aws

Developer Guide

Amazon Keyspaces (for Apache Cassandra)



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Amazon Keyspaces (for Apache Cassandra): Developer Guide

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Table of Contents

What is Amazon Keyspaces? 1
How it works 2
High-level architecture 2
Cassandra data model 5
Accessing Amazon Keyspaces 6
Use cases 7
What is CQL? 7
Compare Amazon Keyspaces with Cassandra 9
Functional differences with Apache Cassandra 10
Apache Cassandra APIs, operations, and data types 11
Asynchronous creation and deletion of keyspaces and tables 11
Authentication and authorization 11
Batch 11
Change data capture (CDC) 11
Cluster configuration 12
Connections 12
`IN` keyword 13
`FROZEN` collections 13
Lightweight transactions 14
Load balancing 14
Pagination 14
Partitioners 14
Prepared statements 15
Range delete 15
System tables 15
Timestamps 16
User-defined types (UDTs) 16
Supported Cassandra APIs, operations, functions, and data types 16
Cassandra API support 17
Cassandra control plane API support 18
Cassandra data plane API support 19
Cassandra function support 19
Cassandra data type support 20
Supported Cassandra consistency levels 22

Write consistency levels ... 22
Read consistency levels ... 23
Unsupported consistency levels ... 24
Migrating to Amazon Keyspaces ... 25
Migrating from Cassandra ... 26
Compatibility ... 27
Estimate pricing ... 27
Migration strategy ... 36
Online migration ... 37
Offline migration ... 49
Hybrid migration ... 51
Migration tools ... 55
Loading data using cqlsh ... 56
Loading data using DSBulk ... 68
Accessing Amazon Keyspaces ... 86
Sign up for an AWS account ... 86
Setting up Amazon Keyspaces ... 86
Using the console ... 87
CloudShell console integration ... 87
Using AWS CloudShell ... 89
AWS CloudShell integration options ... 89
Prerequisites ... 90
Getting started with AWS CloudShell ... 90
Obtaining IAM permissions for AWS CloudShell ... 90
Installing the cqlsh client ... 91
Configuring TLS certificates ... 92
Connecting to Amazon Keyspaces ... 92
Using CQLSH with Amazon Keyspaces ... 92
Persisting data in AWS CloudShell ... 92
Best practices ... 93
Troubleshooting ... 93
Example: How to interact with Amazon Keyspaces using AWS CloudShell ... 93
Create programmatic access credentials ... 95
Create service-specific credentials ... 96
Create IAM credentials for AWS authentication ... 98
Service endpoints ... 106

Ports and protocols ... 107
Global endpoints ... 107
AWS GovCloud (US) Region FIPS endpoints ... 113
China Regions endpoints ... 114
Streams endpoints ... 114
Connecting to dual-stack endpoints ... 119
IPv6 support in Amazon Keyspaces ... 120
DNS resolution in Amazon Keyspaces ... 120
Using `cqlsh` ... 121
Using the `cqlsh-expansion` ... 122
How to manually configure `cqlsh` connections for TLS ... 127
Using the AWS CLI ... 128
Downloading and Configuring the AWS CLI ... 129
Using the AWS CLI with Amazon Keyspaces ... 129
Using the API ... 133
Using a Cassandra client driver ... 133
Using a Cassandra Java client driver ... 134
Using a Cassandra Python client driver ... 151
Using a Cassandra Node.js client driver ... 155
Using a Cassandra .NET Core client driver ... 159
Using a Cassandra Go client driver ... 161
Using a Cassandra Perl client driver ... 167
Configure cross-account access ... 168
Configure cross-account access in a shared VPC ... 169
Configure cross-account access without a shared VPC ... 173
Getting started ... 178
Prerequisites ... 179
Create a keyspace ... 179
Check keyspace creation status ... 183
Create a table ... 183
Check table creation status ... 192
CRUD operations ... 192
Create ... 193
Read ... 197
Update ... 201
Delete ... 202

Delete a table ... 204
Delete a keyspace ... 207
Tutorials and solutions ... 210
Connecting with VPC endpoints ... 210
Prerequisites ... 211
Step 1: Launch an Amazon EC2 instance ... 211
Step 2: Configure your Amazon EC2 instance ... 213
Step 3: Create a VPC endpoint for Amazon Keyspaces ... 216
Step 4: Configure permissions for the VPC endpoint connection ... 221
Step 5: Configure monitoring ... 225
Step 6: (Optional) Best practices for connections ... 226
Step 7: (Optional) Clean up ... 229
Integrating with Apache Spark ... 230
Prerequisites ... 231
Step 1: Configure Amazon Keyspaces ... 232
Step 2: Configure the Apache Cassandra Spark Connector ... 233
Step 3: Create the app config file ... 235
Step 4: Prepare the source data and the target table ... 238
Step 5: Write and read Amazon Keyspaces data ... 239
Troubleshooting ... 242
Connecting from Amazon EKS ... 244
Prerequisites ... 245
Step 1: Configure the Amazon EKS cluster ... 247
Step 2: Configure the application ... 252
Step 3: Create application image ... 255
Step 4: Deploy the application to Amazon EKS ... 256
Step 5: (Optional) Cleanup ... 262
Exporting data to Amazon S3 ... 264
Prerequisites ... 265
Step 1: Bootstrap infrastructure and AWS Glue jobs ... 266
Step 2: Run the export job ... 269
Step 3: (Optional) Schedule the export job ... 271
Step 4: (Optional) Cleanup ... 273
Managing serverless resources ... 276
Estimate row size ... 277
Estimate the encoded size of columns ... 278

Estimate the encoded size of data values based on data type ... 278
Consider the impact of Amazon Keyspaces features on row size ... 280
Choose the right formula to calculate the encoded size of a row ... 281
Row size calculation example ... 282
Estimate capacity consumption ... 284
Estimate the capacity consumption of range queries ... 284
Estimate the read capacity consumption of limit queries ... 285
Estimate the read capacity consumption of table scans ... 286
Estimate capacity consumption of LWT ... 287
Estimate capacity consumption of static columns ... 288
Estimate capacity for a multi-Region table ... 292
Estimate capacity consumption with CloudWatch ... 293
Configure read/write capacity modes ... 293
Configure on-demand capacity mode ... 294
Configure provisioned capacity mode ... 296
View the capacity mode of a table ... 298
Change capacity mode ... 300
Configure pre-warming ... 302
Manage throughput capacity with auto scaling ... 317
How Amazon Keyspaces automatic scaling works ... 317
How auto scaling works for multi-Region tables ... 319
Usage notes ... 320
Configure and update auto scaling policies ... 321
Use burst capacity ... 334
Working with Amazon Keyspaces features ... 335
System keyspaces ... 336
`system` ... 337
`system_schema` ... 338
`system_schema_mcs` ... 340
`system_multiregion_info` ... 342
User-defined types (UDTs) ... 344
Configure permissions ... 345
Create a UDT ... 349
View UDTs ... 353
Delete a UDT ... 356
Working with CQL queries ... 357

Use IN SELECT ... 358
Use batch statements ... 362
Order results ... 369
Paginate results ... 370
Working with CDC streams ... 371
How CDC streams work ... 372
Use CDC streams ... 376
Working with partitioners ... 411
Change the partitioner ... 411
Client-side timestamps ... 413
Integration with AWS services ... 414
Create table with client-side timestamps ... 415
Configure client-side timestamps ... 418
Use client-side timestamps in queries ... 420
Multi-Region replication ... 421
Benefits ... 422
Capacity modes and pricing ... 423
How it works ... 424
Usage notes ... 428
Configure multi-Region replication ... 431
Backup and restore with point-in-time recovery ... 458
How it works ... 459
Use point-in-time recovery ... 464
Expire data with Time to Live ... 477
Integration with AWS services ... 478
Create table with default TTL value ... 479
Update table default TTL value ... 483
Create table with custom TTL ... 486
Update table custom TTL ... 488
Use INSERT to set custom TTL for new rows ... 491
Use UPDATE to set custom TTL for rows and columns ... 491
Working with AWS SDKs ... 493
Working with tags ... 494
Tagging restrictions ... 495
Tag keyspaces, tables, and streams ... 495
Create cost allocation reports ... 514

