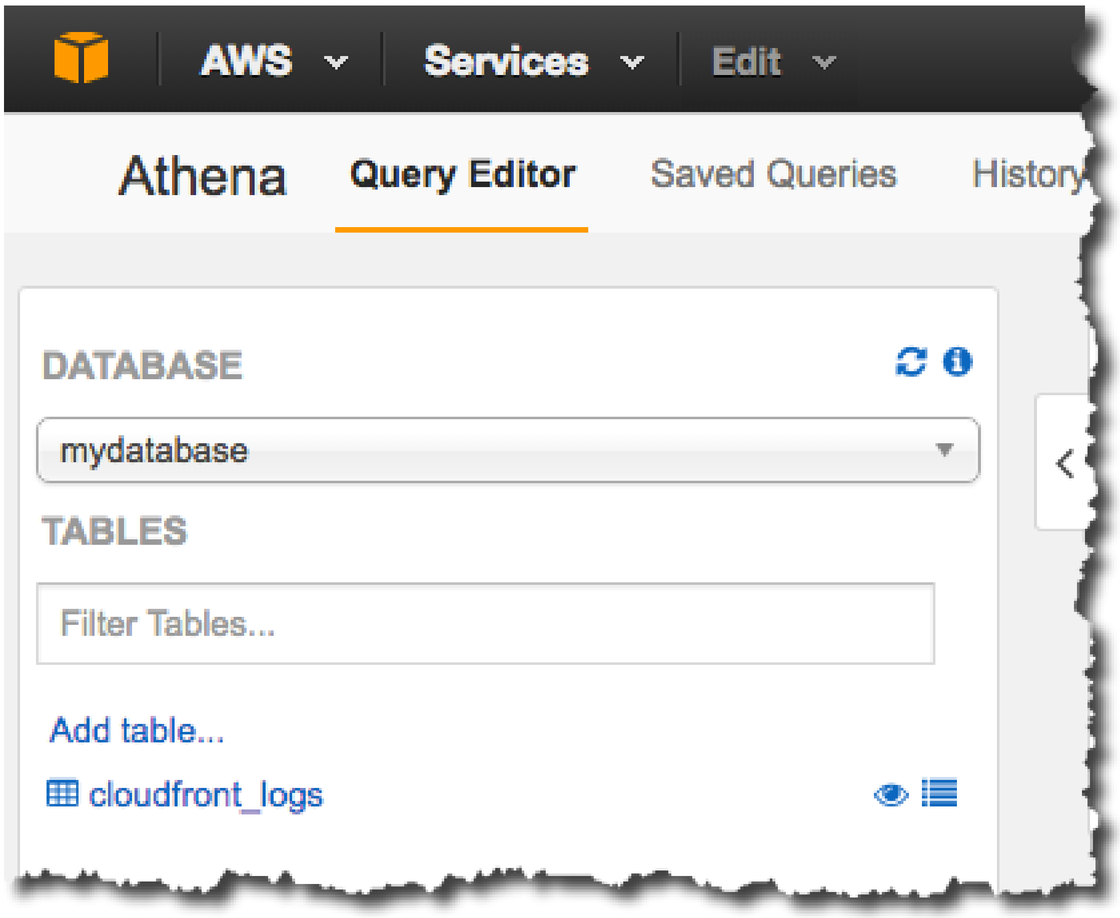
To create a table

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/`.

```
CREATE EXTERNAL TABLE IF NOT EXISTS 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
+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+[^\(]+[\(]([^\;]+).*\%20([^
\/]+)[\/](.*)$"
  ) LOCATION 's3://athena-examples-myregion/cloudfront/plaintext/';
```

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



Step 3: Query Data

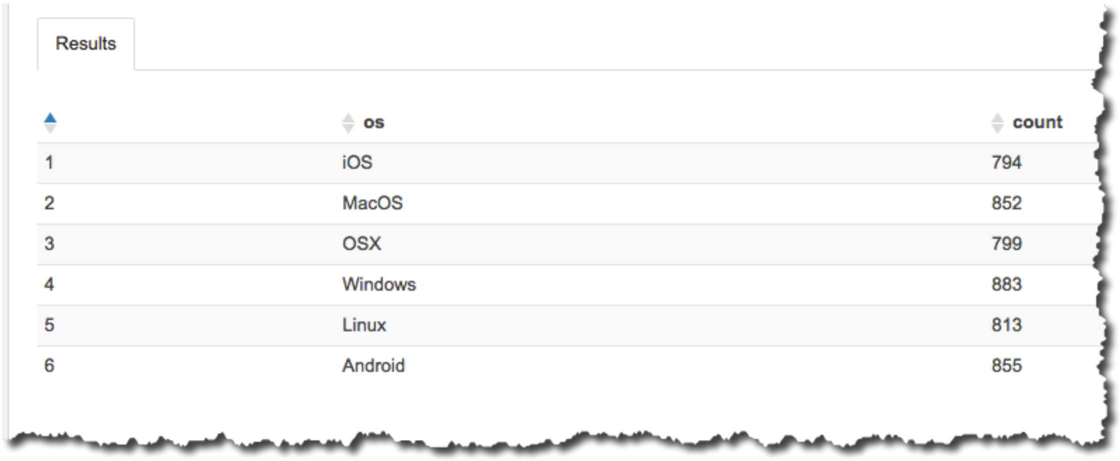
Now that you have the `cloudfront_logs` table created in Athena based on the data in Amazon S3, you can run queries on the table and see the results in Athena.

To run a query

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

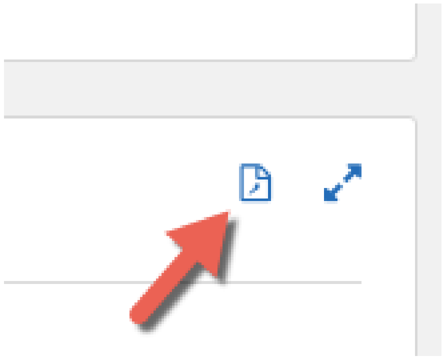
```
SELECT os, COUNT(*) count
FROM cloudfront_logs
WHERE date BETWEEN date '2014-07-05' AND date '2014-08-05'
GROUP BY os;
```

   Results are returned that look like the following:

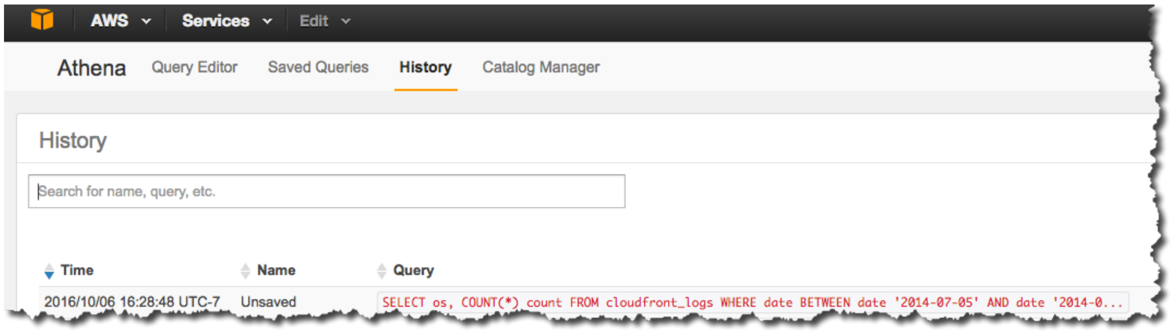


	os	count
1	iOS	794
2	MacOS	852
3	OSX	799
4	Windows	883
5	Linux	813
6	Android	855

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



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. 85).



Time	Name	Query
2016/10/06 16:28:48 UTC-7	Unsaved	SELECT os, COUNT(*) count FROM cloudfront_logs WHERE date BETWEEN date '2014-07-05' AND date '2014-0...

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. 83).

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. 241).

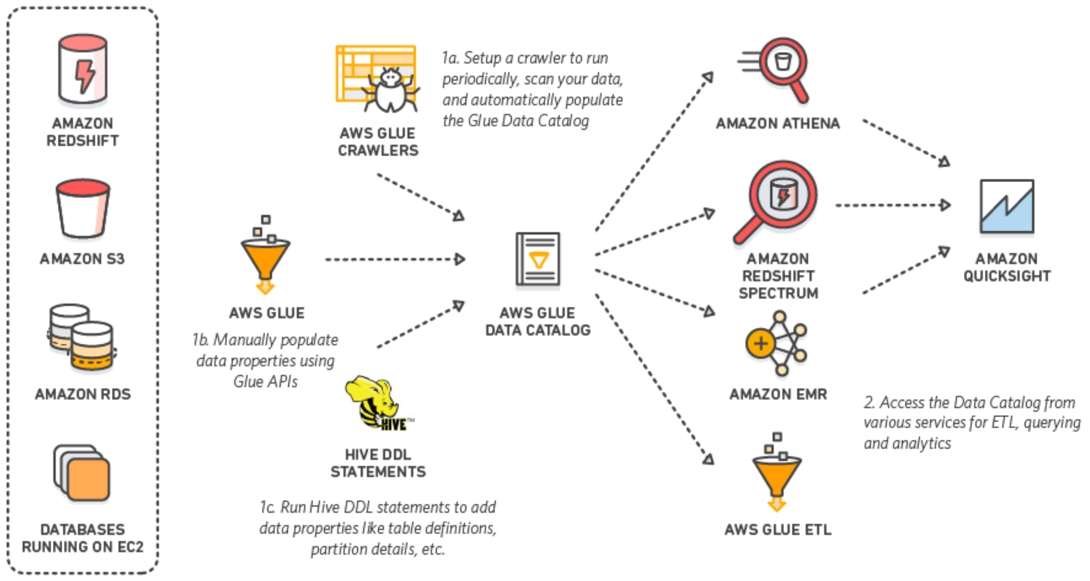
For more information about AWS SDK for Java documentation and downloads, see the *SDKs* section in Tools for Amazon Web Services.

Using the CLI

You can access Amazon Athena using the AWS CLI. For more information, see the AWS CLI Reference for Athena.

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 source data, storing the associated metadata in the AWS Glue Data Catalog. When you create a table in Athena, you can choose to create it using an AWS Glue crawler.


AMAZON REDSHIFT
AMAZON S3
AMAZON RDS
DATABASES RUNNING ON EC2
AWS GLUE CRAWLERS
1a. Setup a crawler to run periodically, scan your data, and automatically populate the Glue Data Catalog
AWS GLUE
1b. Manually populate data properties using Glue APIs
HIVE DDL STATEMENTS
1c. Run Hive DDL statements to add data properties like table definitions, partition details, etc.
AWS GLUE DATA CATALOG
AMAZON ATHENA
AMAZON REDSHIFT SPECTRUM
AMAZON EMR
AWS GLUE ETL
AMAZON QUICKSIGHT
2. Access the Data Catalog from various services for ETL, querying and analytics

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. 32) For more information about the benefits of using AWS Glue with Athena, see Why should I upgrade to the AWS Glue Data Catalog? (p. 31)

Topics

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. 31). 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. 33).

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": [ "*" ]
        }
     ]
 }
```

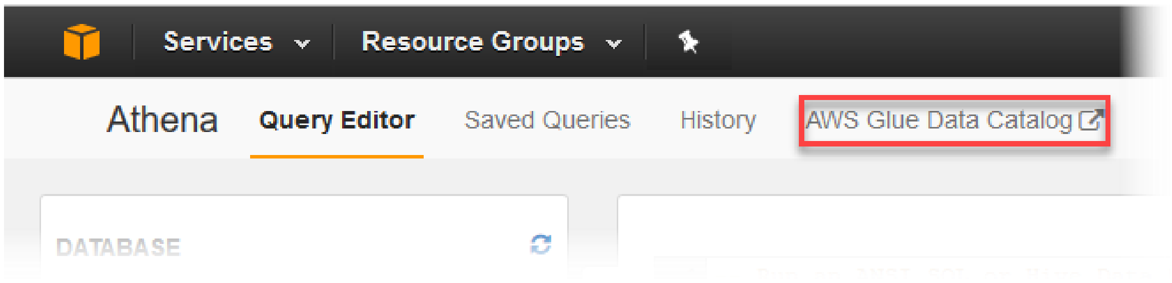
Step 2 - Update Customer-Managed/Inline Policies Associated with Athena Users

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. 47).

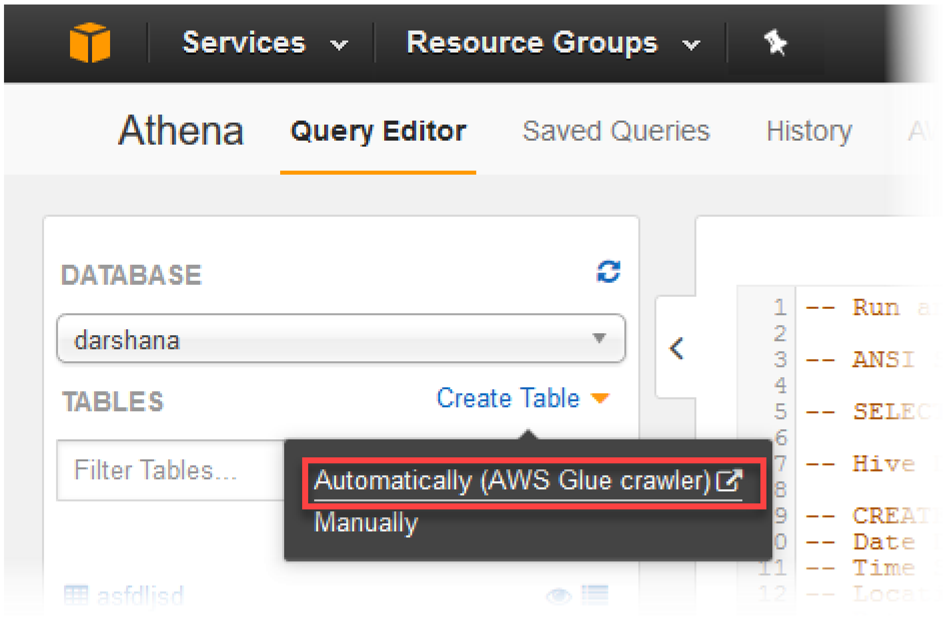
```
{
  "Effect":"Allow",
  "Action":[
    "glue:CreateDatabase",
    "glue:DeleteDatabase",
    "glue:GetDatabase",
    "glue:GetDatabases",
    "glue:UpdateDatabase",
    "glue:CreateTable",
    "glue:DeleteTable",
    "glue:BatchDeleteTable",
    "glue:UpdateTable",
    "glue:GetTable",
    "glue:GetTables",
    "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. 34).



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?

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. 29).

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. 29).

Is there risk of data loss during the upgrade?

No.

Is my data also moved during this upgrade?

No. The migration only affects metadata.

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 conventions to follow so that Athena and AWS Glue work well together.

In this topic

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.

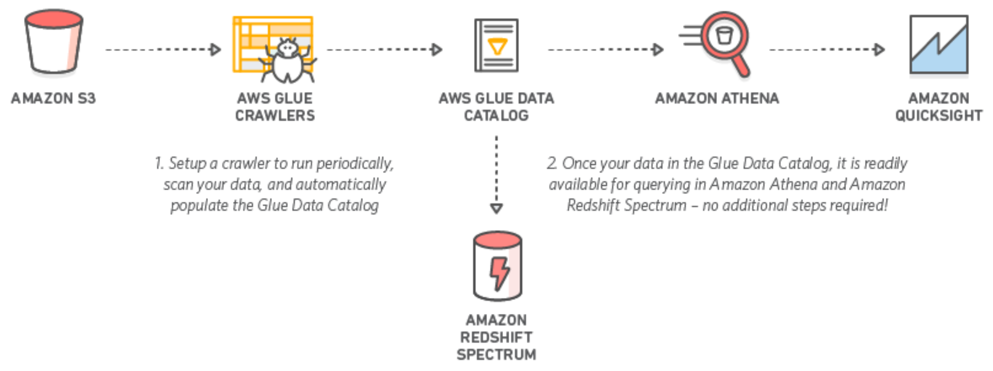
Using AWS Glue Crawlers

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*.