Create CloudFormation resources ... 515
Amazon Keyspaces and CloudFormation templates ... 515
Learn more about CloudFormation ... 515
NoSQL Workbench ... 516
Download ... 517
Getting started ... 517
Visualize a data model ... 519
Create a data model ... 523
Edit a data model ... 525
Commit a data model ... 527
Sample data models ... 538
Release history ... 539
Code examples ... 540
Basics ... 540
Hello Amazon Keyspaces ... 541
Learn the basics ... 546
Actions ... 608
Libraries and tools ... 660
Libraries and examples ... 660
Amazon Keyspaces (for Apache Cassandra) developer toolkit ... 660
Amazon Keyspaces (for Apache Cassandra) examples ... 660
AWS Signature Version 4 (SigV4) authentication plugins ... 660
Highlighted sample and developer tool repos ... 661
Amazon Keyspaces Protocol Buffers ... 661
CloudFormation template to create Amazon CloudWatch dashboard for Amazon Keyspaces (for Apache Cassandra) metrics ... 661
Using Amazon Keyspaces (for Apache Cassandra) with AWS Lambda ... 661
Using Amazon Keyspaces (for Apache Cassandra) with Spring ... 662
Using Amazon Keyspaces (for Apache Cassandra) with Scala ... 662
Using Amazon Keyspaces (for Apache Cassandra) with AWS Glue ... 662
Amazon Keyspaces (for Apache Cassandra) Cassandra query language (CQL) to CloudFormation converter ... 662
Amazon Keyspaces (for Apache Cassandra) helpers for Apache Cassandra driver for Java . 663
Amazon Keyspaces (for Apache Cassandra) snappy compression demo ... 663
Amazon Keyspaces (for Apache Cassandra) and Amazon S3 codec demo ... 663
Best practices ... 664

NoSQL design ... 665
NoSQL vs. RDBMS ... 666
Two key concepts ... 666
General approach ... 667
Connections ... 668
How they work ... 668
How to configure connections ... 669
How to configure retry policies ... 671
VPC endpoint connections ... 671
How to monitor connections ... 672
How to handle connection errors ... 673
Data modeling ... 674
Partition key design ... 675
Cost optimization ... 677
Evaluate your costs at the table level ... 678
Evaluate your table's capacity mode ... 679
Evaluate your table's Application Auto Scaling settings ... 684
Identify your unused resources ... 691
Evaluate your table usage patterns ... 696
Evaluate your provisioned capacity for right-sized provisioning ... 697
Troubleshooting ... 707
General errors ... 708
General errors ... 708
Connection errors ... 710
Errors connecting to an Amazon Keyspaces endpoint ... 710
Capacity management errors ... 722
Serverless capacity errors ... 722
Data definition language errors ... 727
Data definition language errors ... 727
Monitoring Amazon Keyspaces ... 732
Monitoring with CloudWatch ... 733
Using metrics ... 734
Metrics and dimensions ... 735
View metrics ... 758
Create alarms ... 759
Logging with CloudTrail ... 759

Configuring log file entries in CloudTrail ... 760
DDL information in CloudTrail ... 761
DML information in CloudTrail ... 762
Understanding log file entries ... 763
Security ... 774
Data protection ... 775
Encryption at rest ... 776
Encryption in transit ... 797
Internetwork traffic privacy ... 797
AWS Identity and Access Management ... 798
Audience ... 799
Authenticating with identities ... 799
Managing access using policies ... 800
How Amazon Keyspaces works with IAM ... 802
Identity-based policy examples ... 807
AWS managed policies ... 815
Troubleshooting ... 825
Using service-linked roles ... 828
Compliance validation ... 837
Resilience ... 838
Infrastructure security ... 839
Using interface VPC endpoints ... 840
Using interface VPC endpoints with streams ... 846
Configuration and vulnerability analysis for Amazon Keyspaces ... 850
Security best practices ... 850
Preventative security best practices ... 850
Detective security best practices ... 852
CQL language reference ... 855
Language elements ... 856
Identifiers ... 856
Constants ... 856
Terms ... 857
Data types ... 857
JSON encoding of Amazon Keyspaces data types ... 861
DDL statements ... 864
Keyspaces ... 865

Tables ... 868
Types ... 882
DML statements ... 884
SELECT ... 885
INSERT ... 887
UPDATE ... 889
DELETE ... 891
Built-in functions ... 891
Scalar functions ... 892
Quotas ... 894
Amazon Keyspaces service quotas ... 894
Increasing or decreasing throughput (for provisioned tables) ... 900
Increasing provisioned throughput ... 900
Decreasing provisioned throughput ... 901
Amazon Keyspaces encryption at rest ... 901
Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces ... 901
Amazon Keyspaces UDT quotas and default values ... 901
Document history ... 903

What is Amazon Keyspaces (for Apache Cassandra)?

Amazon Keyspaces (for Apache Cassandra) is a scalable, highly available, and managed Apache Cassandra–compatible database service. With Amazon Keyspaces, you don't have to provision, patch, or manage servers, and you don't have to install, maintain, or operate software.

Amazon Keyspaces is serverless, so you pay for only the resources that you use, and the service automatically scales tables up and down in response to application traffic. You can build applications that serve thousands of requests per second with virtually unlimited throughput and storage.

> **Note**
>
> Apache Cassandra is an open-source, wide-column datastore that is designed to handle large amounts of data. For more information, see Apache Cassandra.

Amazon Keyspaces makes it easy to migrate, run, and scale Cassandra workloads in the AWS Cloud. With just a few clicks on the AWS Management Console or a few lines of code, you can create keyspaces and tables in Amazon Keyspaces, without deploying any infrastructure or installing software.

With Amazon Keyspaces, you can run your existing Cassandra workloads on AWS using the same Cassandra application code and developer tools that you use today.

With the pricing calculator for Amazon Keyspaces (for Apache Cassandra) available on Github, you can estimate your monthly costs for Amazon Keyspaces based on your existing Apache Cassandra workload. Enter metrics from your Cassandra nodetool status output and intended serverless configuration for Amazon Keyspaces to compare direct costs between the two solutions. Note that this calculator focuses only on the operational costs of Amazon Keyspaces compared to your existing Cassandra deployment. It doesn't include total cost of ownership (TCO) factors like infrastructure maintenance, operational overhead, or support costs for Cassandra.

For a list of available AWS Regions and endpoints, see Service endpoints for Amazon Keyspaces.

We recommend that you start by reading the following sections:

Topics

- Amazon Keyspaces: How it works
- Amazon Keyspaces use cases
- What is Cassandra Query Language (CQL)?

Amazon Keyspaces: How it works

Amazon Keyspaces removes the administrative overhead of managing Cassandra. To understand why, it's helpful to begin with Cassandra architecture and then compare it to Amazon Keyspaces.

Topics

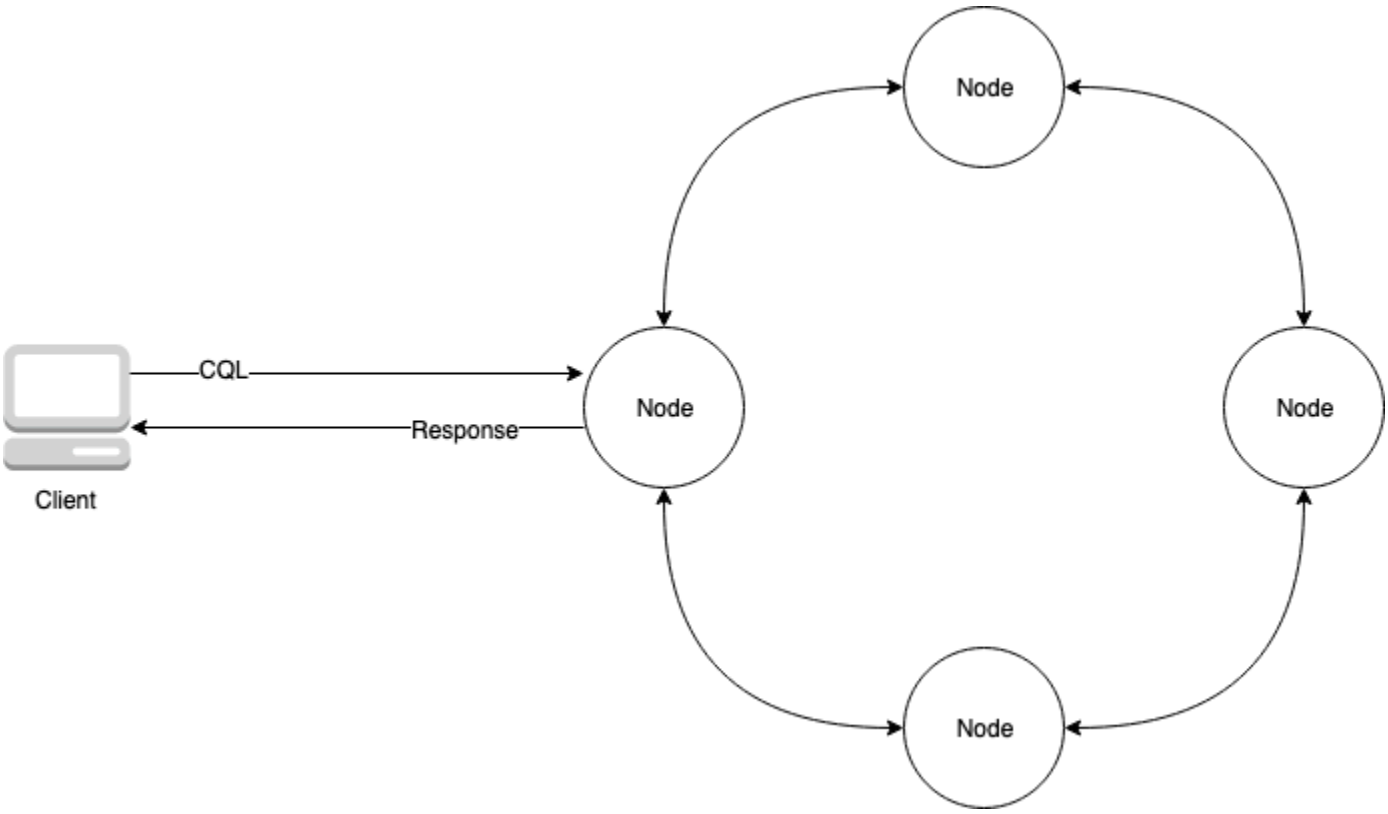
- High-level architecture: Apache Cassandra vs. Amazon Keyspaces
- Cassandra data model
- Accessing Amazon Keyspaces from an application

High-level architecture: Apache Cassandra vs. Amazon Keyspaces

Traditional Apache Cassandra is deployed in a cluster made up of one or more nodes. You are responsible for managing each node and adding and removing nodes as your cluster scales.

A client program accesses Cassandra by connecting to one of the nodes and issuing Cassandra Query Language (CQL) statements. *CQL* is similar to SQL, the popular language used in relational databases. Even though Cassandra is not a relational database, CQL provides a familiar interface for querying and manipulating data in Cassandra.

The following diagram shows a simple Apache Cassandra cluster, consisting of four nodes.



A production Cassandra deployment might consist of hundreds of nodes, running on hundreds of physical computers across one or more physical data centers. This can cause an operational burden for application developers who need to provision, patch, and manage servers in addition to installing, maintaining, and operating software.

With Amazon Keyspaces (for Apache Cassandra), you don't need to provision, patch, or manage servers, so you can focus on building better applications. Amazon Keyspaces offers two throughput capacity modes for reads and writes: on-demand and provisioned. You can choose your table's throughput capacity mode to optimize the price of reads and writes based on the predictability and variability of your workload.

With on-demand mode, you pay for only the reads and writes that your application actually performs. You do not need to specify your table's throughput capacity in advance. Amazon Keyspaces accommodates your application traffic almost instantly as it ramps up or down, making it a good option for applications with unpredictable traffic.

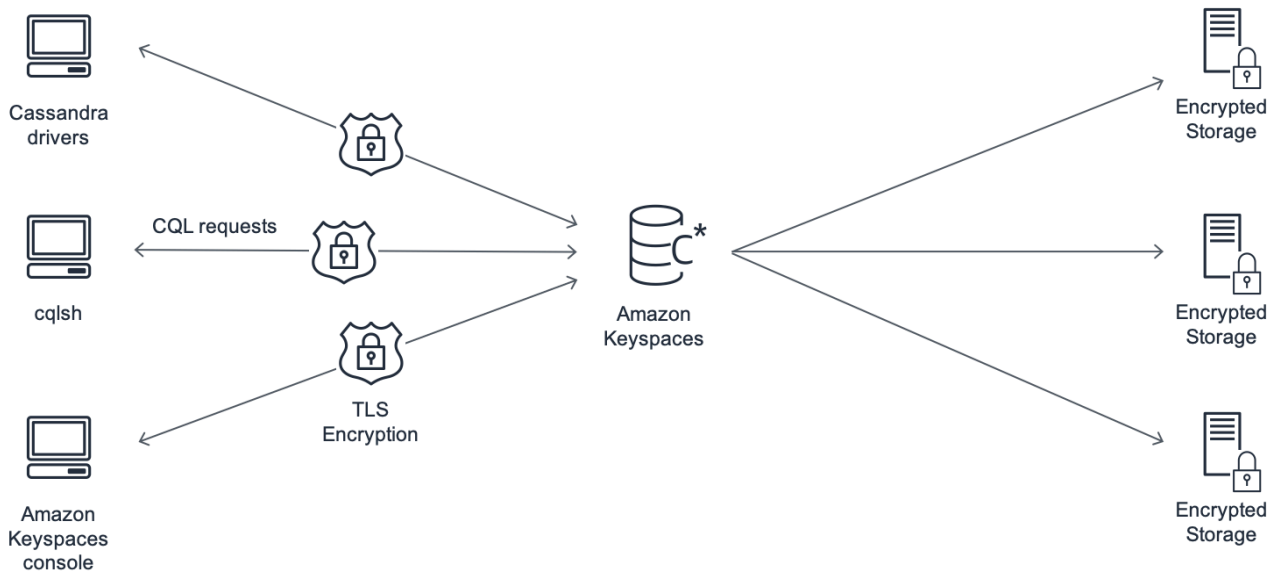
Provisioned capacity mode helps you optimize the price of throughput if you have predictable application traffic and can forecast your table's capacity requirements in advance. With provisioned capacity mode, you specify the number of reads and writes per second that you expect your

application to perform. You can increase and decrease the provisioned capacity for your table automatically by enabling automatic scaling.

You can change the capacity mode of your table once per day as you learn more about your workload's traffic patterns, or if you expect to have a large burst in traffic, such as from a major event that you anticipate will drive a lot of table traffic. For more information about read and write capacity provisioning, see the section called "Configure read/write capacity modes".

Amazon Keyspaces (for Apache Cassandra) stores three copies of your data in multiple Availability Zones for durability and high availability. In addition, you benefit from a data center and network architecture that is built to meet the requirements of the most security-sensitive organizations. Encryption at rest is automatically enabled when you create a new Amazon Keyspaces table and all client connections require Transport Layer Security (TLS). Additional AWS security features include monitoring, AWS Identity and Access Management, and virtual private cloud (VPC) endpoints. For an overview of all available security features, see *Security*.

The following diagram shows the architecture of Amazon Keyspaces.



A client program accesses Amazon Keyspaces by connecting to a predetermined endpoint (hostname and port number) and issuing CQL statements. For a list of available endpoints, see the section called "Service endpoints".

Cassandra data model

How you model your data for your business case is critical to achieving optimal performance from Amazon Keyspaces. A poor data model can significantly degrade performance.

Even though CQL looks similar to SQL, the backends of Cassandra and relational databases are very different and must be approached differently. The following are some of the more significant issues to consider:

Storage

You can visualize your Cassandra data in tables, with each row representing a record and each column a field within that record.

Table design: Query first

There are no `JOIN`s in CQL. Therefore, you should design your tables with the shape of your data and how you need to access it for your business use cases. This might result in de-normalization with duplicated data. You should design each of your tables specifically for a particular access pattern.

Partitions

Your data is stored in partitions on disk. The number of partitions your data is stored in and how it is distributed across the partitions is determined by your *partition key*. How you define your partition key can have a significant impact upon the performance of your queries. For best practices, see the section called “Partition key design”.

Primary key

In Cassandra, data is stored as a key-value pair. Every Cassandra table must have a primary key, which is the unique key to each row in the table. The primary key is the composite of a required partition key and optional clustering columns. The data that comprises the primary key must be unique across all records in a table.

- **Partition key** – The partition key portion of the primary key is required and determines which partition of your cluster the data is stored in. The partition key can be a single column, or it can be a compound value composed of two or more columns. You would use a compound partition key if a single column partition key would result in a single partition or a very few partitions having most of the data and thus bearing the majority of the disk I/O operations.
- **Clustering column** – The optional clustering column portion of your primary key determines how the data is clustered and sorted within each partition. If you include a clustering column

in your primary key, the clustering column can have one or more columns. If there are multiple columns in the clustering column, the sorting order is determined by the order that the columns are listed in the clustering column, from left to right.

For more information about NoSQL design and Amazon Keyspaces, see the section called "NoSQL design". For more information about Amazon Keyspaces and data modeling, see the section called "Data modeling".

Accessing Amazon Keyspaces from an application

Amazon Keyspaces (for Apache Cassandra) implements the Apache Cassandra Query Language (CQL) API, so you can use CQL and Cassandra drivers that you already use. Updating your application is as easy as updating your Cassandra driver or `cqlsh` configuration to point to the Amazon Keyspaces service endpoint. For more information about the required credentials, see the section called "Create IAM credentials for AWS authentication".

> **Note**
>
> To help you get started, you can find end-to-end code samples of connecting to Amazon Keyspaces by using various Cassandra client drivers in the Amazon Keyspaces code example repository on GitHub.

Consider the following Python program, which connects to a Cassandra cluster and queries a table.

```
from cassandra.cluster import Cluster
#TLS/SSL configuration goes here

ksp = 'MyKeyspace'
tbl = 'WeatherData'

cluster = Cluster(['NNN.NNN.NNN.NNN'], port=NNNN)
session = cluster.connect(ksp)

session.execute('USE ' + ksp)

rows = session.execute('SELECT * FROM ' +  tbl)
for row in rows:
    print(row)
```

To run the same program against Amazon Keyspaces, you need to:

- **Add the cluster endpoint and port**: For example, the host can be replaced with a service endpoint, such as `cassandra.us-east-1.amazonaws.com` and the port number with: 9142.
- **Add the TLS/SSL configuration**: For more information on adding the TLS/SSL configuration to connect to Amazon Keyspaces by using a Cassandra client Python driver, see Using a Cassandra Python client driver to access Amazon Keyspaces programmatically.