AMAZON S3
AWS GLUE CRAWLERS
AWS GLUE DATA CATALOG
AMAZON ATHENA
AMAZON QUICKSIGHT
1. Setup a crawler to run periodically, scan your data, and automatically populate the Glue Data Catalog
2. Once your data in the Glue Data Catalog, it is readily available for querying in Amazon Athena and Amazon Redshift Spectrum – no additional steps required!
AMAZON REDSHIFT SPECTRUM

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:

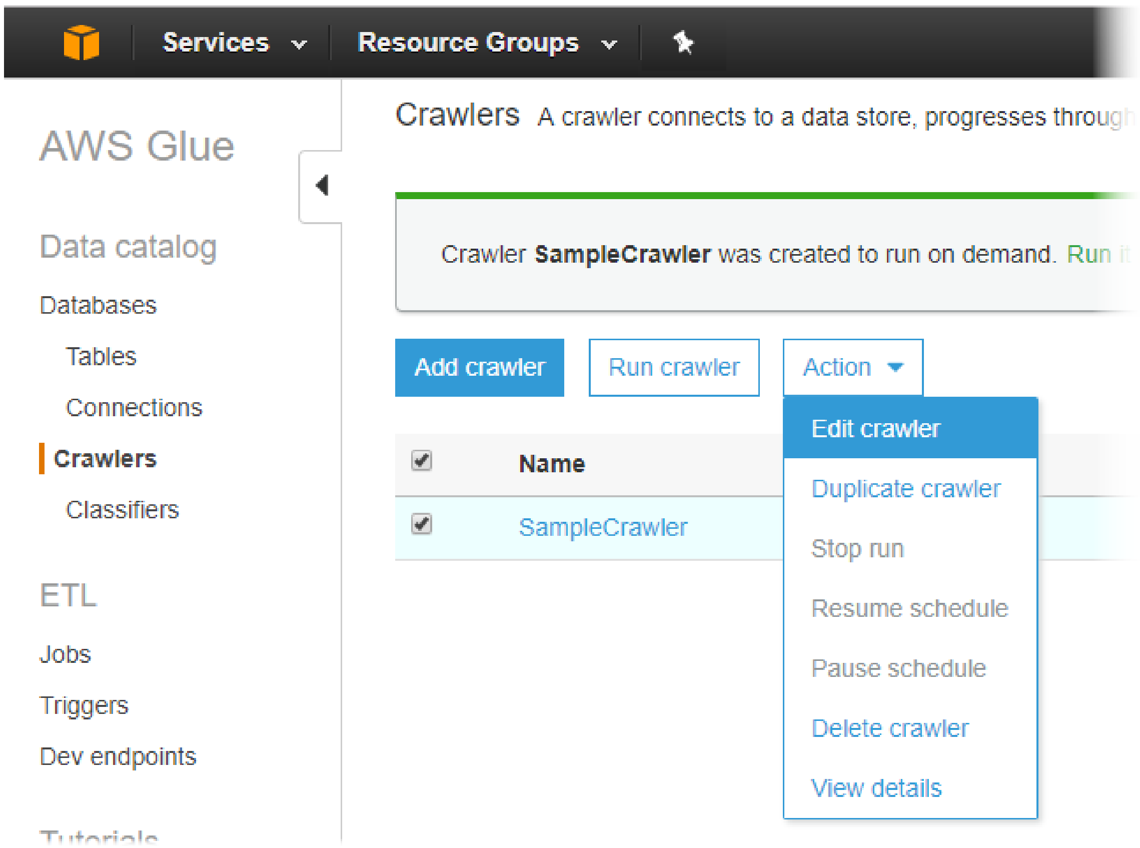
```
s3://bucket01/folder1/table1/partition1/file.txt
s3://bucket01/folder1/table1/partition2/file.txt
s3://bucket01/folder1/table1/partition3/file.txt
s3://bucket01/folder1/table2/partition4/file.txt
s3://bucket01/folder1/table2/partition5/file.txt
```

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.

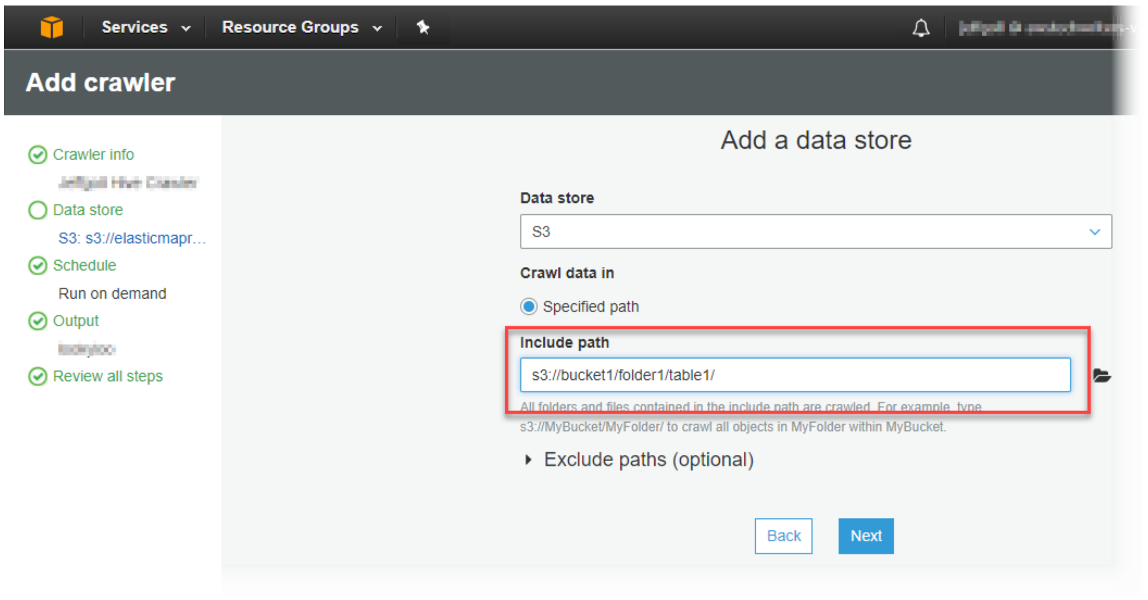
To add another data store to an existing crawler in AWS Glue

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**.



Crawler **SampleCrawler** was created to run on demand. Run it

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**.



Data store: S3

Crawl data in: Specified path

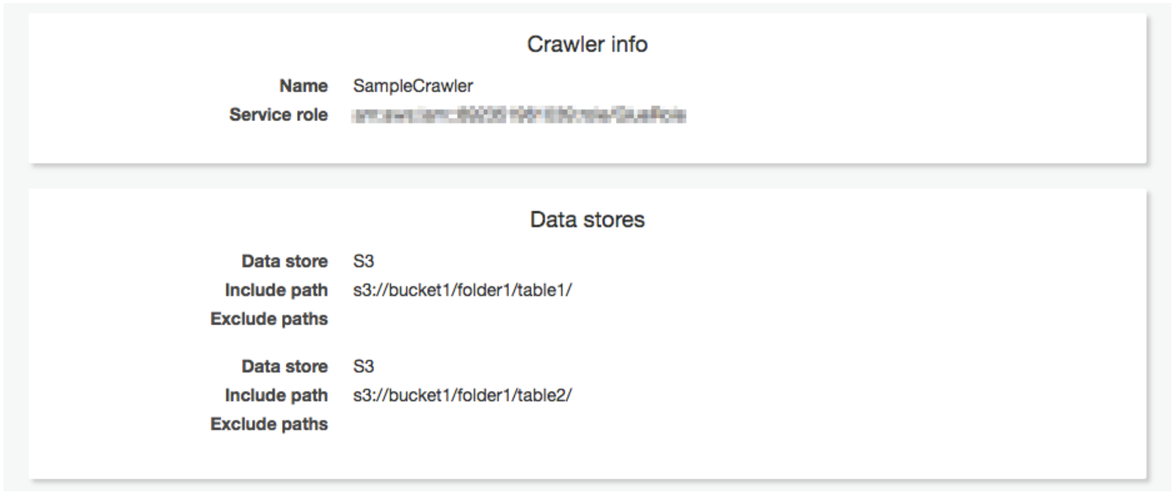
Include path: s3://bucket1/folder1/table1/

All folders and files contained in the include path are crawled. For example, type s3://MyBucket/MyFolder/ to crawl all objects in MyFolder within MyBucket.

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	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. 35).

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. 38).

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. 198).

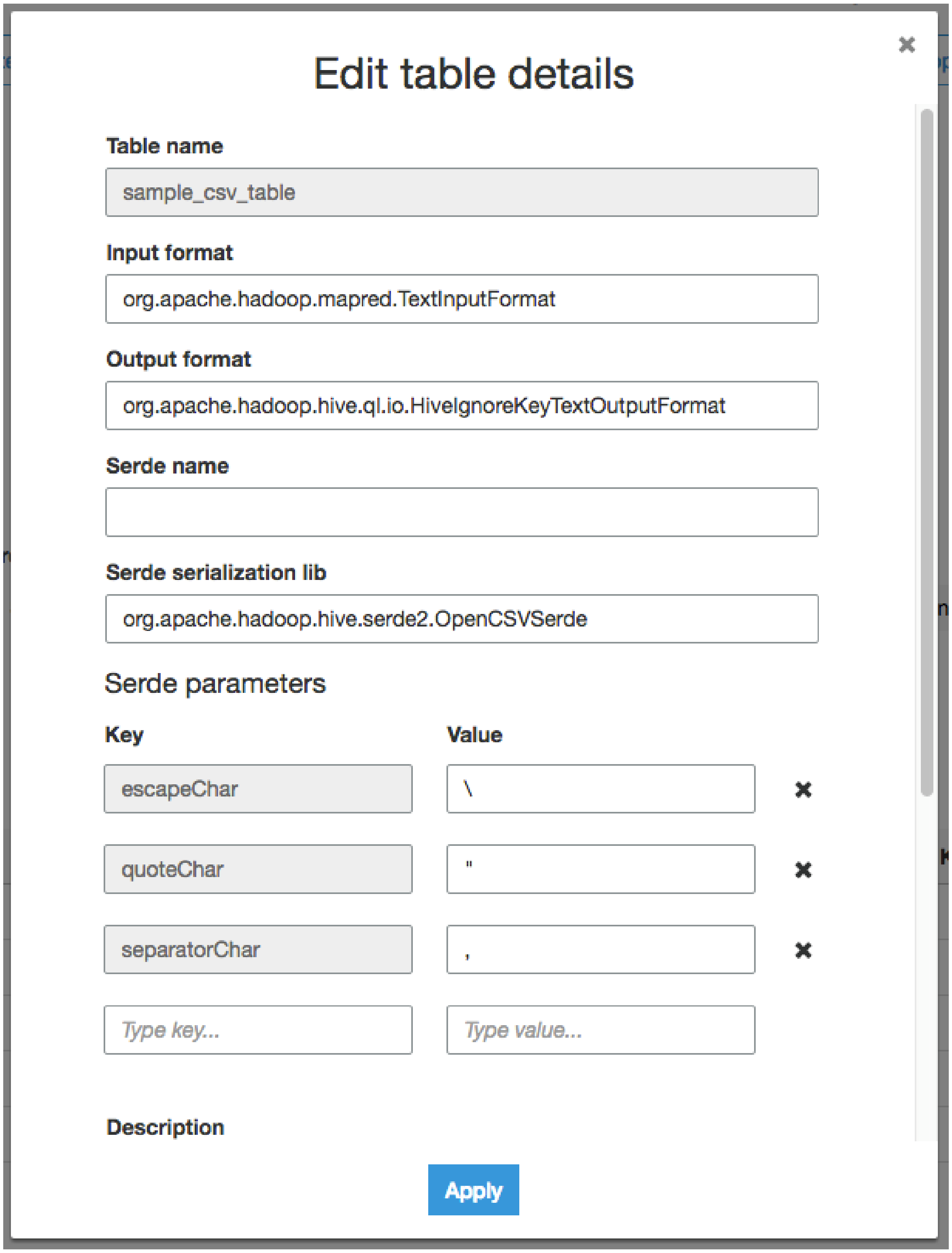
In this case, make the following changes:

- 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

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")
```

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

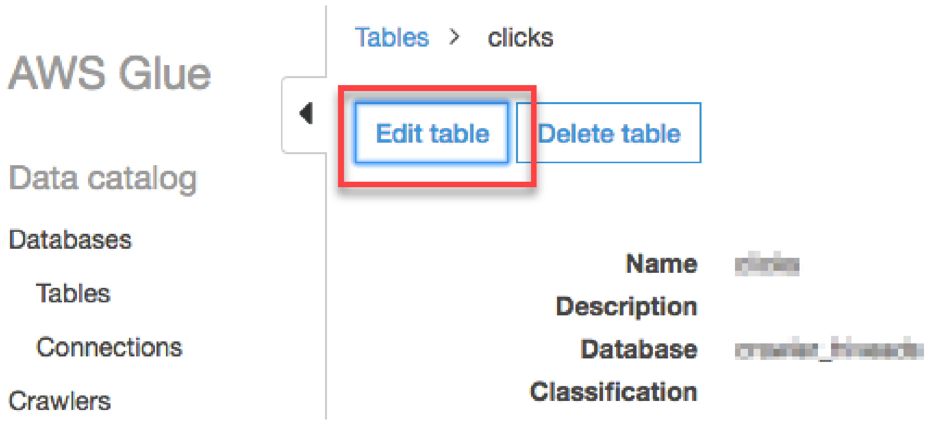
Tables that you create in Athena must have a table property added to them called a `classification`, which identifies the format of the data. This allows AWS Glue to use the tables for ETL jobs. The classification values can be `csv`, `parquet`, `orc`, `avro`, or `json`. An example `CREATE TABLE` statement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

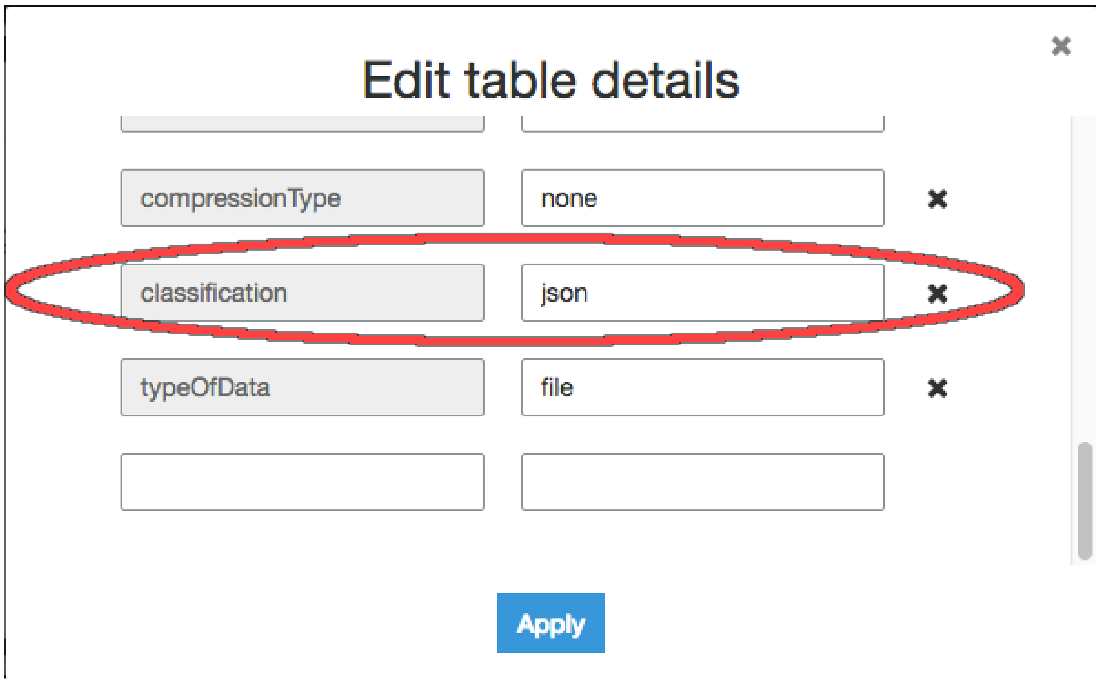
To change the classification property using the console

1. **Choose Edit Table.**



Name [redacted]
Description
Database [redacted]
Classification

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



compressionType	none
classification	json
typeOfData	file

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*.

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

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 2.0.7 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 AthenaJDBC41-2.0.7.jar is compatible with JDBC 4.1 and requires JDK 7.0 or later.
- The AthenaJDBC42-2.0.7.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

Now you are ready to migrate from the previous version and install and configure this version of the JDBC driver.

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.

Migration from Previous Version of the JDBC Driver

The current JDBC driver version 2.0.7 is a drop-in replacement of the previous version of the JDBC driver version 2.0.6, and is backwards compatible with the JDBC driver version 2.0.6, with the following step that you must perform to ensure the driver runs.

> **Important**
> To ensure that you can use the JDBC driver versions 2.0.5 or greater, 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. 50). For more information about upgrading to versions 2.0.5 or greater from version 2.0.2, see the JDBC Driver Migration Guide. Additionally, ensure that port 444 is open to outbound traffic.

For more information about the previous versions of the JDBC driver, see Using the Previous Version of the JDBC Driver (p. 249).

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 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

Driver Version	Download Link
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. 50).

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

Driver Version 1.0.4	Download Link
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
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

Security

Amazon Athena uses IAM policies to restrict access to Athena operations. Encryption options enable you to encrypt query result files in Amazon S3 and query data encrypted in Amazon S3. Users must have the appropriate permissions to access the Amazon S3 locations and decrypt files.

Topics

Access Control Policies

To run queries in Athena, you must have the appropriate permissions for:

- The Athena actions.
- The Amazon S3 locations where the underlying data is stored that you are going to query in Athena.
- The resources that you store in AWS Glue Data Catalog, such as databases and tables, that you are going to query in Athena.
- The encrypted metadata in the AWS Glue Data Catalog (if you migrated to using that metadata in Athena and the metadata is encrypted).
- Actions on Athena workgroups (p. 158).

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

To allow or deny Athena service actions for yourself or other users, use identity-based (IAM) policies attached to principals, such as users or groups.

Each identity-based (IAM) policy consists of statements that define the actions that are allowed or denied. For a list of actions, see the Amazon Athena API Reference.

Managed policies are easy to use and are automatically updated with the required actions as the service evolves. 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*.

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. 48).
- The `AWSQuicksightAthenaAccess` managed policy grants access to actions that Amazon QuickSightneeds to integrate with Athena. Attach this policy to principals who use Amazon QuickSight in conjunction with Athena. See AWSQuicksightAthenaAccess Managed Policy (p. 50).

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. 51).

If you have migrated to using AWS Glue with Athena, and have chosen to encrypt your AWS Glue Data Catalog, you must specify additional actions to the identity-based IAM policies that you use in Athena. For more information, see Access to Encrypted Metadata in the AWS Glue Data Catalog (p. 58).

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. 161) and the section called "Workgroup Example Policies" (p. 162).

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": [
                "s3:GetObject",
                "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 in conjunction 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 driver version 2.0.2, or the ODBC driver version 1.0.3, ensure the access policy includes all of the actions listed in AWSQuicksightAthenaAccess Managed Policy (p. 50).

For information about the latest version of the JDBC driver, see Connect with the JDBC Driver (p. 43).

For information about the latest version of the ODBC driver, see Connect with the ODBC Driver (p. 44).

Access to Amazon S3

In addition to the allowed actions for Athena that you define in IAM identity-based policies, if you or your users need to create tables and work with underlying data, you must grant appropriate access to the Amazon S3 location of the data.

You can do this 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 later in Cross-Account Access (p. 58).

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

After you upgrade (p. 29) to the AWS Glue Data Catalog, you can define resource-level policies for the following Data Catalog objects that are used in Athena:

- Databases
- Tables

These policies enable you to define fine-grained access to databases and tables. You define resource-level permissions in identity-based (IAM) policies in the IAM Console.

Important
This section discusses identity-based (IAM) policies that allow you to define fine-grained access to specific resources. These are not the same as 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 identity-based (IAM) policies used in AWS Glue	Identity-Based Policies (IAM Policies) in the *AWS Glue Developer Guide*.

In this section

Limitations

Consider the following limitations when using fine-grained access control with the AWS Glue Data Catalog and Athena:

- You must upgrade (p. 29) from a data catalog managed in Athena to the AWS Glue Data Catalog.
- 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. 54).
- 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. Functions are specific to AWS Glue, however, for delete actions in Athena, you must include permissions to them, if you delete a database. See Fine-Grained Policy Examples (p. 54).

  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 this resource (table or database) and all ancestors of this resource in the Data Catalog. For example, for a table, its ancestors are database and catalog for the account. For a database, its ancestor is the catalog for this account. See Fine-Grained Policy Examples (p. 54).
- For a delete action in Athena, such as `DROP DATABASE` or `DROP TABLE`, you additionally need permissions to call this delete action on all descendants of this resource in the Data Catalog. For example, to delete a database you need permissions on the database, on its ancestor, which is the catalog, and on all descendants, which are the tables and the user defined functions. A table does not have descendants, and therefore, to run `DROP TABLE`, you need permissions to this action on the table and its ancestors. See Fine-Grained Policy Examples (p. 54).
- 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

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 for Athena to work with the AWS Glue Data Catalog:

```
{
   "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, this means that:

- 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 identity-based (IAM) policies that allow fine-grained access to databases and tables in Athena.

As with any IAM policy, you define these policies in the IAM Console. 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	Allows you to create the database named `example_db`.
	`{`
	`   "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"`
	`   ]`
	` }`

DDL Statement	Example of an IAM access policy granting access to the resource
ALTER DATABASE	Allows you to modify the properties for the `example_db` database.

```
{
   "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:catalog",
     "arn:aws:glue:us-east-1:123456789012:database/example_db"
   ]
 }
```

DDL Statement	Example of an IAM access policy granting access to the resource
DROP DATABASE	Allows you to drop the `example_db` database, including all tables in it.

```
{
   "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/*"
   ]
 }
```

DDL Statement	Example of an IAM access policy granting access to the resource
SHOW DATABASES	Allows you to list all databases in the AWS Glue Data Catalog.

```
{
   "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/*"
   ]
 }
```

DDL Statement	Example of an IAM access policy granting access to the resource
CREATE TABLE	Allows you to create a table named `test` in the `example_db` database.

```
{
   "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"
   ]
 }
```

DDL Statement	Example of an IAM access policy granting access to the resource

SHOW TABLES	Allows you to list all tables in the `example_db` database.
	```
	{
	   "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/*"
	   ]
	 }
	```

DROP TABLE	Allows you to drop a partitioned table named `test` in the `example_db` database. If your table does not have partitions, do not include partition actions.
	```
	{
	   "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"
	   ]
	 }
	```

Access to Encrypted Metadata in the AWS Glue Data Catalog

The encryption of objects in the AWS Glue Data Catalog is available only if you have upgraded to using AWS Glue with Athena.

You can optionally 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 you encrypt your AWS Glue Data Catalog, you must add the following actions to all of your policies 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 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`.

Workgroup and Tag Policies

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:

```
"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 list of workgroup policies, see the section called “Workgroup Example Policies” (p. 162).

For a list of tag-based policies for workgroups, see Tag-Based IAM Access Control Policies (p. 184).

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. 161).

Enabling Federated Access to Athena API

This section discusses federated access that allows a user or client application in your organization to call 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).

In this case, to authenticate users, use the JDBC or ODBC driver with SAML.2.0 support that accesses Active Directory Federation Services (AD FS) 3.0 and enables a client application to call Athena API operations.

For more information about SAML 2.0 support in AWS, see About SAML 2.0 Federation in the *IAM User Guide*.

> **Note**
> Federated access to Athena API is supported for a particular type of identity provider (IdP), the Active Directory Federation Service (AD FS 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. 43) and Connecting to Amazon Athena with ODBC (p. 44).

Topics

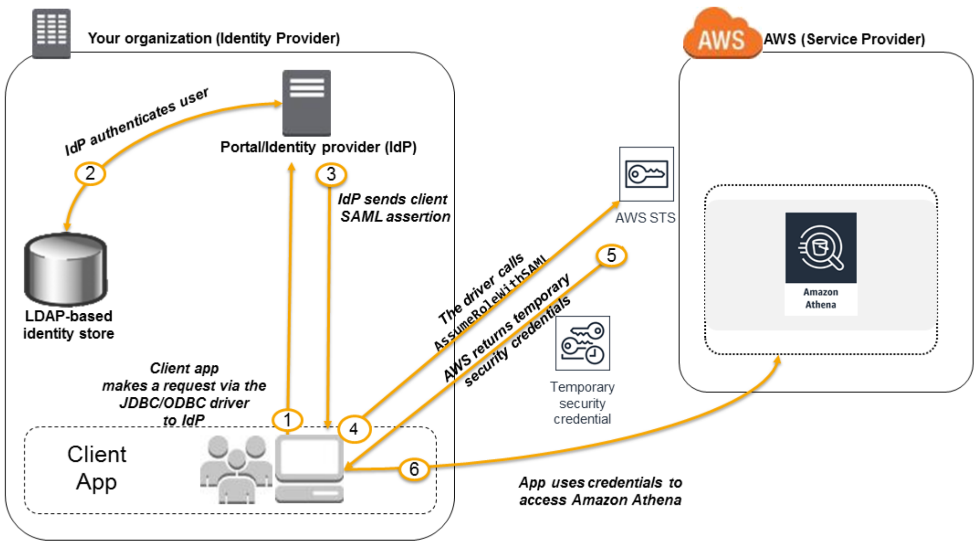
Before You Begin

Before you begin, complete the following prerequisites:

- Inside your organization, install and configure the AD FS 3.0 as your IdP.
- On the Athena side, install and configure the latest available versions of JDBC or ODBC drivers that include support for federated access compatible with SAML 2.0. For information, see Using Athena with the JDBC Driver (p. 43) and Connecting to Amazon Athena with ODBC (p. 44).

Architecture Diagram

The following diagram illustrates this process.


Your organization (Identity Provider)
AWS
AWS (Service Provider)
IdP authenticates user
Portal/Identity provider (IdP)
2
3
IdP sends client SAML assertion
AWS STS
5
LDAP-based identity store
The driver calls AssumeRoleWithSAML
AWS returns temporary security credentials
Amazon Athena
Temporary security credential
Client app makes a request via the JDBC/ODBC driver to IdP
1
4
Client App
6
App uses credentials to access Amazon Athena

In this diagram:

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 AD FS 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 Athena API

In this procedure, actions take place either on the side of your organization, or within AWS. The procedure provides steps that establish trust between your organization's IdP and your AWS account to enable SAML-based federated access to the AWS 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 (AD FS), 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 (AD FS) 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 (AD FS), 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 AD FS, 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. 43) and Connecting to Amazon Athena with ODBC (p. 44).

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.

   The high-level summary of configuring the connection string to the drivers is as follows:

   - 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 AD FS IdP.
   - For `idp_host`, provide the host name of the AD FS IdP server.
   - For `idp_port`, provide the port number that the AD FS IdP listens on for the SAML assertion request.

- 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.
- Optionally, set `ssl_insecure` to `true`. In this case, the driver does not check the authenticity of the SSL certificate for the AD FS IdP server. Setting to `true` is needed if the AD FS IdP's SSL certificate has not been configured to be trusted by the driver.
- 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, 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. 60).
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.

Configuring Encryption Options

You can run queries in Athena to query encrypted data in Amazon S3 by indicating data encryption when you create a table. You can also encrypt the query results in Amazon S3, and the data in the AWS Glue Data Catalog.

You can encrypt:

- The results of all queries in Amazon S3, which Athena stores in a location known as the *S3 staging directory*. 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. 63).
- The data in the AWS Glue Data Catalog. For information, see Permissions to Encrypted Metadata in the AWS Glue Data Catalog (p. 65).

Topics

Amazon S3 Encryption Options Supported in Athena

Athena supports the following Amazon S3 encryption options, both for encrypted datasets in Amazon S3 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.

These options encrypt data at rest in Amazon S3. Regardless of whether you use these options, transport layer security (TLS) encrypts objects in-transit between Athena resources and between Athena and Amazon S3. Query results stream to JDBC clients as plain text and are encrypted using TLS.

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.

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.

Encrypting Query Results Stored in Amazon S3

You set up query-result encryption using the Athena console. If you connect using the JDBC driver, you configure driver options. Specify the type of encryption to use and the Amazon S3 staging directory location.

To configure the JDBC driver to encrypt your query results using any of the encryption protocols that Athena supports, see Using Athena with the JDBC Driver (p. 43).

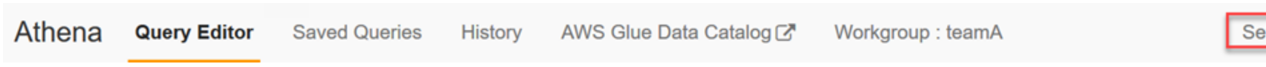
You can configure the setting for encryption of query results in two ways:

- **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. 168) 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. 166). Workgroup settings include query results location and encryption.

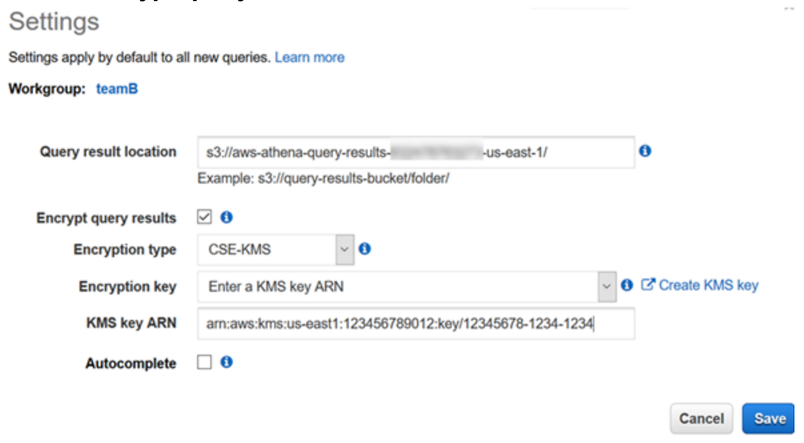
To encrypt query results stored in Amazon S3 using the console

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 driver are not used. For more information, see Workgroup Settings Override Client-Side Settings (p. 166).

1. In the Athena console, choose **Settings**.



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-[redacted]-us-east-1/

Example: s3://query-results-bucket/folder/

Encrypt query results: ☑

Encryption type: CSE-KMS

Encryption key: Enter a KMS key ARN

Create KMS key

KMS key ARN: arn:aws:kms:us-east1:123456789012:key/12345678-1234-1234

Autocomplete: ☐

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**.

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. 47) and Amazon S3 Permissions (p. 51).
- 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*.

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. 58).

Creating Tables Based on Encrypted Datasets in Amazon S3

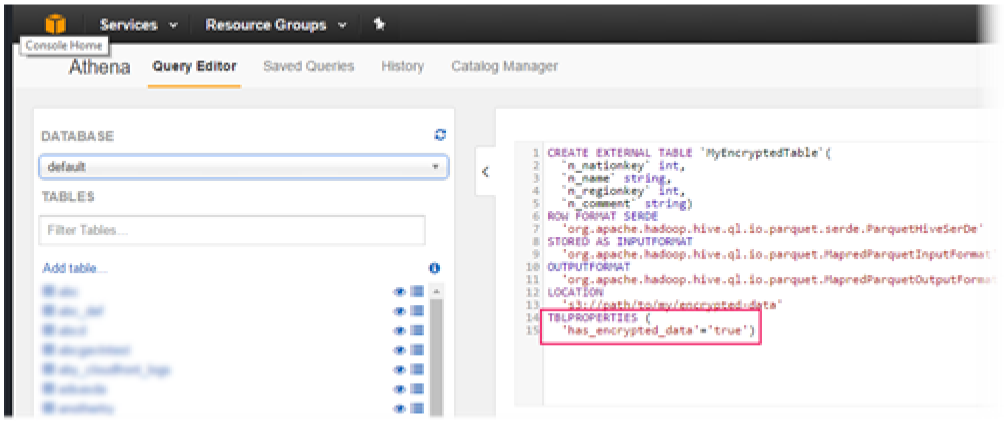
When you create a table, indicate to Athena that a dataset is encrypted in Amazon S3. This is not required when using SSE-KMS. For both SSE-S3 and AWS KMS encryption, Athena determines the proper materials to use to decrypt the dataset and create the table, so you don't need to provide key information.

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.

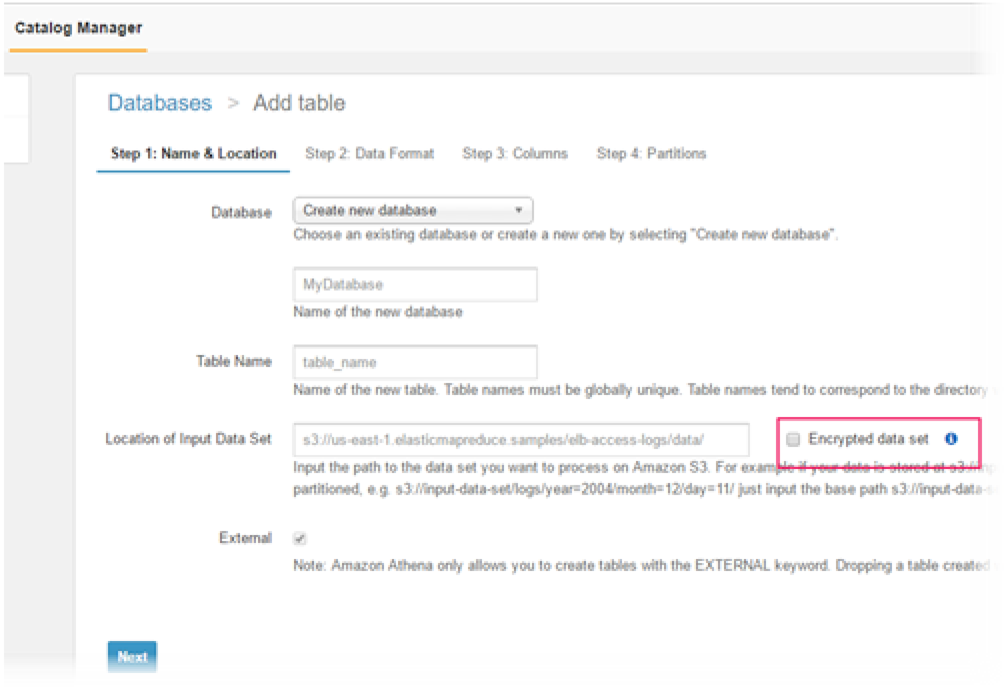
- Use the CREATE TABLE (p. 223) statement with a `TBLPROPERTIES` clause that specifies `'has_encrypted_data'='true'`.