Amazon Keyspaces use cases

The following are just some of the ways in which you can use Amazon Keyspaces:

- **Build applications that require low latency** – Process data at high speeds for applications that require single-digit-millisecond latency, such as industrial equipment maintenance, trade monitoring, fleet management, and route optimization.
- **Build applications using open-source technologies** – Build applications on AWS using open-source Cassandra APIs and drivers that are available for a wide range of programming languages, such as Java, Python, Ruby, Microsoft .NET, Node.js, PHP, C++, Perl, and Go. For code examples, see *Libraries and tools*.
- **Move your Cassandra workloads to the cloud** – Managing Cassandra tables yourself is time-consuming and expensive. With Amazon Keyspaces, you can set up, secure, and scale Cassandra tables in the AWS Cloud without managing infrastructure. For more information, see *Managing serverless resources*.

What is Cassandra Query Language (CQL)?

Cassandra Query Language (CQL) is the primary language for communicating with Apache Cassandra. Amazon Keyspaces (for Apache Cassandra) is compatible with the CQL 3.x API (backward-compatible with version 2.x).

In CQL, data is stored in tables, columns, and rows. In this sense CQL is similar to Structured Query Language (SQL). These are the key concepts in CQL.

- **CQL elements** – The fundamental elements of CQL are identifiers, constants, terms, and data types.

- **Data Definition Language (DDL)** – DDL statements are used to manage data structures like keyspaces and tables, which are AWS resources in Amazon Keyspaces. DDL statements are control plane operations in AWS.
- **Data Manipulation Language (DML)** – DML statements are used to manage data within tables. DML statements are used for selecting, inserting, updating, and deleting data. These are data plane operations in AWS.
- **Built-in functions** – Amazon Keyspaces supports a variety of built-in scalar functions that you can use in CQL statements.

For more information about CQL, see CQL language reference for Amazon Keyspaces (for Apache Cassandra). For functional differences with Apache Cassandra, see the section called "Functional differences with Apache Cassandra".

To run CQL queries, you can do one of the following:

- Use the CQL editor in the AWS Management Console.
- Use AWS CloudShell and the cqlsh-expansion.
- Use a `cqlsh` client.
- Use an Apache 2.0 licensed Cassandra client driver.

In addition to CQL, you can perform Data Definition Language (DDL) operations in Amazon Keyspaces using the AWS SDKs and the AWS Command Line Interface.

For more information about using these methods to access Amazon Keyspaces, see Accessing Amazon Keyspaces (for Apache Cassandra).

How does Amazon Keyspaces (for Apache Cassandra) compare to Apache Cassandra?

To establish a connection to Amazon Keyspaces, you can either use a public AWS service endpoint or a private endpoint using Interface VPC endpoints (AWS PrivateLink) in the Amazon Virtual Private Cloud . Depending on the endpoint used, Amazon Keyspaces can appear to the client in one of the following ways.

AWS service endpoint connection

This is a connection established over any public endpoint. In this case, Amazon Keyspaces appears as a **nine-node** Apache Cassandra 3.11.2 cluster to the client.

Interface VPC endpoint connection

This is a private connection established using an interface VPC endpoint. In this case, Amazon Keyspaces appears as a **three-node** Apache Cassandra 3.11.2 cluster to the client.

Independent of the connection type and the number of nodes that are visible to the client, Amazon Keyspaces provides virtually limitless throughput and storage. To do this, Amazon Keyspaces maps the nodes to load balancers that route your queries to one of the many underlying storage partitions. For more information about connections, see the section called “How they work”.

Amazon Keyspaces stores data in partitions. A partition is an allocation of storage for a table, backed by solid state drives (SSDs). Amazon Keyspaces automatically replicates your data across multiple Availability Zones within an AWS Region for durability and high availability. As your throughput or storage needs grow, Amazon Keyspaces handles the partition management for you and automatically provisions the required additional partitions.

Amazon Keyspaces supports all commonly used Cassandra data-plane operations, such as creating keyspaces and tables, reading data, and writing data. Amazon Keyspaces is serverless, so you don’t have to provision, patch, or manage servers. You also don’t have to install, maintain, or operate software. As a result, in Amazon Keyspaces you don't need to use the Cassandra control plane API operations to manage cluster and node settings.

Amazon Keyspaces automatically configures settings such as replication factor and consistency level to provide you with high availability, durability, and single-digit-millisecond performance.

For even more resiliency and low-latency local reads, Amazon Keyspaces offers multi-Region replication.

Topics

- Functional differences: Amazon Keyspaces vs. Apache Cassandra
- Supported Cassandra APIs, operations, functions, and data types
- Supported Apache Cassandra read and write consistency levels and associated costs

Functional differences: Amazon Keyspaces vs. Apache Cassandra

The following are the functional differences between Amazon Keyspaces and Apache Cassandra.

Topics

- Apache Cassandra APIs, operations, and data types
- Asynchronous creation and deletion of keyspaces and tables
- Authentication and authorization
- Batch
- Change data capture (CDC)
- Cluster configuration
- Connections
- IN keyword
- FROZEN collections
- Lightweight transactions
- Load balancing
- Pagination
- Partitioners
- Prepared statements
- Range delete
- System tables
- Timestamps

- User-defined types (UDTs)

Apache Cassandra APIs, operations, and data types

Amazon Keyspaces supports all commonly used Cassandra data-plane operations, such as creating keyspaces and tables, reading data, and writing data. To see what is currently supported, see Supported Cassandra APIs, operations, functions, and data types.

Asynchronous creation and deletion of keyspaces and tables

Amazon Keyspaces performs data definition language (DDL) operations, such as creating and deleting keyspaces , tables, and types asynchronously. To learn how to monitor the creation status of resources, see the section called “Check keyspace creation status” and the section called “Check table creation status”. For a list of DDL statements in the CQL language reference, see the section called “DDL statements”.

Authentication and authorization

Amazon Keyspaces (for Apache Cassandra) uses AWS Identity and Access Management (IAM) for user authentication and authorization, and supports the equivalent authorization policies as Apache Cassandra. As such, Amazon Keyspaces does not support Apache Cassandra's security configuration commands.

Batch

Amazon Keyspaces supports the following batch commands:

- **Logged batch** – supports up to 100 commands per batch.
- **Unlogged batch** – supports up to 30 commands per batch.

Only **INSERT**, **UPDATE**, or **DELETE** commands are permitted in a batch.

Change data capture (CDC)

In Apache Cassandra, change data capture (CDC) copies commit log segments that capture table updates to a specified directory on the node. Each change record in the CDC log can include updates across multiple keyspaces and tables. When a row is updated or deleted, the Apache Cassandra CDC log shows only the modified columns. The log doesn't include the previous state of

the data before the change. To understand the full details of the data modifications, you need to deserialize these logs using specific Cassandra tools.

With Amazon Keyspaces CDC streams, you can select the type of information that the CDC stream collects for each row. By default, Amazon Keyspaces CDC streams capture the version of the row before and after the change occurred. Amazon Keyspaces CDC provides de-duplicated and ordered change records at the table level.

In Amazon Keyspaces, each CDC stream is an AWS resource with an Amazon Resource Name (ARN) and your application can consume Amazon Keyspaces CDC streams using the Amazon Keyspaces CDC API using one of the available endpoints.

For more information about Amazon Keyspaces CDC, see the section called "Working with CDC streams".

Cluster configuration

Amazon Keyspaces is serverless, so there are no clusters, hosts, or Java virtual machines (JVMs) to configure. Cassandra's settings for compaction, compression, caching, garbage collection, and bloom filtering are not applicable to Amazon Keyspaces and are ignored if specified.

Connections

You can use existing Cassandra drivers to communicate with Amazon Keyspaces, but you need to configure the drivers differently. Amazon Keyspaces supports up to 3,000 CQL queries per TCP connection per second, but there is no limit on the number of connections a driver can establish.

Most open-source Cassandra drivers establish a connection pool to Cassandra and load balance queries over that pool of connections. Amazon Keyspaces exposes 9 peer IP addresses to drivers, and the default behavior of most drivers is to establish a single connection to each peer IP address. Therefore, the maximum CQL query throughput of a driver using the default settings is 27,000 CQL queries per second.

To increase this number, we recommend increasing the number of connections per IP address your driver is maintaining in its connection pool. For example, setting the maximum connections per IP address to 2 doubles the maximum throughput of your driver to 54,000 CQL queries per second.

As a best practice, we recommend configuring drivers to use 500 CQL queries per second per connection to allow for overhead and to improve distribution. In this scenario, planning for 18,000 CQL queries per second requires 36 connections. Configuring the driver for 4 connections across 9

endpoints provides for 36 connections performing 500 request per second. For more information about best practices for connections, see the section called “Connections”.

When connecting with VPC endpoints, there might be fewer endpoints available. This means that you have to increase the number of connections in the driver configuration. For more information about best practices for VPC connections, see the section called “VPC endpoint connections”.

IN keyword

Amazon Keyspaces supports the IN keyword in the SELECT statement. IN is not supported with UPDATE and DELETE. When using the IN keyword in the SELECT statement, the results of the query are returned in the order of how the keys are presented in the SELECT statement. In Cassandra, the results are ordered lexicographically.

When using ORDER BY, full re-ordering with disabled pagination is not supported and results are ordered within a page. Slice queries are not supported with the IN keyword. TOKENS are not supported with the IN keyword. Amazon Keyspaces processes queries with the IN keyword by creating subqueries. Each subquery counts as a connection towards the 3,000 CQL queries per TCP connection per second limit. For more information, see the section called “Use IN SELECT”.

FROZEN collections

The FROZEN keyword in Cassandra serializes multiple components of a collection data type into a single immutable value that is treated like a BLOB. INSERT and UPDATE statements overwrite the entire collection.

Amazon Keyspaces supports up to 8 levels of nesting for frozen collections by default. For more information, see the section called “Amazon Keyspaces service quotas”.

Amazon Keyspaces doesn't support inequality comparisons that use the entire frozen collection in a conditional UPDATE or SELECT statement. The behavior for collections and frozen collections is the same in Amazon Keyspaces.

When you're using frozen collections with client-side timestamps, in the case where the timestamp of a write operation is the same as the timestamp of an existing column that isn't expired or tombstoned, Amazon Keyspaces doesn't perform comparisons. Instead, it lets the server determine the latest writer, and the latest writer wins.

For more information about frozen collections, see the section called “Collection types”.

Lightweight transactions

Amazon Keyspaces (for Apache Cassandra) fully supports compare and set functionality on **INSERT**, **UPDATE**, and **DELETE** commands, which are known as *lightweight transactions* (LWTs) in Apache Cassandra. As a serverless offering, Amazon Keyspaces (for Apache Cassandra) provides consistent performance at any scale, including for lightweight transactions. With Amazon Keyspaces, there is no performance penalty for using lightweight transactions.

Load balancing

The `system.peers` table entries correspond to Amazon Keyspaces load balancers. For best results, we recommend using a round robin load-balancing policy and tuning the number of connections per IP to suit your application's needs.

Pagination

Amazon Keyspaces paginates results based on the number of rows that it reads to process a request, not the number of rows returned in the result set. As a result, some pages might contain fewer rows than you specify in PAGE SIZE for filtered queries. In addition, Amazon Keyspaces paginates results automatically after reading 1 MB of data to provide customers with consistent, single-digit millisecond read performance. For more information, see the section called “Paginate results”.

In tables with static columns, both Apache Cassandra and Amazon Keyspaces establish the partition's static column value at the start of each page in a multi-page query. When a table has large data rows, as a result of the Amazon Keyspaces pagination behavior, the likelihood is higher that a range read operation result could return more pages for Amazon Keyspaces than for Apache Cassandra. Consequently, there is a higher likelihood in Amazon Keyspaces that concurrent updates to the static column could result in the static column value being different in different pages of the range read result set.

Partitioners

The default partitioner in Amazon Keyspaces is the Cassandra-compatible `Murmur3Partitioner`. In addition, you have the choice of using either the Amazon Keyspaces `DefaultPartitioner` or the Cassandra-compatible `RandomPartitioner`.

With Amazon Keyspaces, you can safely change the partitioner for your account without having to reload your Amazon Keyspaces data. After the configuration change has completed, which takes

approximately 10 minutes, clients will see the new partitioner setting automatically the next time they connect. For more information, see the section called “Working with partitioners”.

Prepared statements

Amazon Keyspaces supports the use of prepared statements for data manipulation language (DML) operations, such as reading and writing data. Amazon Keyspaces does not currently support the use of prepared statements for data definition language (DDL) operations, such as creating tables and keyspaces. DDL operations must be run outside of prepared statements.

Range delete

> **Important**
>
> Starting July 1, 2026, range delete operations will transition from synchronous to asynchronous processing. After this change, a successful response confirms that your delete request has been accepted, but the deletion may still be in progress. To verify that deletion is complete, query for items in the specified range. When the query returns no results, deletion is complete.

Amazon Keyspaces supports deleting rows in range. A range is a contiguous set of rows within a partition. You specify a range in a DELETE operation by using a WHERE clause. You can specify the range to be an entire partition.

Furthermore, you can specify a range to be a subset of contiguous rows within a partition by using relational operators (for example, '>', '<'), or by including the partition key and omitting one or more clustering columns. With Amazon Keyspaces, you can delete up to 1,000 rows within a range in a single operation.

Range deletes are not isolated. Individual row deletions are visible to other operations while a range delete is in process.

System tables

Amazon Keyspaces populates the system tables that are required by Apache 2.0 open-source Cassandra drivers. The system tables that are visible to a client contain information that's unique to the authenticated user. The system tables are fully controlled by Amazon Keyspaces and are read-only. For more information, see the section called “System keyspaces”.

Read-only access to system tables is required, and you can control it with IAM access policies. For more information, see the section called "Managing access using policies". You must define tag-based access control policies for system tables differently depending on whether you use the AWS SDK or Cassandra Query Language (CQL) API calls through Cassandra drivers and developer tools. To learn more about tag-based access control for system tables, see the section called "Amazon Keyspaces resource access based on tags".

If you access Amazon Keyspaces using Amazon VPC endpoints, you see entries in the `system.peers` table for each Amazon VPC endpoint that Amazon Keyspaces has permissions to see. As a result, your Cassandra driver might issue a warning message about the control node itself in the `system.peers` table. You can safely ignore this warning.

Timestamps

In Amazon Keyspaces, cell-level timestamps that are compatible with the default timestamps in Apache Cassandra are an opt-in feature.

The `USING TIMESTAMP` clause and the `WRITETIME` function are only available when client-side timestamps are turned on for a table. To learn more about client-side timestamps in Amazon Keyspaces, see the section called "Client-side timestamps".

User-defined types (UDTs)

The inequality operator is not supported for UDTs in Amazon Keyspaces.

To learn how to work with UDTs in Amazon Keyspaces, see the section called "User-defined types (UDTs)".

To review how many UDTs are supported per keyspace, supported levels of nesting, and other default values and quotas related to UDTs, see the section called "Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces".

Supported Cassandra APIs, operations, functions, and data types

Amazon Keyspaces (for Apache Cassandra) is compatible with Cassandra Query Language (CQL) 3.11 API (backward-compatible with version 2.x).

Amazon Keyspaces supports all commonly used Cassandra data-plane operations, such as creating keyspaces and tables, reading data, and writing data.

The following sections list the supported functionality.

Topics

- Cassandra API support
- Cassandra control plane API support
- Cassandra data plane API support
- Cassandra function support
- Cassandra data type support

Cassandra API support

API operation	Supported
`CREATE KEYSPACE`	Yes
`ALTER KEYSPACE`	Yes
`DROP KEYSPACE`	Yes
`CREATE TABLE`	Yes
`ALTER TABLE`	Yes
`DROP TABLE`	Yes
`CREATE INDEX`	No
`DROP INDEX`	No
`UNLOGGED BATCH`	Yes
`LOGGED BATCH`	Yes
`SELECT`	Yes
`INSERT`	Yes
`DELETE`	Yes

API operation	Supported
UPDATE	Yes
USE	Yes
CREATE TYPE	Yes
ALTER TYPE	No
DROP TYPE	Yes
CREATE TRIGGER	No
DROP TRIGGER	No
CREATE FUNCTION	No
DROP FUNCTION	No
CREATE AGGREGATE	No
DROP AGGREGATE	No
CREATE MATERIALIZED VIEW	No
ALTER MATERIALIZED VIEW	No
DROP MATERIALIZED VIEW	No
TRUNCATE	No

Cassandra control plane API support

Because Amazon Keyspaces is managed, the Cassandra control plane API operations to manage cluster and node settings are not required. As a result, the following Cassandra features are not applicable.

Feature	Reason
Durable writes toggle	All writes are durable
Read repair settings	Not applicable
GC grace seconds	Not applicable
Bloom filter settings	Not applicable
Compaction settings	Not applicable
Compression settings	Not applicable
Caching settings	Not applicable
Security settings	Replaced by IAM

Cassandra data plane API support

Feature	Supported
JSON support for SELECT and INSERT statements	Yes
Static columns	Yes
Time to Live (TTL)	Yes

Cassandra function support

For more information about the supported functions, see the section called “Built-in functions”.