```
CREATE EXTERNAL TABLE `MyEncryptedTable`(
  `n_nationkey` int,
  `n_name` string,
  `n_regionkey` int,
  `n_comment` string)
ROW FORMAT SERDE
  'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS INPUTFORMAT
  'org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat'
OUTPUTFORMAT
  'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputForma
LOCATION
  's3://path/to/my/encrypted-data'
TBLPROPERTIES (
  'has_encrypted_data'='true')
```

- Use the JDBC driver (p. 43) and set the `TBLPROPERTIES` value as shown in the previous example, when you execute CREATE TABLE (p. 223) 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**.



Database: Create new database
Choose an existing database or create a new one by selecting "Create new database".

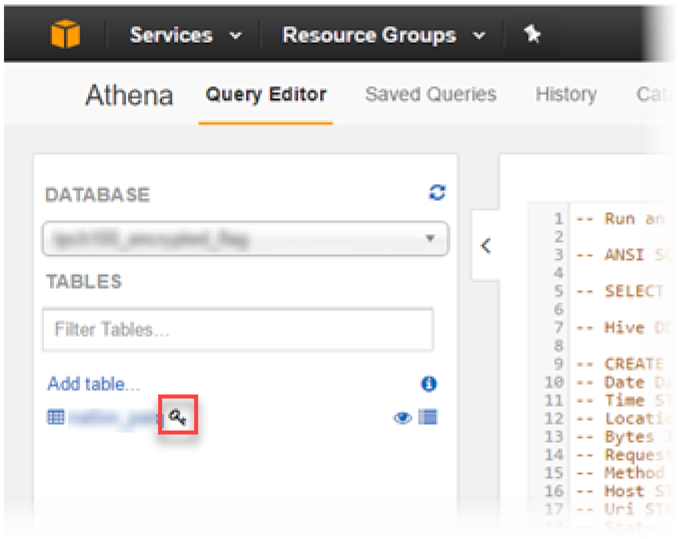
MyDatabase
Name of the new database

Table Name: 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: s3://us-east-1.elasticmapreduce.samples/elb-access-logs/data/ ☐ 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://
partitioned, e.g. s3://input-data-set/logs/year=2004/month=12/day=11/ just input the base path s3://input-data-

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.



```
-- Run an
-- ANSI S
-- SELECT
-- Hive D
-- CREATE
-- Date D
-- Time S
-- Locati
-- Bytes
-- Reques
-- Method
-- Host S
-- Uri ST
```

Working with Source Data

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

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. 192).

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 Setting User and Amazon S3 Bucket Permissions (p. 47).
- 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. 62).
- 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 does not support Requester Pays buckets.
- 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. 238).

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

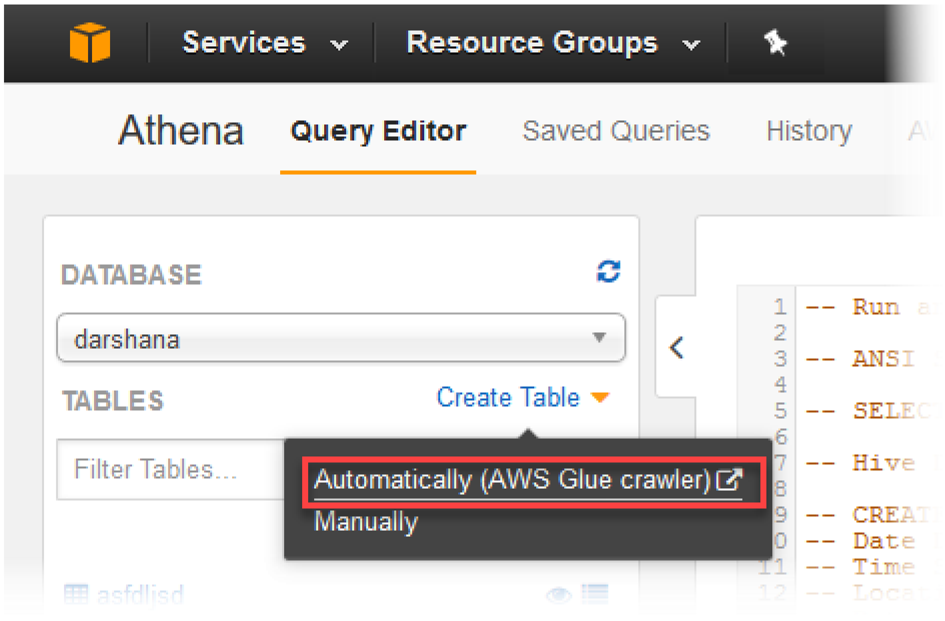
If you use `CREATE TABLE` without the `EXTERNAL` keyword, Athena issues an error; only tables with the `EXTERNAL` keyword can be created. We recommend that you always use the `EXTERNAL` keyword. When you drop a table in Athena, only the table metadata is removed; the data remains in Amazon S3.

UDF and UDAF Are Not Supported

User-defined functions (UDF or UDAFs) and stored procedures are not supported.

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. 34).



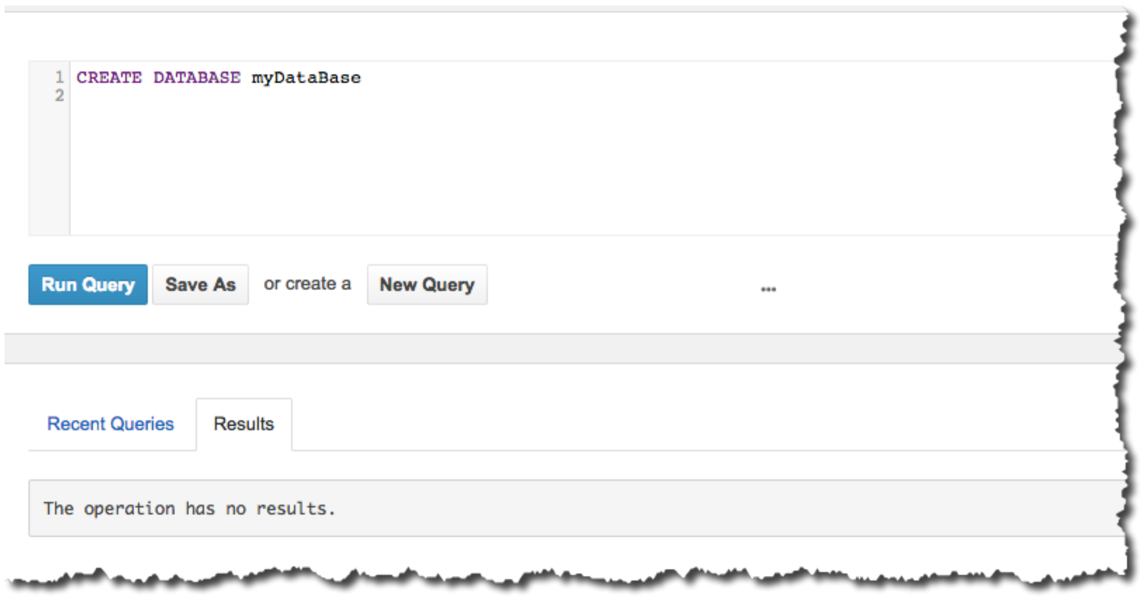
To create a table using the wizard

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.

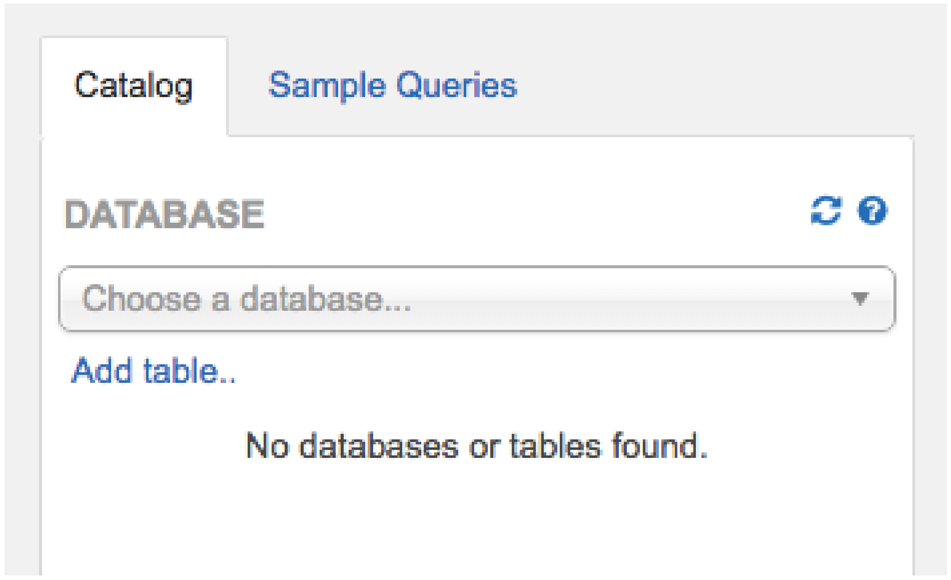
1. Open the Athena console at https://console.aws.amazon.com/athena/.
2. Choose **Query Editor**.
3. Enter `CREATE DATABASE myDataBase` and choose **Run Query**.



```
CREATE DATABASE myDataBase
```

```
The operation has no results.
```

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



No databases or tables found.

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,
    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+([^ ]+)\\s
+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+[^\(]+[\(]([^\;]+).*\%20([^\/]+)[\/](.*)$"
) LOCATION 's3://athena-examples/cloudfront/plaintext/';
```

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 backtics 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 Views (p. 86), enclose them in double quotes (").

- List of Reserved Keywords in DDL Statements (p. 72)
- List of Reserved Keywords in SQL SELECT Statements (p. 72)
- Examples of Queries with Reserved Keywords (p. 73)

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, TANSFORM, TRIGGER, TRUE, TRUNCATE,
 UNBOUNDED,UNION,
UNIQUEJOIN, UPDATE, USER, USING, UTC_TMESTAMP, 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 data catalog that Athena uses. If you migrated to AWS Glue, this is the catalog from AWS Glue. You also specify the location in Amazon S3 for your table in this format: `s3://bucketname/keyname/`.

Use these tips and examples when you specify the location in Amazon S3.

- Athena reads all files in an Amazon S3 location you specify in the `CREATE TABLE` statement, and cannot ignore any files included in the prefix. When you create tables, include in the Amazon S3 path only the files you want Athena to read. Use AWS Lambda functions to scan files in the source location, remove any empty files, and move unneeded files to another location.
- In the `LOCATION` clause, use a trailing slash for your bucket.

Use:

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

Do not use any of the following items in file locations.

- Do not use filenames, underscores, wildcards, or glob patterns for specifying file locations.
- Do not add the full HTTP notation, such as `s3.amazon.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.amazon.com
S3://bucket/prefix//prefix/
arn:aws:s3:::bucketname/prefix
```

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.

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 below:

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. 192).

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    ap3HcVKAWfXtgIPu6WpuUfAfL0DQEc
2009-04-12-13-20    17uchtodoS9kdeQP1x0XThKl5IuRsV
2009-04-12-13-20    JOUf1SCtRwviGw8sVcghqE5h0nkgtp
2009-04-12-13-20    NQ2XP0J0dvVbCXJ0pb4XvqJ5A4QxxH
2009-04-12-13-20    fFAItiBMsgqro9kRdIwbeX60SROaxr
2009-04-12-13-20    V4og4R9W6G3QjHHwF7gI1cSqig5D1G
2009-04-12-13-20    hPEPtBwk45msmwWTxPVVo1kVu4v11b
2009-04-12-13-20    v0SkfxegheD90gp31UCr6FplnKpx6i
2009-04-12-13-20    1iD9odVgOIi4QWkwHMcOhmwTkWDKfj
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/plaintext/ --recursive

2016-11-23 17:54:46   11789573 elb/plaintext/2015/01/01/part-r-00000-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46    8776899 elb/plaintext/2015/01/01/part-r-00001-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46    9309800 elb/plaintext/2015/01/01/part-r-00002-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47    9412570 elb/plaintext/2015/01/01/part-r-00003-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47   10725938 elb/plaintext/2015/01/01/part-r-00004-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:46    9439710 elb/plaintext/2015/01/01/part-r-00005-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47          0 elb/plaintext/2015/01/01_$folder$
2016-11-23 17:54:47    9012723 elb/plaintext/2015/01/02/part-r-00006-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47    7571816 elb/plaintext/2015/01/02/part-r-00007-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:47    9673393 elb/plaintext/2015/01/02/part-r-00008-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48   11979218 elb/plaintext/2015/01/02/part-r-00009-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48    9546833 elb/plaintext/2015/01/02/part-r-00010-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48   10960865 elb/plaintext/2015/01/02/part-r-00011-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48          0 elb/plaintext/2015/01/02_$folder$
2016-11-23 17:54:48   11360522 elb/plaintext/2015/01/03/part-r-00012-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48   11211291 elb/plaintext/2015/01/03/part-r-00013-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:48    8633768 elb/plaintext/2015/01/03/part-r-00014-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49   11891626 elb/plaintext/2015/01/03/part-r-00015-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49    9173813 elb/plaintext/2015/01/03/part-r-00016-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49   11899582 elb/plaintext/2015/01/03/part-r-00017-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:49          0 elb/plaintext/2015/01/03_$folder$
```

```
2016-11-23 17:54:50    8612843 elb/plaintext/2015/01/04/part-r-00018-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50   10731284 elb/plaintext/2015/01/04/part-r-00019-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50    9984735 elb/plaintext/2015/01/04/part-r-00020-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50    9290089 elb/plaintext/2015/01/04/part-r-00021-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:50    7896339 elb/plaintext/2015/01/04/part-r-00022-ce65fca5-d6c6-40e6-
b1f9-190cc4f93814.txt
2016-11-23 17:54:51    8321364 elb/plaintext/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. 43).

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. 91) 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. 98) 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": "mvlrdwrmef",
    "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 3.0.04506; 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": "J9NOccA3dDMFlixCuSOtl9QBbjs6aS",
    "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**.

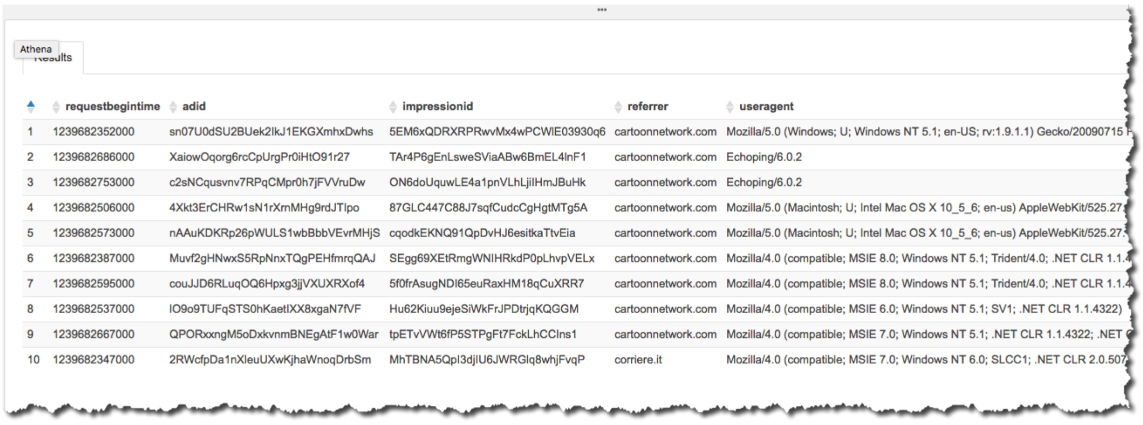
6. Run the following query to show that you can query this data:

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

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

parquet_hive

The results should show output similar to this:



	requestbegintime	adid	impressionid	referrer	useragent
1	1239682352000	sn07U0dSU2BUek2lkJ1EKGXmhxDwhs	5EM6xQDRXRPRwvMx4wPCWlE03930q6	cartoonnetwork.com	Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.9.1.1) Gecko/20090715
2	1239682686000	XaiowOqorg6rcCpUrgPr0iHtO91r27	TAr4P6gEnLsweSViaABw6BmEL4lnF1	cartoonnetwork.com	Echoping/6.0.2
3	1239682753000	c2sNCqusvnv7RPqCMpr0h7jFVVruDw	ON6doUquwLE4a1pnVLhLjiIHmJBuHk	cartoonnetwork.com	Echoping/6.0.2
4	1239682506000	4Xkt3ErCHRw1sN1rXrnMHg9rdJTlpo	87GLC447C88J7sqfCudcCgHgtMTg5A	cartoonnetwork.com	Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10_5_6; en-us) AppleWebKit/525.27
5	1239682573000	nAAuKDKRp26pWULS1wbBbbVEvrMHjS	cqodkEKNQ91QpDvHJ6esitkaTtvEia	cartoonnetwork.com	Mozilla/5.0 (Macintosh; U; Intel Mac OS X 10_5_6; en-us) AppleWebKit/525.27
6	1239682387000	Muvf2gHNwxS5RpNnxTQgPEHfmrqQAJ	SEgg69XEtRmgWNIHRkdP0pLhvpVELx	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 5.1; Trident/4.0; .NET CLR 1.1.4
7	1239682595000	couJJD6RLuqOQ6Hpxg3jjVXUXRXof4	5f0frAsugNDI65euRaxHM18qCuXRR7	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 5.1; Trident/4.0; .NET CLR 1.1.4
8	1239682537000	lO9o9TUFqSTS0hKaetIXX8xgaN7fVF	Hu62Kiuu9ejeSiWkFrJPDtrjqKQGGM	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 1.1.4322)
9	1239682667000	QPORxxngM5oDxkvnmBNEgAtF1w0War	tpETvVWt6fP5STPgFt7FckLhCCIns1	cartoonnetwork.com	Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1; .NET CLR 1.1.4322; .NET
10	1239682347000	2RWcfpDa1nXleuUXwKjhaWnoqDrbSm	MhTBNA5Qpl3djlU6JWRGlq8whjFvqP	corriere.it	Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 6.0; SLCC1; .NET CLR 2.0.507

Querying Data in Amazon Athena Tables

Examples of Athena queries in this section show you how to work with arrays, concatenate, filter, flatten, sort, and query data in them. Other examples include queries for data in tables with nested structures and maps, and tables that contain JSON-encoded values.

Topics

Query Results

Athena stores query results in Amazon S3.

Each query that you run has:

- A results file stored automatically in a CSV format (*.csv), and
- An Athena metadata file (`*.csv.metadata`).

  Note
  You can delete metadata files (`*.csv.metadata`) without causing errors, but important information about the query is lost.

If necessary, you can access the result files to work with them.

Topics

You can specify the query results location in one of the following ways:

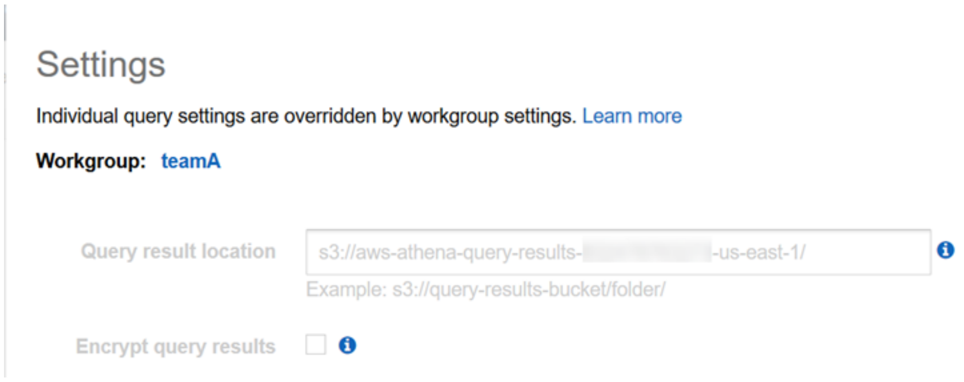
- **For individual queries**. This way of specifying the settings is known as *client-side query settings*. The client-side settings include query results location and encryption configuration. To view or change the query results location for *individual* queries, choose **Settings** in the upper right pane of the Athena console, or use the OutputLocation API.
- **For all queries in a workgroup**. This way of specifying the settings is known as *workgroup settings*. The workgroup settings include the results location and encryption configuration. To view or change the query results location for all queries in a workgroup, choose the **Workgroup:<workgroup_name>** tab in the console, switch to your workgroup, view or edit the workgroup, and specify the location in the **Query result location** field. For more information, see Workgroup Settings (p. 166) and Managing Workgroups (p. 167). You can also specify this setting with WorkGroupConfiguration in the API.

Important

If you use the API or the drivers, you must specify the query results location in one of the two ways: for individual queries (client-side query settings), or for all queries in the workgroup. You cannot omit specifying the location altogether. If the location is not specified in either way, Athena issues an error at query execution. If you use the Athena console, and don't specify the query results location using one of the methods, Athena uses the default location (p. 84).

The client-side query settings are used *only* if your workgroup's settings, which include query results location and encryption, are not enforced. If your workgroup's settings override client-side settings, then the location and encryption configuration you specify in the **Settings** are not used. This applies to queries you run in the console, by using the API operations, or the driver. If **Override client-side settings** is selected, your query uses the workgroup's settings, even though the settings specified for this particular query may differ from the workgroup's settings. For more information, see Workgroup Settings Override Client-Side Settings (p. 166).

If you select **Override client-side settings** for the workgroup, the following screen displays when you choose **Settings**. This indicates that client-side settings are not used for queries in this workgroup.



Settings

Individual query settings are overridden by workgroup settings. Learn more

Workgroup: teamA

Query result location: s3://aws-athena-query-results-[redacted]-us-east-1/

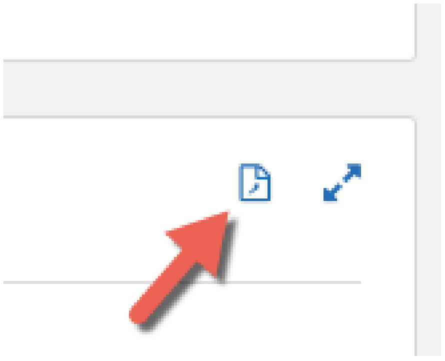
Example: s3://query-results-bucket/folder/

Encrypt query results: ☐

Saving Query Results

After you run the query, the results appear in the **Results** pane.

To save the results of the most recent query to CSV, choose the file icon.



To save the results of a query you ran previously, choose **History**, locate your query, and use **Download Results**.

The Default Location for Query Results

Important

The default location for query results is used in the Athena console *only* if you run your queries in the console, have not set the results location for queries in the workgroup, and if the workgroup settings do not override client-side settings. For more information, see Workgroup Settings Override Client-Side Settings (p. 166).

In this case only, Athena stores individual query results in this Amazon S3 bucket by default:

```
aws-athena-query-results-<ACCOUNTID>-<REGION>
```

Note
The default location is used only for queries you run in the Athena console. 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.

Query results are saved based on the name of the query and the date the query ran, as follows:

```
{QueryLocation}/{QueryName|Unsaved}/{yyyy}/{mm}/{dd}/{QueryID}.csv
```

```
{QueryLocation}/{QueryName|Unsaved}/{yyyy}/{mm}/{dd}/{QueryID}.csv.metadata
```

In this notation:

- `QueryLocation` is the base location for all query results if the workgroup's settings are not used. To view or change this location, choose **Settings** in the upper right pane. You can enter a new value for **Query result location** at any time. You can also choose to encrypt individual query results in Amazon S3. For more information, see Configuring Encryption Options (p. 62).
- `QueryName` is the name of the query for which the results are saved. If the query wasn't saved, `Unsaved` appears. To see a list of queries and examine their SQL statements, choose **Saved queries**.
- `yyyy/mm/dd/` is the date the query ran.
- `QueryID` is the unique ID of the query.

Viewing Query History

To view your recent query history, use **History**. Athena retains query history for 45 days.

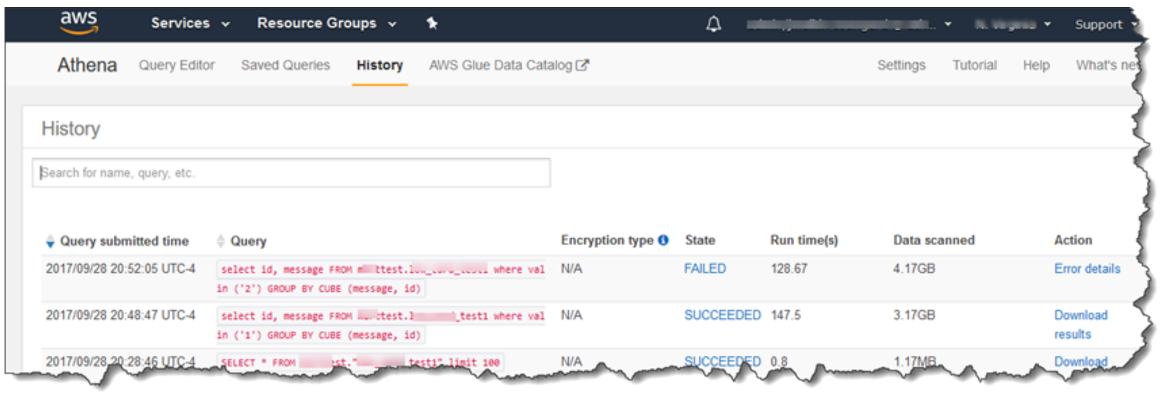
Note
Starting on December 1, 2017, Athena retains query history for 45 days.

To retain query history for a longer period, write a program using methods from Athena API and the AWS CLI to periodically retrieve the query history and save it to a data store:

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 AWS CLI command from the Amazon S3 API.

Viewing Query History

1. To view a query in your history for up to 45 days after it ran, 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.



History

Search for name, query, etc.

Query submitted time	Query	Encryption type	State	Run time(s)	Data scanned	Action
2017/09/28 20:52:05 UTC-4	`select id, message FROM m[redacted]ttest.l[redacted] where val in ('2') GROUP BY CUBE (message, id)`	N/A	FAILED	128.67	4.17GB	Error details
2017/09/28 20:48:47 UTC-4	`select id, message FROM [redacted]test.l[redacted]_test1 where val in ('1') GROUP BY CUBE (message, id)`	N/A	SUCCEEDED	147.5	3.17GB	Download results
2017/09/28 20:28:46 UTC-4	`SELECT * FROM [redacted]st."[redacted]test1" limit 100`	N/A	SUCCEEDED	0.8	1.17MB	Download

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. 228).

Topics

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. 228)	Creates a new view from a specified `SELECT` query. For more information, see Creating Views (p. 89). The optional `OR REPLACE` clause lets you update the existing view by replacing it.
DESCRIBE VIEW (p. 229)	Shows the list of columns for the named view. This allows you to examine the attributes of a complex view.
DROP VIEW (p. 230)	Deletes an existing view. The optional `IF EXISTS` clause suppresses the error if the view does not exist. For more information, see Deleting Views (p. 91).
SHOW CREATE VIEW (p. 232)	Shows the SQL statement that creates the specified view.
SHOW VIEWS (p. 234)	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. You can also see the list of views in the left pane in the console.
SHOW COLUMNS (p. 231)	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. 51) 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. 71).
- 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. 72).
- 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. 51).

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. 234) 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

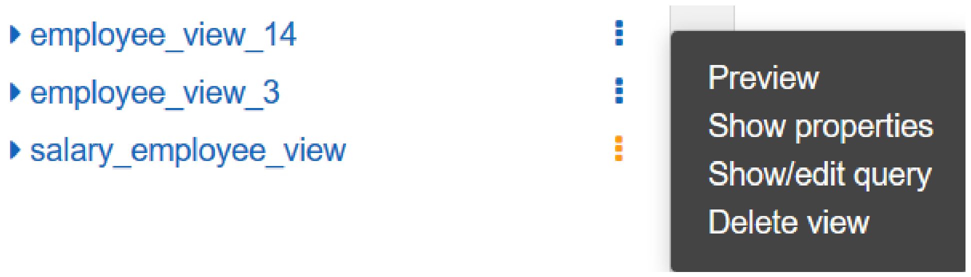
A view shows up in the console only if you have already created it.

1. In the Athena console, choose **Views**, choose a view, then expand it.

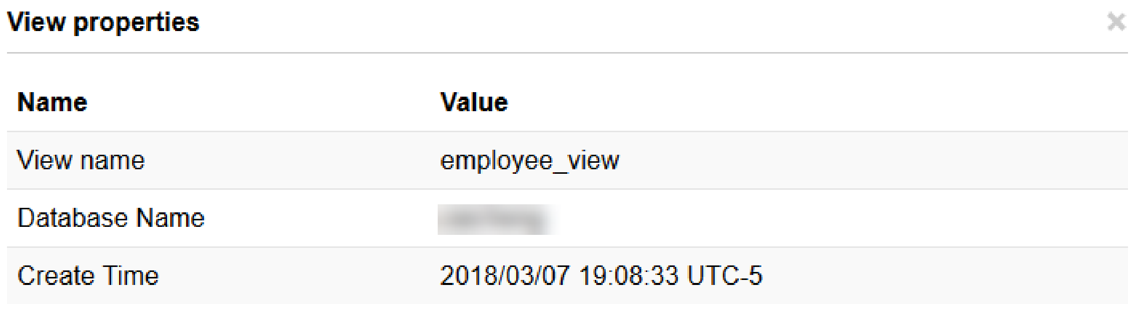
   The view displays, with the columns it contains, as shown in the following example:

   salary_view
id (string)
name (string)

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

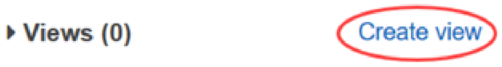
Creating Views

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.

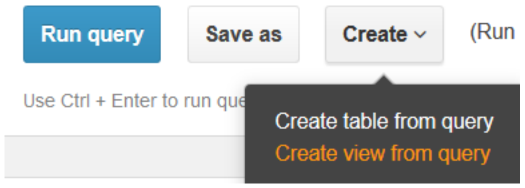
1. In the Athena console, choose **Create view**.

   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. 228) and Examples of Views (p. 90).

   View names cannot contain special characters, other than underscore `(_)`. See Names for Tables, Databases, and Columns (p. 71). Avoid using Reserved Keywords (p. 72) 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. 232).

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. 228).

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. 230).

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. 226).

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. 78).
- Create copies of existing tables that contain only the data you need.

Topics

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	The CTAS query syntax differs from the syntax of `CREATE [EXTERNAL] TABLE` used for creating tables. See CREATE TABLE AS (p. 226). **Note** 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. 72), 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. 71).
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	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. You can specify the location for storing your CTAS query results. If omitted and if your workgroup does not override client-side settings (p. 166), Athena uses this location by default: `s3://aws-athena-query-results-<account>-<region>/<query-name-or-unsaved>/<year>/<month/<date>/<query-id>/`. 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. 170). If the workgroup in which a query will run is configured with an enforced query results location (p. 166), 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;`
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 5: Storing Results of a CTAS Query in Another Format (p. 98).
Compression formats	GZIP compression is used for CTAS query results by default. For Parquet and ORC, you can also specify SNAPPY. See Example 4: Specifying Data Storage and Compression Formats for CTAS Query Results (p. 98).
Partitioning	You can partition the results data of a CTAS query by one or more columns. When creating a partitioned table, Athena automatically adds partitions to the AWS Glue Data Catalog. **Important** The results of a CTAS query in Athena can have a maximum of 100 partitions that Athena creates for you when writing CTAS query results to a specified location in Amazon S3. If the number of partitions to which the results data is written in parallel exceeds 100, Athena issues an error. List partition columns at the end of the `SELECT` statement in a CTAS query. For more information, see Example 7: CTAS Queries with Partitions (p. 99) and Bucketing vs Partitioning (p. 96).
Bucketing	You can configure buckets for storing the results of a CTAS query and bucket data by one or more columns. There is no limit to the number of buckets you can specify. For more information, see Example 8: A CTAS Query with Bucketing (p. 100) and Bucketing vs Partitioning (p. 96).
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. 62).
Data types	Column data types for a CTAS query are the same as specified for the original query.

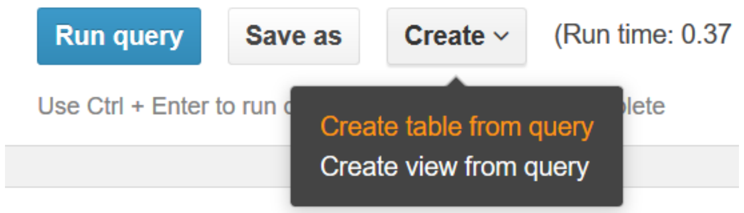
Running CTAS Queries in the Console

In the Athena console, you can:

- Create a CTAS query from another query (p. 93)
- Create a CTAS query from scratch (p. 93)

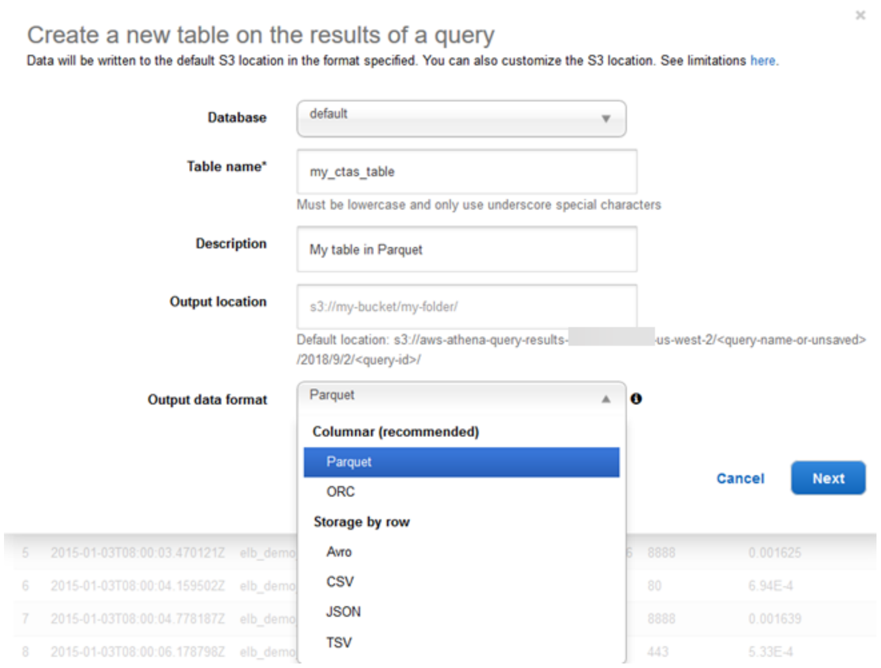
To create a CTAS query from another query

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. 166), 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. 78).



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

Must be lowercase and only use underscore special characters

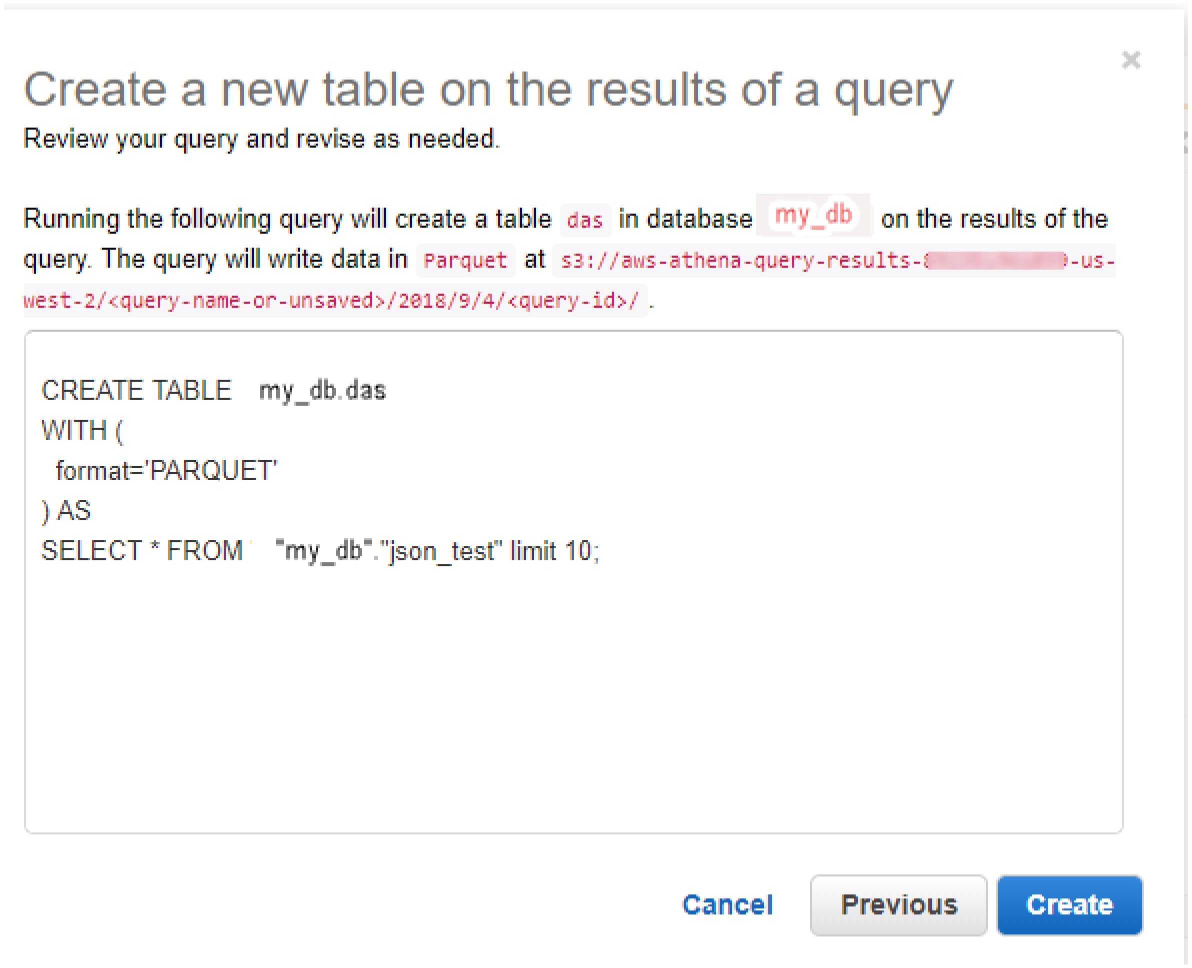
Description: My table in Parquet

Output location: s3://my-bucket/my-folder/

Default location: s3://aws-athena-query-results-[redacted]-us-west-2/<query-name-or-unsaved>/2018/9/2/<query-id>/

Output data format: Parquet

f. Choose **Next** to review your query and revise it as needed. For query syntax, see CREATE TABLE AS (p. 226). 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-[redacted]-us-west-2/<query-name-or-unsaved>/2018/9/4/<query-id>/`.

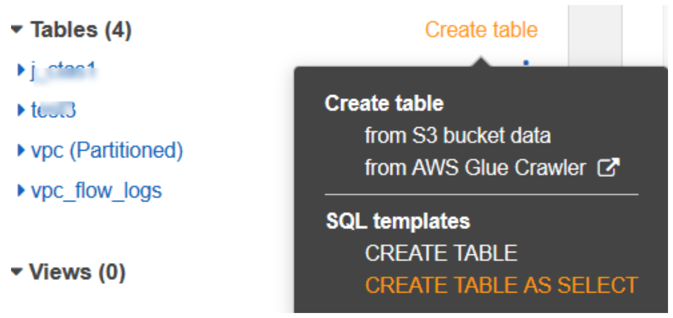
```
CREATE TABLE   my_db.das
WITH (
 format='PARQUET'
) AS
SELECT * FROM   "my_db"."json_test" limit 10;
```

   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. 226).
3. Choose **Run query**.
4. Optionally, choose **Save as** to save the query.

See also Examples of CTAS Queries (p. 97).

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. 91).

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. 226).

  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.

  You can specify any number of buckets for your CTAS query results, using one or more columns as bucket names.

  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. 226).

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 `timestamp` 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. 226).

In this section:

Example Example 1: Selecting All Columns with CTAS

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 2: Selecting Specific Columns from One or More Tables with CTAS

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 3: Creating an Empty Copy of an Existing Table with CTAS

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 4: Specifying Data Storage and Compression Formats for CTAS Query Results

The following example creates a new CTAS query that saves data in Parquet. This allows you to change the storage format from the one used by the original table. 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 5: Storing Results of a CTAS Query in Another Format

The following CTAS query takes the results from another query, which could be stored in CSV or another text format, and stores them in ORC:

```
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 6: CTAS Queries without Partitions

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 7: CTAS Queries with Partitions

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. 227). For more information about choosing the columns for partitioning, see Bucketing vs Partitioning (p. 96).

> **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 partitions.

```
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 tables1;
```

```
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 8: A CTAS Query with Bucketing

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. You can create an unlimited number of buckets and bucket by one or more columns. For syntax, see CTAS Table Properties (p. 227).

For information about choosing the columns for bucketing, see Bucketing vs Partitioning (p. 96).

```
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;
```

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

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. 107).

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 |
+---------------------+
```

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`

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. 135).

```
SELECT
  CAST(useridentity.accountid AS bigint) as newid
FROM cloudtrail_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. 104).

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 Arrays with 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 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

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. 203).

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. 203).
- 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. 203).

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. 117)
- Converting JSON to Athena Data Types (p. 117)

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. 103).

```
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

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?

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. 203).

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. 125)
- Geospatial Relationship Functions (p. 127)
- Operation Functions (p. 128)
- Accessor Functions (p. 130)

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 `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 `polygon`. Example:

```
SELECT ST_Polygon('polygon ((1 1, 4 1, 1 4))')
```

ST_GEOMETRY_TO_TEXT (varbinary)

Converts each of the specified geometry data types 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)'),
 'T********')
```

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_EXTERIOR_RING(ST_POLYGON(1,1, 1,4, 4,1))
```

```
SELECT ST_EXTERIOR_RING(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_SYMMETRIC_DIFFERENCE(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 `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 types, 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 types, 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)

Returns `TRUE` (type `boolean`) if and only if the specified geometry is empty. 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_MAX_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   |
+-------------------------+
```

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, andNetwork 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. 43), 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

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

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.gzip). 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://MyLogFiles/AWSLogs/`.
- To analyze data from a specific date, account, and Region, use `` LOCATION `s3://MyLogFiles/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. 117).

```
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/';
```

4. 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. 137). 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. 137).

  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. 117).

  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. 139)
- Example Query for CloudFront logs (p. 140)

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. 206) 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. 72).

```
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,
  fle_status STRING,
  fle_encrypted_fields INT
)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '\t'
LOCATION 's3://CloudFront_bucket_name/AWSLogs/ACCOUNT_ID/'
TBLPROPERTIES ( 'skip.header.line.count'='2' )
```

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 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. 141)
- Elastic Load Balancing Example Queries (p. 141)

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.

```
CREATE EXTERNAL TABLE IF NOT EXISTS elb_logs (

 timestamp string,
 elb_name string,
 request_ip string,
 request_port int,
 backend_ip string,
 backend_port int,
 request_processing_time double,
 backend_processing_time double,
 client_response_time double,
 elb_response_code string,
 backend_response_code string,
 received_bytes bigint,
 sent_bytes bigint,
 request_verb string,
 url string,
 protocol string,
 user_agent string,
 ssl_cipher string,
 ssl_protocol string
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES (
 'serialization.format' = '1',
 'input.regex' = '([^ ]*) ([^ ]*) ([^ ]*):([0-9]*) ([^ ]*)[:-]([0-9]*) ([-.0-9]*)
 ([-.0-9]*) ([-.0-9]*) (|[-0-9]*) (-|[-0-9]*) ([-0-9]*) ([-0-9]*) \\\"([^ ]*) ([^ ]*)
 (- |[^ ]*)\\\" (\"[^\"]*\") ([A-Z0-9-]+) ([A-Za-z0-9.-]*)$' )
LOCATION 's3://your_log_bucket/prefix/AWSLogs/AWS_account_ID/elasticloadbalancing/'
```

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. 141)

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. 142)
- Network Load Balancer Example Queries (p. 143)

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' =
        '([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*):([0-9]*) ([^ ]*):([0-9]*)
 ([-.0-9]*) ([-.0-9]*) ([-0-9]*) ([-0-9]*) ([-0-9]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*)
 ([^ ]*) ([^ ]*)($| [^ ]*)')
```

```
            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. 143)
- Example Queries for ALB logs (p. 144)

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.

```
CREATE EXTERNAL TABLE IF NOT EXISTS alb_logs (
            type string,
            time string,
            elb string,
            client_ip string,
            client_port int,
            target_ip string,
            target_port int,
            request_processing_time double,
            target_processing_time double,
            response_processing_time double,
            elb_status_code string,
            target_status_code string,
            received_bytes bigint,
            sent_bytes bigint,
            request_verb string,
            request_url string,
            request_proto string,
            user_agent string,
            ssl_cipher string,
            ssl_protocol string,
            target_group_arn string,
            trace_id string,
            domain_name string,
            chosen_cert_arn string,
            matched_rule_priority string,
            request_creation_time string,
            actions_executed string,
            redirect_url string,
            lambda_error_reason string,
            new_field string
            )
            ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
            WITH SERDEPROPERTIES (
            'serialization.format' = '1',
            'input.regex' =
        '([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*):([0-9]*) ([^ ]*)[:-]([0-9]*) ([-.0-9]*)
 ([-.0-9]*) ([-.0-9]*) (|[-0-9]*) (-|[-0-9]*) ([-0-9]*) ([-0-9]*) \"([^ ]*) ([^ ]*) (-
 |[^ ]*)\" \"([^\"]*)\" ([A-Z0-9-]+) ([A-Za-z0-9.-]*) ([^ ]*) \"([^\"]*)\" \"([^\"]*)\"
 \"([^\"]*)\" ([-.0-9]*) ([^ ]*) \"([^\"]*)\" \"([^\"]*)\"($| \"[^ ]*\")(.*)')
            LOCATION 's3://your-alb-logs-directory/AWSLogs/<ACCOUNT-ID>/
elasticloadbalancing/<REGION>';
```

2. 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.