Function	Supported
`Aggregate` functions	No
`Blob` conversion	Yes

Function	Supported
`Cast`	Yes
`Datetime` functions	Yes
Timeconversion functions	Yes
`TimeUuid` functions	Yes
`Token`	Yes
`User defined functions (UDF)`	No
`Uuid`	Yes

Cassandra data type support

The following table lists the Apache Cassandra data types supported in Amazon Keyspaces. For more information about data types in Amazon Keyspaces, see the section called “Data types”.

Data type	Supported
`ascii`	Yes
`bigint`	Yes
`blob`	Yes
`boolean`	Yes
`counter`	Yes
`date`	Yes
`decimal`	Yes
`double`	Yes
`float`	Yes

Data type	Supported
frozen	Yes
inet	Yes
int	Yes
list	Yes
map	Yes
set	Yes
smallint	Yes
text	Yes
time	Yes
timestamp	Yes
timeuuid	Yes
tinyint	Yes
tuple	Yes
user-defined types (UDTs)	Yes
uuid	Yes
varchar	Yes
varint	Yes

Supported Apache Cassandra read and write consistency levels and associated costs

The topics in this section describe which Apache Cassandra consistency levels are supported for read and write operations in Amazon Keyspaces (for Apache Cassandra).

Topics

- Write consistency levels
- Read consistency levels
- Unsupported consistency levels

Write consistency levels

Amazon Keyspaces replicates all write operations three times across multiple Availability Zones for durability and high availability. Writes are durably stored before they are acknowledged using the `LOCAL_QUORUM` consistency level. For each 1 KB write, you are billed 1 write capacity unit (WCU) for tables using provisioned capacity mode or 1 write request unit (WRU) for tables using on-demand mode.

You can use `cqlsh` to set the consistency for all queries in the current session to `LOCAL_QUORUM` using the following code.

```
CONSISTENCY LOCAL_QUORUM;
```

To configure the consistency level programmatically, you can set the consistency with the appropriate Cassandra client drivers. For example, the 4.x version Java drivers allow you to set the consistency level in the `app config` file as shown below.

```
basic.request.consistency = LOCAL_QUORUM
```

If you're using a 3.x version Java Cassandra driver, you can specify the consistency level for the session by adding `.withQueryOptions(new QueryOptions().setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM)` as shown in the following code example.

```
Session session = Cluster.builder()
```

```
                        .addContactPoint(endPoint)
                        .withPort(portNumber)
                        .withAuthProvider(new SigV4AuthProvider("us-east-1"))
                        .withSSL()
                        .withQueryOptions(new
QueryOptions().setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM)
                        .build()
                        .connect();
```

To configure the consistency level for specific write operations, you can define the consistency when you call `QueryBuilder.insertInto` with a `setConsistencyLevel` argument when you're using the Java driver.

Read consistency levels

Amazon Keyspaces supports three read consistency levels: `ONE`, `LOCAL_ONE`, and `LOCAL_QUORUM`. During a `LOCAL_QUORUM` read, Amazon Keyspaces returns a response reflecting the most recent updates from all prior successful write operations. Using the consistency level `ONE` or `LOCAL_ONE` can improve the performance and availability of your read requests, but the response might not reflect the results of a recently completed write.

For each 4 KB read using `ONE` or `LOCAL_ONE` consistency, you are billed 0.5 read capacity units (RCUs) for tables using provisioned capacity mode or 0.5 read request units (RRUs) for tables using on-demand mode. For each 4 KB read using `LOCAL_QUORUM` consistency, you are billed 1 read capacity unit (RCU) for tables using provisioned capacity mode or 1 read request units (RRU) for tables using on-demand mode.

Billing based on read consistency and read capacity throughput mode per table for each 4 KB of reads

Consistency level	Provisioned	On-demand
`ONE`	0.5 RCUs	0.5 RRUs
`LOCAL_ONE`	0.5 RCUs	0.5 RRUs
`LOCAL_QUORUM`	1 RCU	1 RRU

To specify a different consistency for read operations, call `QueryBuilder.select` with a `setConsistencyLevel` argument when you're using the Java driver.

Unsupported consistency levels

The following consistency levels are not supported by Amazon Keyspaces and will result in exceptions.

Unsupported consistency levels

Apache Cassandra	Amazon Keyspaces
EACH_QUORUM	Not supported
QUORUM	Not supported
ALL	Not supported
TWO	Not supported
THREE	Not supported
ANY	Not supported
SERIAL	Not supported
LOCAL_SERIAL	Not supported

Migrating to Amazon Keyspaces (for Apache Cassandra)

Migrating to Amazon Keyspaces (for Apache Cassandra) presents a range of compelling benefits for businesses and organizations. Here are some key advantages that make Amazon Keyspaces an attractive choice for migration.

- **Scalability** – Amazon Keyspaces is designed to handle massive workloads and scale seamlessly to accommodate growing data volumes and traffic. With traditional Cassandra, scaling is not performed on demand and requires planning for future peaks. With Amazon Keyspaces, you can easily scale your tables up or down based on demand, ensuring that your applications can handle sudden spikes in traffic without compromising performance.
- **Performance** – Amazon Keyspaces offers low-latency data access, enabling applications to retrieve and process data with exceptional speed. Its distributed architecture ensures that read and write operations are distributed across multiple nodes, delivering consistent, single-digit millisecond response times even at high request rates.
- **Fully managed** – Amazon Keyspaces is a fully managed service provided by AWS. This means that AWS handles the operational aspects of database management, including provisioning, configuration, patching, backups, and scaling. This allows you to focus more on developing your applications and less on database administration tasks.
- **Serverless architecture** – Amazon Keyspaces is serverless. You pay only for capacity consumed with no upfront capacity provisioning required. You don't have servers to manage or instances to choose. This pay-per-request model offers cost efficiency and minimal operational overhead, as you only pay for the resources you consume without the need to provision and monitor capacity.
- **NoSQL flexibility with schema** – Amazon Keyspaces follows a NoSQL data model, providing flexibility in schema design. With Amazon Keyspaces, you can store structured, semi-structured, and unstructured data, making it well-suited for handling diverse and evolving data types. Additionally, Amazon Keyspaces performs schema validation on write allowing for a centralized evolution of the data model. This flexibility enables faster development cycles and easier adaptation to changing business requirements.
- **High availability and durability** – Amazon Keyspaces replicates data across multiple Availability Zones within an AWS Region, ensuring high availability and data durability. It automatically handles replication, failover, and recovery, minimizing the risk of data loss or service disruptions. Amazon Keyspaces provides an availability SLA of up to 99.999%. For even more resiliency and low-latency local reads, Amazon Keyspaces offers multi-Region replication.

- **Security and compliance** – Amazon Keyspaces integrates with AWS Identity and Access Management for fine-grained access control. It provides encryption at rest and in-transit, helping to improve the security of your data. Amazon Keyspaces has been assessed by third-party auditors for security and compliance with specific programs, including HIPAA, PCI DSS, and SOC, enabling you to meet regulatory requirements. For more information, see the section called "Compliance validation".
- **Integration with AWS Ecosystem** – As part of the AWS ecosystem, Amazon Keyspaces seamlessly integrates with other AWS services, for example AWS CloudFormation, Amazon CloudWatch, and AWS CloudTrail. This integration enables you to build serverless architectures, leverage infrastructure as code, and create real-time data-driven applications. For more information, see *Monitoring Amazon Keyspaces*.

Topics

- Create a migration plan for migrating from Apache Cassandra to Amazon Keyspaces
- How to select the right tool for bulk uploading or migrating data to Amazon Keyspaces

Create a migration plan for migrating from Apache Cassandra to Amazon Keyspaces

For a successful migration from Apache Cassandra to Amazon Keyspaces, we recommend a review of the applicable migration concepts and best practices as well as a comparison of the available options.

This topic outlines how the migration process works by introducing several key concepts and the tools and techniques available to you. You can evaluate the different migration strategies to select the one that best meets your requirements.

Topics

- Functional compatibility
- Estimate Amazon Keyspaces pricing
- Choose a migration strategy
- Online migration to Amazon Keyspaces: strategies and best practices
- Offline migration process: Apache Cassandra to Amazon Keyspaces
- Using a hybrid migration solution: Apache Cassandra to Amazon Keyspaces

Functional compatibility

Consider the functional differences between Apache Cassandra and Amazon Keyspaces carefully before the migration. Amazon Keyspaces supports all commonly used Cassandra data-plane operations, such as creating keyspaces and tables, reading data, and writing data.

However there are some Cassandra APIs that Amazon Keyspaces doesn't support. For more information about supported APIs, see the section called “Supported Cassandra APIs, operations, functions, and data types”. For an overview of all functional differences between Amazon Keyspaces and Apache Cassandra, see the section called “Functional differences with Apache Cassandra”.

To compare the Cassandra APIs and schema that you're using with supported functionality in Amazon Keyspaces, you can run a compatibility script available in the Amazon Keyspaces toolkit on GitHub.

How to use the compatibility script

1. Download the compatibility Python script from GitHub and move it to a location that has access to your existing Apache Cassandra cluster.
2. The compatibility script uses similar parameters as CQLSH. For `--host` and `--port` enter the IP address and the port you use to connect and run queries to one of the Cassandra nodes in your cluster.

   If your Cassandra cluster uses authentication, you also need to provide `-username` and `-password`. To run the compatibility script, you can use the following command.

   ```
   python toolkit-compat-tool.py --host hostname or IP -u "username" -p "password" --port native transport port
   ```

Estimate Amazon Keyspaces pricing

This section provides an overview of the information you need to gather from your Apache Cassandra tables to calculate the estimated cost for Amazon Keyspaces. Each one of your tables requires different data types, needs to support different CQL queries, and maintains distinctive read/write traffic.

Thinking of your requirements based on tables aligns with Amazon Keyspaces table-level resource isolation and read/write throughput capacity modes. With Amazon Keyspaces, you can define read/write capacity and automatic scaling policies for tables independently.

Understanding table requirements helps you prioritize tables for migration based on functionality, cost, and migration effort.

Collect the following Cassandra table metrics before a migration. This information helps to estimate the cost of your workload on Amazon Keyspaces.

- **Table name** – The name of the fully qualified keyspace and table name.
- **Description** – A description of the table, for example how it's used, or what type of data is stored in it.
- **Average reads per second** – The average number of coordinate-level reads against the table over a large time interval.
- **Average writes per second** – The average number of coordinate-level writes against the table over a large time interval.
- **Average row size in bytes** – The average row size in bytes.
- **Storage size in GBs** – The raw storage size for a table.
- **Read consistency breakdown** – The percentage of reads that use eventual consistency (`LOCAL_ONE` or `ONE`) vs. strong consistency (`LOCAL_QUORUM`).

This table shows an example of the information about your tables that you need to pull together when planning a migration.

Table name	Description	Average reads per second	Average writes per second	Average row size in bytes	Storage size in GBs	Read consistency breakdown
mykeyspace.mytable	Used to store shopping cart history	10,000	5,000	2,200	2,000	100% `LOCAL_ONE`

Table name	Description	Average reads per second	Average writes per second	Average row size in bytes	Storage size in GBs	Read consistency breakdown
mykeyspace.mytable2	Used to store latest profile information	20,000	1,000	850	1,000	25% LOCAL_QUORUM 75% LOCAL_ONE

How to collect table metrics

This section provides step by step instructions on how to collect the necessary table metrics from your existing Cassandra cluster. These metrics include row size, table size, and read/write requests per second (RPS). They allow you to assess throughput capacity requirements for an Amazon Keyspaces table and estimate pricing.

How to collect table metrics on the Cassandra source table

1. Determine row size

   Row size is important for determining the read capacity and write capacity utilization in Amazon Keyspaces. The following diagram shows the typical data distribution over a Cassandra token range.



You can use a row size sampler script available on GitHub to collect row size metrics for each table in your Cassandra cluster.

The script exports table data from Apache Cassandra by using `cqlsh` and `awk` to calculate the min, max, average, and standard deviation of row size over a configurable sample set of table data. The row size sampler passes the arguments to `cqlsh`, so the same parameters can be used to connect and read from your Cassandra cluster.

The following statement is an example of this.

```
./row-size-sampler.sh 10.22.33.44 9142 \\
   -u "username" -p "password" --ssl
```

For more information on how row size is calculated in Amazon Keyspaces, see the section called “Estimate row size”.

2. Determine table size

With Amazon Keyspaces, you don't need to provision storage in advance. Amazon Keyspaces monitors the billable size of your tables continuously to determine your storage charges. Storage is billed per GB-month. Amazon Keyspaces table size is based on the raw size (uncompressed) of a single replica.

To monitor the table size in Amazon Keyspaces, you can use the metric `BillableTableSizeInBytes`, which is displayed for each table in the AWS Management Console.

To estimate the billable size of your Amazon Keyspaces table, you can use either one of these two methods:

- Use the average row size and multiply by the number or rows.

  You can estimate the size of the Amazon Keyspaces table by multiplying the average row size by the number of rows from your Cassandra source table. Use the row size sample script from the previous section to capture the average row size. To capture the row count, you can use tools like `dsbulk count` to determine the total number of rows in your source table.

- Use the `nodetool` to gather table metadata.

Nodetool is an administrative tool provided in the Apache Cassandra distribution that provides insight into the state of the Cassandra process and returns table metadata. You can use nodetool to sample metadata about table size and with that extrapolate the table size in Amazon Keyspaces.

The command to use is nodetool tablestats. Tablestats returns the table's size and compression ratio. The table's size is stored as the tablelivespace for the table and you can divide it by the compression ratio. Then multiple this size value by the number of nodes. Finally divide by the replication factor (typically three).

This is the complete formula for the calculation that you can use to assess table size.

```
((tablelivespace / compression ratio) * (total number of nodes))/ (replication
 factor)
```

Let's assume that your Cassandra cluster has 12 nodes. Running the nodetool tablestats command returns a tablelivespace of 200 GB and a compression ratio of 0.5. The keyspace has a replication factor of three.

This is how the calculation for this example looks like.

```
(200 GB / 0.5) * (12 nodes)/ (replication factor of 3)
                        = 4,800 GB / 3
                        = 1,600 GB is the table size estimate for Amazon
 Keyspaces
```

3. Capture the number of reads and writes

To determine the capacity and scaling requirements for your Amazon Keyspaces tables, capture the read and write request rate of your Cassandra tables before the migration.

Amazon Keyspaces is serverless and you only pay for what you use. In general, the price of read/write throughput in Amazon Keyspaces is based on the number and size of the requests.

There are two capacity modes in Amazon Keyspaces:

- On-demand – This is a flexible billing option capable of serving thousands of requests per second without the need for capacity planning. It offers pay-per-request pricing for read and write requests so that you pay only for what you use.

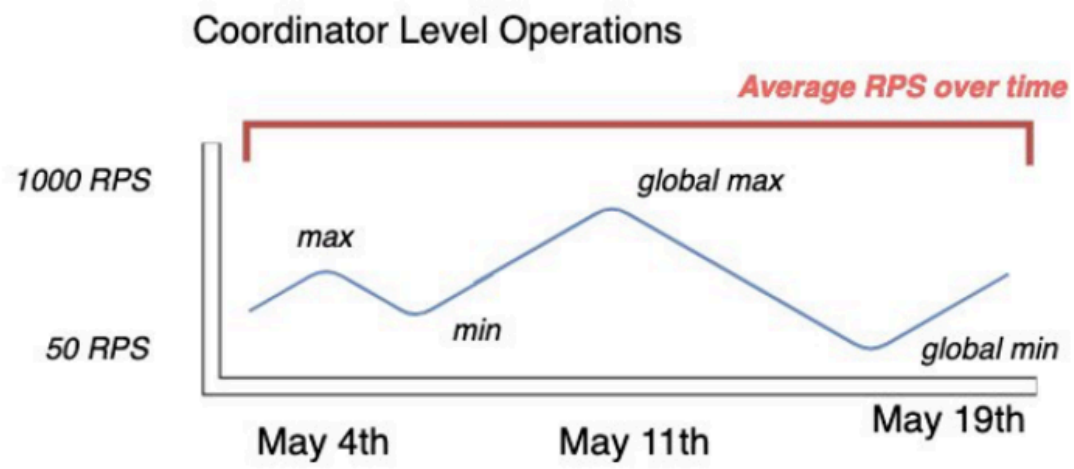
- Provisioned – If you choose provisioned throughput capacity mode, you specify the number of reads and writes per second that are required for your application. This helps you manage your Amazon Keyspaces usage to stay at or below a defined request rate to maintain predictability.

  Provisioned mode offers auto scaling to automatically adjust your provisioned rate to scale up or scale down to improve operational efficiency. For more information about serverless resource management, see *Managing serverless resources*.

Because you provision read and write throughput capacity in Amazon Keyspaces separately, you need to measure the request rate for reads and writes in your existing tables independently.

To gather the most accurate utilization metrics from your existing Cassandra cluster, capture the average requests per second (RPS) for coordinator-level read and write operations over an extended period of time for a table that is aggregated over all nodes in a single data center.

Capturing the average RPS over a period of at least several weeks captures peaks and valleys in your traffic patterns, as shown in the following diagram.



You have two options to determine the read and write request rate of your Cassandra table.

- Use existing Cassandra monitoring

  You can use the metrics shown in the following table to observe read and write requests. Note that the metric names can change based on the monitoring tool that you're using.

Dimension	Cassandra JMX metric
Writes	`org.apache.cassandra.metrics:type=ClientRequest,scope=Write,name=Latency#Count`
Reads	`org.apache.cassandra.metrics:type=ClientRequest,scope=Read,name=Latency#Count`

- Use the `nodetool`

  Use `nodetool tablestats` and `nodetool info` to capture average read and write operations from the table. `tablestats` returns the total read and write count from the time the node has been initiated. `nodetool info` provides the up-time for a node in seconds.