- Creating the Table for VPC Flow Logs (p. 145)
- Example Queries for Amazon VPC Flow Logs (p. 146)

Creating the Table for VPC Flow Logs

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. 206). In addition, in this query, fields are terminated by a space.
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. 34).

```
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.

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

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. 149).

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	AVRO	PARQUET Read by Name (default)	PARQUET Read by Index	ORC: Read by Index (default)	ORC: Read by Name
Rename columns (p. 153)	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. 152)	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. 152)	Store your data in CSV or TSV, JSON, AVRO, and in ORC and Parquet if they are read by name.	Y	Y	Y	Y	N	N	Y
Remove columns (p. 153)	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
Reorder columns (p. 154)	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. 155)	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. 150).
- 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. 150).

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_shippriority` 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. 152)
- Adding Columns at the End of the Table (p. 152)
- Removing Columns (p. 153)
- Renaming Columns (p. 153)
- Reordering Columns (p. 154)
- Changing a Column's Data Type (p. 155)

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. 149).

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_shippriority` 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*. If you use ORC formats, you must configure ORC to read by name. Parquet reads by name by default. For information, see Index Access in ORC and Parquet (p. 149).

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. 149).
- 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_shippriority` 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. 149).

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_shippriority` 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_shippriority` 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. 149).

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_shippriority` 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. 156).

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. 148).

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.

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

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

Workgroups allow you to:

Isolate users, teams, applications, or workloads into groups.	Each workgroup has its own distinct query history and a list of saved queries. For more information, see How Workgroups Work (p. 159). 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. 166).
Enforce costs constraints.	You can set two types of cost constraints for queries in a workgroup: • **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. For detailed steps, see Setting Data Usage Control Limits (p. 176).
Track query-related metrics for all workgroup queries in CloudWatch.	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. 175) for each of your workgroups within the Athena console. In CloudWatch, you can create custom dashboards, and set thresholds and alarms on these metrics.

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. 166).

Limitations for Workgroups

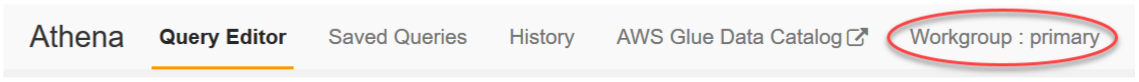
- You can create up to 1000 workgroups per Region in your account.
- The primary workgroup cannot be deleted.
- You can open up to ten query tabs within each workgroup. When you switch between workgroups, your query tabs remain open for up to three workgroups.

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. 171) 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. 161).
   - 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. 166).
   - 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. 63).
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. 168).
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. 161). For example JSON policies, see Workgroup Example Policies (p. 59).

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. 166).

   Important
   If you override client-side settings (p. 166), 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. 176) 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. 172).

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. 162).

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. 162).
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. 162).

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. 161).

- Example Policy for Full Access to All Workgroups (p. 162)
- Example Policy for Full Access to a Specified Workgroup (p. 163)
- Example Policy for Running Queries in a Specified Workgroup (p. 164)
- Example Policy for Running Queries in the Primary Workgroup (p. 164)
- Example Policy for Management Operations on a Specified Workgroup (p. 165)
- Example Policy for Listing Workgroups (p. 165)
- Example Policy for Running and Stopping Queries in a Specific Workgroup (p. 165)
- Example Policy for Working with Named Queries in a Specific Workgroup (p. 165)

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"
            ]
        }
    ]
}
```

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. 164).

```
"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. 166). 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. 170).

You can also set query limits (p. 174) for queries in workgroups.

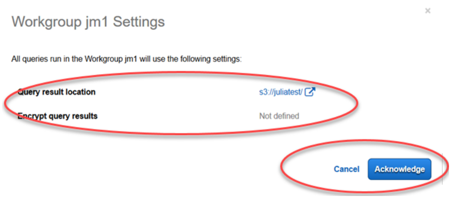
Workgroup Settings Override Client-Side Settings

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.



Workgroup jm1 Settings

All queries run in the Workgroup jm1 will use the following settings:

Query result location	s3://juliatest/
Encrypt query results	Not defined

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. 170).

Managing Workgroups

In the https://console.aws.amazon.com/athena/, you can perform the following tasks:

Statement	Description
Create a Workgroup (p. 168)	Create a new workgroup.
Edit a Workgroup (p. 169)	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. 170)	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. 170)	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. 171)	Switch between workgroups to which you have access.
Enable and Disable a Workgroup (p. 171)	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.

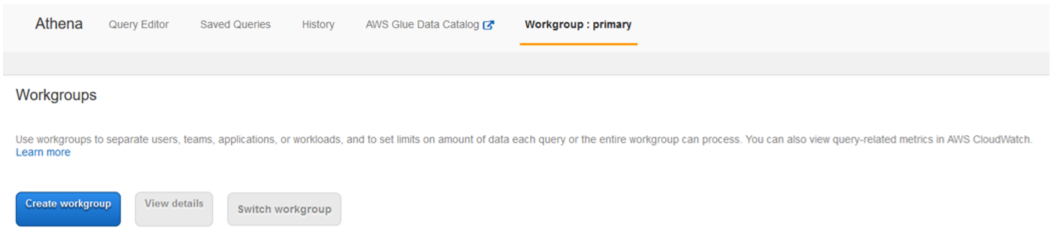
Statement	Description
Specify a Workgroup in Which to Run Queries (p. 172)	Before you can run queries, you must specify to Athena which workgroup to use. You must have permissions to the workgroup.

Create a Workgroup

Creating a workgroup requires permissions to `CreateWorkgroup` API actions. See Access to Athena Workgroups (p. 59) and IAM Policies for Accessing Workgroups (p. 161). If you are adding tags, you also need to add permissions to `TagResource`. See the section called “Tag Policy Examples” (p. 184).

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**.



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.

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 *must* 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 *AWS Key Management Service Developer Guide*.
Publish to CloudWatch	This field is selected by default. Publish query metrics to Amazon CloudWatch. See Viewing Query Metrics (p. 175).
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. 166).
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. 180).

4. Choose **Create workgroup**. The workgroup appears in the list in the **Workgroups** panel.

Alternatively, use the API operations to create a workgroup.

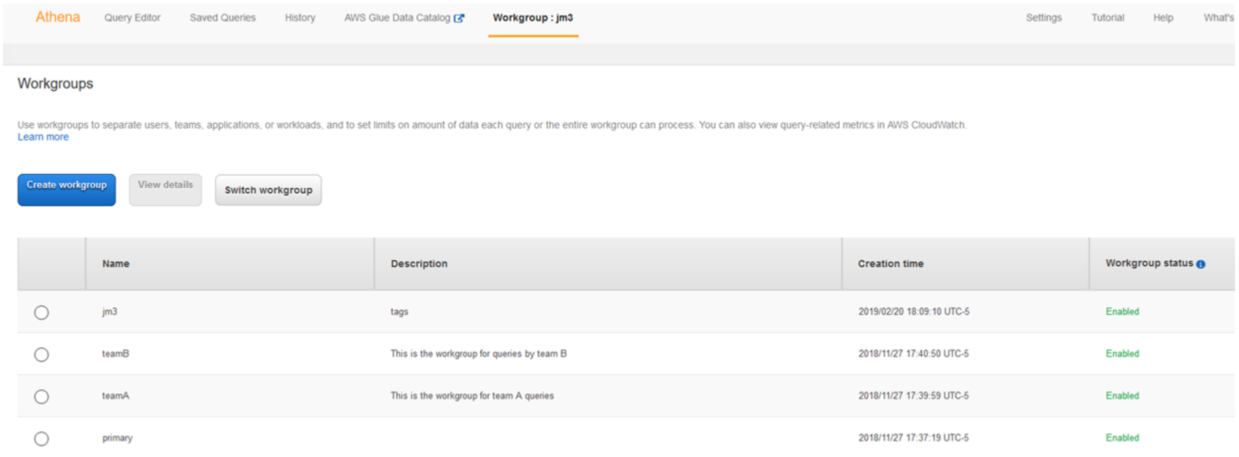
Important
After you create workgroups, create IAM Policies for Workgroups (p. 161) IAM that allow you to run workgroup-related actions.

Edit a Workgroup

Editing a workgroup requires permissions to `UpdateWorkgroup` API operations. See Access to Athena Workgroups (p. 59) and IAM Policies for Accessing Workgroups (p. 161). If you are adding or editing tags, you also need to have permissions to `TagResource`. See the section called "Tag Policy Examples" (p. 184).

To edit a workgroup in the console

1. In the Athena console, choose the **Workgroup:<workgroup_name>** tab. A **Workgroups** panel displays, listing all of the workgroups in the account.

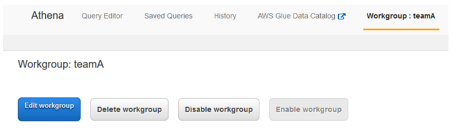


Workgroups

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. You can also view query-related metrics in AWS CloudWatch.

	Name	Description	Creation time	Workgroup status
○	jm3	tags	2019/02/20 18:09:10 UTC-5	Enabled
○	teamB	This is the workgroup for queries by team B	2018/11/27 17:40:50 UTC-5	Enabled
○	teamA	This is the workgroup for team A queries	2018/11/27 17:39:59 UTC-5	Enabled
○	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**.



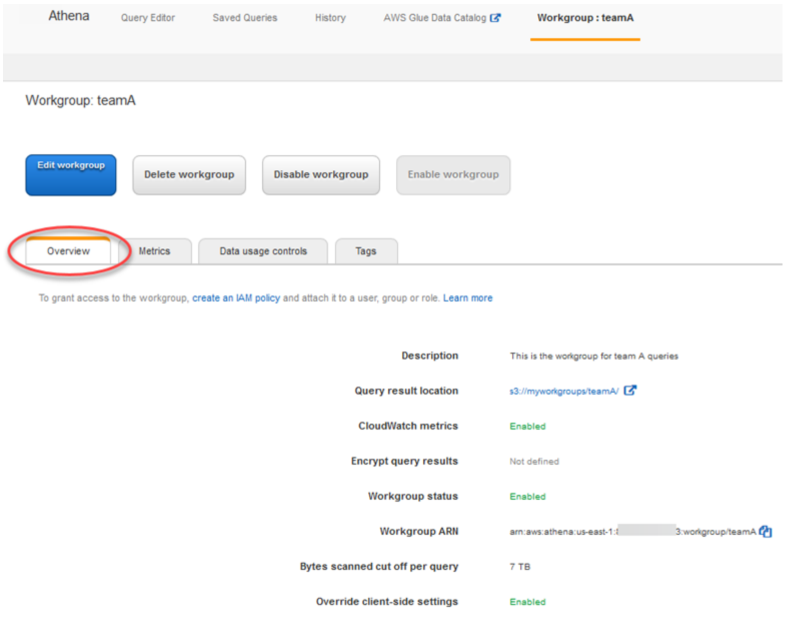
4. Change the fields as needed. For the list of fields, see Create workgroup (p. 168). You can change all fields except for the workgroup's name. If you need to change the name, create another workgroup with the new name and the same settings.
5. Choose **Save**. The updated workgroup appears in the 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:



To grant access to the workgroup, create an IAM policy and attach it to a user, group or role. Learn more

Description	This is the workgroup for team A queries
Query result location	s3://myworkgroups/teamA/
CloudWatch metrics	Enabled
Encrypt query results	Not defined
Workgroup status	Enabled
Workgroup ARN	arn:aws:athena:us-east-1:[redacted]3:workgroup/teamA
Bytes scanned cut off per query	7 TB
Override client-side settings	Enabled

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. 164).

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.

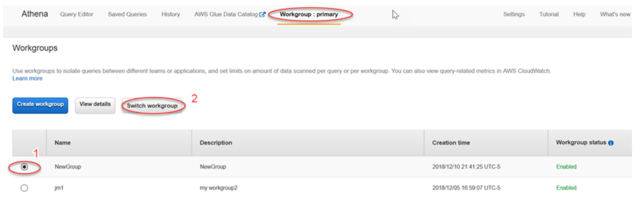
Switch between Workgroups

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**.



Use workgroups to isolate queries between different teams or applications, and set limits on amount of data scanned per query or per workgroup. You can also view query-related metrics in AWS CloudWatch.

	Name	Description	Creation time	Workgroup status
●	NewGroup	NewGroup	2018/12/10 21:41:25 UTC-5	Enabled
○	jm1	my workgroup2	2018/12/05 16:59:07 UTC-5	Enabled

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. 161).
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. 171).
   - 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. 44).

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. 161).

- 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. 172).
- 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 use the Athena console, and don't specify the query results location using one of the methods, Athena uses the default location (p. 84).
- 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**, **ListNamedQueries**, **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. 172).
- If the workgroup in which a query will run is configured with an enforced query results location (p. 166), 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...
`query state CANCELED. Bytes scanned limit was exceeded.`	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.
`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`	A user runs a query in a workgroup, but does not have access to it. Update your policy to have access to the workgroup.
`INVALID_INPUT. WorkGroup <name> is disabled.`	A user runs a query in a workgroup, but the workgroup is disabled. Your workgroup could be disabled by your administrator. It is possible

Error	Occurs when...
	also that you don't have access to it. In both cases, contact an administrator who has access to modify workgroups.
`INVALID_INPUT. WorkGroup <name> is not found.`	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.
`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.`	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.
`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.`	If the workgroup in which a query runs is configured with an enforced query results location (p. 166), and you specify an `external_location` for the CTAS query. In this case, remove the `external_location` 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. 174). 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

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.

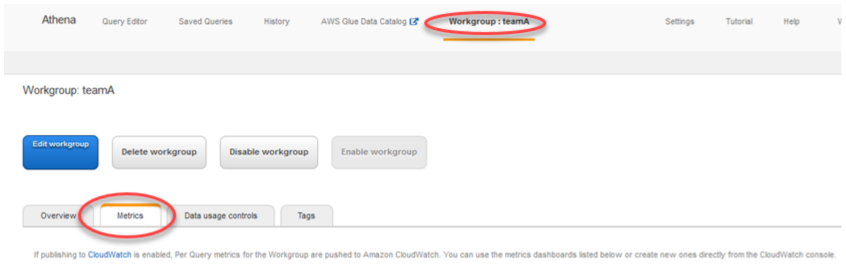
Athena publishes the following metrics to the CloudWatch console:

- `Query Status` (successful, failed, or canceled)
- `Query Execution Time` (in seconds)
- `Query Type` (DDL or DML)
- `Data Processed Per Query`. This is the total amount of data scanned per query (in Megabytes).
- `Workgroup Name`

To view query metrics for a workgroup in the console

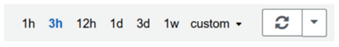
1. Open the Athena console at https://console.aws.amazon.com/athena/.
2. Choose the **Workgroup:*<name>*** tab.

   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.

   If publishing to CloudWatch is enabled, Per Query metrics for the Workgroup are pushed to Amazon CloudWatch. You can use the metrics dashboards listed below or create new ones directly from the CloudWatch console.

   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. The metrics use the `AWS/Athena` namespace.

Metric Name	Description
Total amount of data scanned per query	The amount of data in Megabytes that Athena scanned per query.
Query state	The query state. Valid statistics: Successful, Failed, Canceled
Total query execution time	The amount of time in seconds it takes Athena to run the query.
Query type	The query type. Valid statistics: DDL or DML.
Workgroup name	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. 177).
- 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. 178). 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

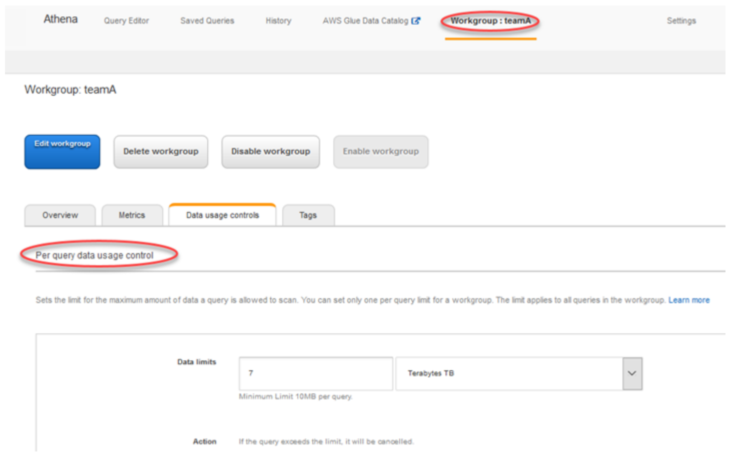
The per-query control limit specifies the total amount of data scanned per query. If any query that runs in the workgroup exceeds the limit, it is canceled. Canceled queries are charged according to Amazon Athena pricing.

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.



Workgroup: teamA

Per query data usage control

Sets the limit for the maximum amount of data a query is allowed to scan. You can set only one per query limit for a workgroup. The limit applies to all queries in the workgroup. Learn more

Data limits: 7 Terabytes TB

Minimum Limit 10MB per query.

Action: If the query exceeds the limit, it will be cancelled.

5. Specify (or update) the field values, as follows:

   - For **Data limit**, specify a value between 10000 KB (minimum) and 7 EB (maximum).

     Note

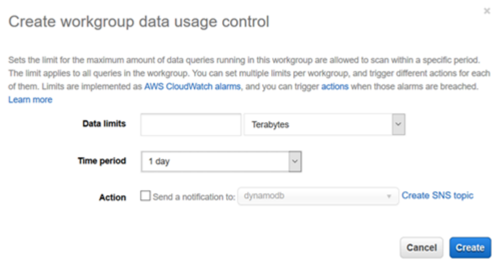
     These are limits imposed by the console for data usage controls within workgroups. They do not represent any query limits in Athena.
   - For units, select the unit value from the drop-down list.
   - Review the default **Action**. The default **Action** is to cancel the query if it exceeds the limit. 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.



Create workgroup data usage control

Sets the limit for the maximum amount of data queries running in this workgroup are allowed to scan within a specific period. The limit applies to all queries in the workgroup. You can set multiple limits per workgroup, and trigger different actions for each of them. Limits are implemented as AWS CloudWatch alarms, and you can trigger actions when those alarms are breached. Learn more

Data limits: Terabytes

Time period: 1 day

Action: ☐ Send a notification to: dynamodb

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

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. 184).

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. 181).

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

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

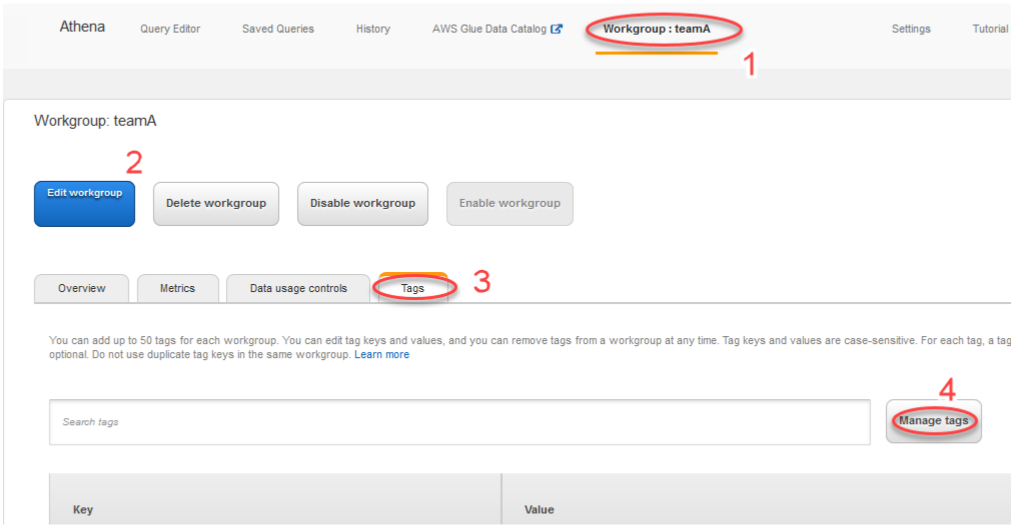
Note
Make sure you give a user IAM permissions to the **TagResource** and **CreateWorkGroup** actions if you want to allow them to add tags when creating a workgroup in the console, or pass in tags upon **CreateWorkGroup**.

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. 168).
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. 181).
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. 181).



You can add up to 50 tags for each workgroup. You can edit tag keys and values, and you can remove tags from a workgroup at any time. Tag keys and values are case-sensitive. For each tag, a tag
optional. Do not use duplicate tag keys in the same workgroup. Learn more

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
`TagResource`	Add or overwrite one or more tags to the workgroup with the specified ARN.
`UntagResource`	Delete one or more tags from the workgroup with the specified ARN.
`ListTagsForResource`	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"
                ]
            }
        }
}
```

Monitoring Logs and Troubleshooting

Examine Athena requests using CloudTrail logs and troubleshoot queries.

Topics

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. 135) and CloudTrail SerDe (p. 196).

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. 188)
- StartQueryExecution (Failed) (p. 189)
- CreateNamedQuery (p. 189)

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. 253)
- Limitations (p. 239)
- Unsupported DDL (p. 238)
- Names for Tables, Databases, and Columns (p. 71)
- Data Types (p. 217)
- Supported SerDes and Data Formats (p. 192)
- Compression Formats (p. 216)
- Reserved Words (p. 72)
- Troubleshooting Workgroups (p. 172)

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

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. 91).

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.	• Use the LazySimpleSerDe for CSV, TSV, and Custom-Delimited Files (p. 206) if your data does not include values enclosed in quotes. • Use the OpenCSVSerDe for Processing CSV (p. 198) 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. 206) and specify the separator character as `FIELDS TERMINATED BY '\t'`.
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. 206) 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.	• Use the Hive JSON SerDe (p. 203). • Use the OpenX JSON SerDe (p. 204).
Apache Avro	A format for storing data in Hadoop that uses JSON-based schemas for record values.	Use the Avro SerDe (p. 193).

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. 211) and ZLIB compression.
Apache Parquet	A format for columnar storage of data in Hadoop.	Use the Parquet SerDe (p. 214) and SNAPPY compression.
Logstash logs	A format for storing logs in Logstash.	Use the Grok SerDe (p. 200).
Apache WebServer logs	A format for storing logs in Apache WebServer.	Use the RegexSerDe for Processing Apache Web Server Logs (p. 195).
CloudTrail logs	A format for storing logs in CloudTrail.	• Use the CloudTrail SerDe (p. 196) to query most fields in CloudTrail logs. • Use the OpenX JSON SerDe (p. 204) for a few fields where their format depends on the service. For more information, see CloudTrail SerDe (p. 196).

Topics

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`, specify the Avro SerDe as follows: `ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.avro.AvroSerDe'`. In `SERDEPROPERTIES`, specify the schema, as shown in the following example.

> **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 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/`.

```
CREATE EXTERNAL TABLE IF NOT EXISTS 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+([^ ]+)\\s
+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+[^\(]+[\(]([^\;]+).*\%20([^\/]+)[\/](.*)$"
 ) LOCATION 's3://athena-examples-myregion/cloudfront/plaintext/';
```

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. 204). Alternatively, to get data out of these fields, use `JSON_EXTRACT` functions. For more information, see Extracting Data From JSON (p. 117).

- `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. 117).

```
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. 135).

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. 206).

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.

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. 86) 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,
 processtype 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:processtype}, 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 ([^\\]]*)')`.

```
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. 203)
- The OpenX JSON SerDe (p. 204)

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. 205).

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`.

ConvertDotsInJsonKeysToUnderscores

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. 72). 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: `^\S+$` and the following value pattern: `^(?!\s*$).+`

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. 207)

- TSV Example (p. 209)

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,
    crsarrtime 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)
    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,
 crsarrtime 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)
 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,
    crsarrtime 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,
    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 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. 223) 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. 226).

- 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.

DDL and SQL Reference

Athena supports a subset of DDL statements and ANSI SQL functions and operators.

Topics

Data Types

When you run `CREATE TABLE`, you must specify column names and their data types. For a complete syntax of this command, see CREATE TABLE (p. 223).

List of Supported Data Types in Athena

Athena supports the following data types:

- `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] [, ...] >

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.

DDL Statements

Use the following DDL statements directly in Athena.

Athena query engine is based on Hive DDL.

Athena does not support all DDL statements. For information, see Unsupported DDL (p. 238).

Topics

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. 74).

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.

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 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`. 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.
- `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. 74).

> **Note**
> After you create a table with partitions, run a subsequent query that consists of the MSCK REPAIR TABLE (p. 231) clause to refresh partition metadata, for example, `MSCK REPAIR TABLE cloudfront_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. 68).

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. 62).

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. 40) 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
+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+([^ ]+)\\s+[^\(]+[\(]([^\;]+).*\%20([^\/]+)
[\/](.*)$"
      ) LOCATION 's3://athena-examples/cloudfront/plaintext/';
```

CREATE TABLE AS

Creates a new table populated with the results of a SELECT (p. 235) query. To create an empty table, use CREATE TABLE (p. 223).

Topics

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. 227).

query

A SELECT (p. 235) 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. 97).

`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. 166), 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. 166), 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. 170).

`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.

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. 89).

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. 231), SHOW CREATE VIEW (p. 232), DESCRIBE VIEW (p. 229), and DROP VIEW (p. 230).

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. 231), SHOW CREATE VIEW (p. 232), SHOW VIEWS (p. 234), and DROP VIEW (p. 230).

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. 91).

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. 228), SHOW COLUMNS (p. 231), SHOW CREATE VIEW (p. 232), SHOW VIEWS (p. 234), and DESCRIBE VIEW (p. 229).

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. 74).

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. 228) and DROP VIEW (p. 230).

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. 231), SHOW CREATE VIEW (p. 232), DESCRIBE VIEW (p. 229), and DROP VIEW (p. 230).

SQL Queries, Functions, and Operators

Use the following functions directly in Athena.

Amazon Athena query engine is based on Presto 0.172. For more information about these functions, see Presto 0.172 Functions and Operators.

Athena does not support all of Presto's features. For information, see Limitations (p. 239).

- SELECT (p. 235)

- 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

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. 83).

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

Limitations

Athena does not support the following features, which are supported by an open source Presto version 0.172.

- User-defined functions (UDFs or UDAFs).
- Stored procedures.
- A particular subset of data types is supported. For more information, see Data Types (p. 217).
- `INSERT INTO` statements.
- The maximum number of partitions you can create in the `CREATE TABLE AS SELECT` (CTAS) statements is 100. For information, see CREATE TABLE AS (p. 226).
- `PREPARED` statements. You cannot run `EXECUTE` with `USING`.
- `CREATE TABLE LIKE`.
- `DESCRIBE INPUT` and `DESCRIBE OUTPUT`.
- `EXPLAIN` statements.
- Federated connectors. For more information, see Connectors.
- 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

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. 241)
  - Create a Client to Access Athena (p. 242)
  - **Working with Query Executions**
    - Start Query Execution (p. 242)
    - Stop Query Execution (p. 245)
    - List Query Executions (p. 246)
  - **Working with Named Queries**
    - Create a Named Query (p. 247)
    - Delete a Named Query (p. 247)
    - List Query Executions (p. 246)

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 the Previous Version of the JDBC Driver

We recommend that you use the current version of the JDBC driver, which is version 2.0.7. For information, see Using Athena with the JDBC Driver (p. 43). If you need to use the previous versions, follow the steps in this section to download and configure the driver.

The previous versions of the JDBC driver are 2.0.6, 2.0.5, and 2.0.2.

The JDBC driver version 1.1.0 is also available for download, however, 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.

Using the Previous Version of the JDBC Driver

1. Download the version of the driver that you need.

   Links for Downloading Previous Versions of the JDBC Driver

Driver Version 2.0.6	**Download Link**
JDBC 2.0.6 compatible with JDBC 4.1 and JDK 7.0 or later	AthenaJDBC41-2.0.6.jar
JDBC 2.0.6 compatible with JDBC 4.2 and JDK 8.0 or later	AthenaJDBC42-2.0.6.jar
Driver Version 2.0.5	**Download Link**
JDBC 2.0.5 compatible with JDBC 4.1 and JDK 7.0 or later	AthenaJDBC41-2.0.5.jar
JDBC 2.0.5 compatible with JDBC 4.2 and JDK 8.0 or later	AthenaJDBC42-2.0.5.jar
Driver Version 2.0.2	**Download Link**
JDBC 2.0.2 compatible with JDBC 4.1 and JDK 7.0 or later	AthenaJDBC41-2.0.2.jar
JDBC 2.0.2 compatible with JDBC 4.2 and JDK 8.0 or later	AthenaJDBC42-2.0.2.jar

2. Download the Release Notes, the License Agreement and Notices for the driver you downloaded in step 1.
3. Use the AWS CLI with the following command:

```
aws s3 cp s3://path_to_the_driver [local_directory]
```

4. To use the driver, see the following documentation:

- To install and configure the JDBC driver version 2.0.6, see the JDBC Driver Installation and Configuration Guide.
- To migrate to this version of the JDBC driver from a 1.x version, see the JDBC Driver Migration Guide.

Instructions for JDBC Driver version 1.1.0

This section includes instructions for the 1.1.0 version of the JDBC driver. Use these instructions only if you have not migrated to the newer (and supported) version of the JDBC driver.

Download the JDBC driver version 1.1.0 that is compatible with JDBC 4.1 and JDK 7.0: 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
`s3_staging_dir`	The S3 location to which your query output is written, for example `s3://query-results-bucket/folder/`, which is established under **Settings** in the Athena Console, https://console.aws.amazon.com/athena/. The JDBC driver then asks Athena to read the results and provide rows of data back to the user.	N/A	Yes
`query_results_encryption_option`	The encryption method to use for the directory specified by `s3_staging_dir`. If not specified, the location is not encrypted. Valid values are `SSE_S3`, `SSE_KMS`, and `CSE_KMS`.	N/A	No
`query_results_aws_kms_key`	The Key ID of the AWS customer master key (CMK) to use if `query_results_encryption_option` specifies `SSE-KMS` or `CSE-KMS`. For example, `123abcde-4e56-56f7-g890-1234h5678i9j`.	N/A	No
`aws_credentials_provider_class`	The credentials provider class name, which implements the `AWSCredentialsProvider` 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

Property Name	Description	Default Value	Is Required
`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: `INFO`, `DEBUG`, `WARN`, `ERROR`, `ALL`, `OFF`, `FATAL`, `TRACE`.	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.CustomSessionsCredentialsProvi
         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. 29).
  - 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. 71) 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**
`BatchGetNamedQuery`, `ListNamedQueries`, `ListQueryExecutions`	5	up to 10
`CreateNamedQuery`, `DeleteNamedQuery`, `GetNamedQuery`	5	up to 20
`BatchGetQueryExecution`	20	up to 40
`StartQueryExecution`, `StopQueryExecution`	20	up to 80
`GetQueryExecution`, `GetQueryResults`	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

This documentation is associated with the May, 18, 2017 version of Amazon Athena.

Latest documentation update: March 5, 2019.

Change	Description	Release Date
Released the new version of the ODBC driver with support for Athena workgroups.	To download the ODBC driver version 1.0.5 and its documentation, see Connecting to Amazon Athena with ODBC (p. 44). For information about this version, see the ODBC Driver Release Notes. 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. 172) to create and manage workgroups, and Athena API tag actions (p. 183) 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.	March 5, 2019
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*.	February 22, 2019
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	February 18, 2019

Change	Description	Release Date
	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. 204).	
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. 158) and Controlling Costs and Monitoring Queries with CloudWatch Metrics (p. 174).	February 18, 2019
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. 142).	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 Athena API" (p. 59).	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

Change	Description	Release Date
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. 91), Considerations and Limitations (p. 91), and Examples (p. 97).	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. 44).	September 6, 2018
Released the JDBC driver version 2.0.5 with default support for streaming results instead of fetching them in pages. Made other improvements in the documentation.	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. 43). For information about streaming results, search for **UseResultsetStreaming** in the JDBC Driver Installation and Configuration Guide.	August 16, 2018
Updated the documentation for querying Amazon Virtual Private Cloud flow logs, which can be stored directly in Amazon S3 in a GZIP format. Updated examples for querying ALB logs.	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. 145). Updated examples for querying ALB logs. For information, see Querying Application Load Balancer Logs (p. 143).	August 7, 2018
Added support for views. Added guidelines for schema manipulations for various data storage formats.	Added support for views. For information, see Views (p. 86). Updated this guide with guidance on handling schema updates for various data storage formats. For information, see Handling Schema Updates (p. 148).	June 5, 2018
Increased default query concurrency limits from five to twenty.	You can submit and run up to twenty `DDL` queries and twenty `SELECT` queries at a time. For information, see Service Limits (p. 253).	May 17, 2018

Change	Description	Release Date
Added query tabs, and an ability to configure auto-complete in the Query Editor.	Added query tabs, and an ability to configure auto-complete in the Query Editor. For information, see Using the Console (p. 27).	May 8, 2018
Released the JDBC driver version 2.0.2.	Released the new version of the JDBC driver (version 2.0.2). For information, see Using Athena with the JDBC Driver (p. 43).	April 19, 2018
Added auto-complete for typing queries in the Athena console.	Added auto-complete for typing queries in the Athena console.	April 6, 2018
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. 136).	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

Change	Description	Release Date
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. 135) and for querying different types of data in Athena. For information, see Querying Data in Amazon Athena Tables (p. 83).	September 5, 2017
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 Configuring Encryption Options (p. 62).	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. 196). • 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.	March 24, 2017
Added support for US East (Ohio).	Added support for Avro SerDe (p. 193) and OpenCSVSerDe for Processing CSV (p. 198), 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 *Amazon Athena User Guide*.	November, 2016

AWS Glossary

For the latest AWS terminology, see the AWS Glossary in the *AWS General Reference*.