  To receive the per second average of read and writes, divide the read and write count by the node up-time in seconds. Then, for reads you divide by the consistency level ad for writes you divide by the replication factor. These calculations are expressed in the following formulas.

  Formula for average reads per second:

  ```
  ((number of reads * number of nodes in cluster) / read consistency quorum
   (2)) / uptime
  ```

  Formula for average writes per second:

  ```
  ((number of writes * number of nodes in cluster) / replication factor of 3) /
   uptime
  ```

  Let's assume we have a 12 node cluster that has been up for 4 weeks. `nodetool info` returns 2,419,200 seconds of up-time and `nodetool tablestats` returns 1 billion writes and 2 billion reads. This example would result in the following calculation.

```
((2 billion reads * 12 in cluster) / read consistency quorum (2)) / 2,419,200
 seconds
=  12 billion reads / 2,419,200 seconds
=  4,960 read request per second
                        ((1 billion writes * 12 in cluster) / replication
 factor of 3) / 2,419,200 seconds
=  4 billion writes / 2,419,200 seconds
=  1,653 write request per second
```

4. Determine the capacity utilization of the table

   To estimate the average capacity utilization, start with the average request rates and the average row size of your Cassandra source table.

   Amazon Keyspaces uses *read capacity units* (RCUs) and *write capacity units* (WCUs) to measure provisioned throughput capacity for reads and writes for tables. For this estimate we use these units to calculate the read and write capacity needs of the new Amazon Keyspaces table after migration.

   Later in this topic we'll discuss how the choice between provisioned and on-demand capacity mode affects billing. But for the estimate of capacity utilization in this example, we assume that the table is in provisioned mode.

   - **Reads** – One RCU represents one `LOCAL_QUORUM` read request, or two `LOCAL_ONE` read requests, for a row up to 4 KB in size. If you need to read a row that is larger than 4 KB, the read operation uses additional RCUs. The total number of RCUs required depends on the row size, and whether you want to use `LOCAL_QUORUM` or `LOCAL_ONE` read consistency.

     For example, reading an 8 KB row requires 2 RCUs using `LOCAL_QUORUM` read consistency, and 1 RCU if you choose `LOCAL_ONE` read consistency.
   - **Writes** – One WCU represents one write for a row up to 1 KB in size. All writes are using `LOCAL_QUORUM` consistency, and there is no additional charge for using lightweight transactions (LWTs).

     The total number of WCUs required depends on the row size. If you need to write a row that is larger than 1 KB, the write operation uses additional WCUs. For example, if your row size is 2 KB, you require 2 WCUs to perform one write request.

   The following formula can be used to estimate the required RCUs and WCUs.

- **Read capacity in RCUs** can be determined by multiplying reads per second by number of rows read per read multiplied by average row size divided by 4KB and rounded up to the nearest whole number.
- **Write capacity in WCUs** can be determined by multiplying the number of requests by the average row size divided by 1KB and rounded up to the nearest whole number.

This is expressed in the following formulas.

```
Read requests per second * ROUNDUP((Average Row Size)/4096 per unit) =  RCUs per
 second

Write requests per second * ROUNDUP(Average Row Size/1024 per unit) = WCUs per
 second
```

For example, if you're performing 4,960 read requests with a row size of 2.5KB on your Cassandra table, you need 4,960 RCUs in Amazon Keyspaces. If you're currently performing 1,653 write requests per second with a row size of 2.5KB on your Cassandra table, you need 4,959 WCUs per second in Amazon Keyspaces.

This example is expressed in the following formulas.

```
4,960 read requests per second * ROUNDUP( 2.5KB /4KB bytes per unit)
= 4,960 read requests per second * 1 RCU
= 4,960 RCUs

1,653 write requests per second * ROUNDUP(2.5KB/1KB per unit)
= 1,653 requests per second * 3 WCUs
= 4,959 WCUs
```

Using `eventual consistency` allows you to save up to half of the throughput capacity on each read request. Each eventually consistent read can consume up to 8KB. You can calculate eventual consistent reads by multiplying the previous calculation by 0.5 as shown in the following formula.

```
4,960 read requests per second * ROUNDUP( 2.5KB /4KB per unit) * .5
= 2,480 read request per second * 1 RCU
= 2,480 RCUs
```

5. Calculate the monthly pricing estimate for Amazon Keyspaces

   To estimate the monthly billing for the table based on read/write capacity throughput, you can calculate the pricing for on-demand and for provisioned mode using different formulas and compare the options for your table.

   Provisioned mode – Read and write capacity consumption is billed on an hourly rate based on the capacity units per second. First, divide that rate by 0.7 to represent the default autoscaling target utilization of 70%. Then multiple by 30 calendar days, 24 hours per day, and regional rate pricing.

   This calculation is summarized in the following formulas.

   ```
   (read capacity per second / .7) * 24 hours * 30 days * regional rate
                  (write capacity per second / .7) * 24 hours * 30 days * regional
    rate
   ```

   On-demand mode – Read and write capacity are billed on a per request rate. First, multiply the request rate by 30 calendar days, and 24 hours per day. Then divide by one million request units. Finally, multiply by the regional rate.

   This calculation is summarized in the following formulas.

   ```
   ((read capacity per second * 30 * 24 * 60 * 60) / 1 Million read request units) *
    regional rate
                  ((write capacity per second * 30 * 24 * 60 * 60) / 1 Million write
    request units) * regional rate
   ```

Choose a migration strategy

You can choose between the following migration strategies when migrating from Apache Cassandra to Amazon Keyspaces:

- **Online** – This is a live migration using dual writes to start writing new data to Amazon Keyspaces and the Cassandra cluster simultaneously. This migration type is recommended for applications that require zero downtime during migration and read after write consistency.

  For more information about how to plan and implement an online migration strategy, see the section called “Online migration”.

- **Offline** – This migration technique involves copying a data set from Cassandra to Amazon Keyspaces during a downtime window. Offline migration can simplify the migration process, because it doesn't require changes to your application or conflict resolution between historical data and new writes.

  For more information about how to plan an offline migration, see the section called “Offline migration”.
- **Hybrid** – This migration technique allows for changes to be replicated to Amazon Keyspaces in near real time, but without read after write consistency.

  For more information about how to plan a hybrid migration, see the section called “Hybrid migration”.

After reviewing the migration techniques and best practices discussed in this topic, you can place the available options in a decision tree to design a migration strategy based on your requirements and available resources.

Online migration to Amazon Keyspaces: strategies and best practices

If you need to maintain application availability during a migration from Apache Cassandra to Amazon Keyspaces, you can prepare a custom online migration strategy by implementing the key components discussed in this topic. By following these best practices for online migrations, you can ensure that application availability and read-after-write consistency are maintained during the entire migration process, minimizing the impact on your users.

When designing an online migration strategy from Apache Cassandra to Amazon Keyspaces, you need to consider the following key steps.

1. **Writing new data**
   - **ZDM Dual Write Proxy for Amazon Keyspaces Migration** – Use the ZDM Dual Write Proxy available on Github to perform zero-downtime migration from Apache Cassandra to Amazon Keyspaces. The ZDM Proxy performs dual writes without the need to refactor existing applications and performs dual reads for query validation.
   - Application dual-writes: You can implement dual writes in your application using existing Cassandra client libraries and drivers. Designate one database as the leader and the other as the follower. Write failures to the follower database are recorded in a dead letter queue (DLQ) for analysis.

- Messaging tier dual-writes: Alternatively, you can configure your existing messaging platform to send writes to both Cassandra and Amazon Keyspaces using an additional consumer. This creates eventually consistent views across both databases.

2. **Migrating historical data**
   - Copy historical data: You can migrate historical data from Cassandra to Amazon Keyspaces using AWS Glue or custom extract, transform, and load (ETL) scripts. Handle conflict resolution between dual writes and bulk loads using techniques like lightweight transactions or timestamps.
   - Use Time-To-Live (TTL): For shorter data retention periods, you can use TTL in both Cassandra and Amazon Keyspaces to avoid uploading unnecessary historical data. As old data expires in Cassandra and new data is written via dual-writes, Amazon Keyspaces eventually catches up.
3. **Validating data**
   - Dual reads: Implement dual reads from both Cassandra (primary) and Amazon Keyspaces (secondary) databases, comparing results asynchronously. Differences are logged or sent to a DLQ.
   - Sample reads: Use Λ functions to periodically sample and compare data across both systems, logging any discrepancies to a DLQ.
4. **Migrating the application**
   - Blue-green strategy: Switch your application to treat Amazon Keyspaces as the primary and Cassandra as the secondary data store in a single step. Monitor performance and roll back if issues arise.
   - Canary deployment: Gradually roll out the migration to a subset of users first, incrementally increasing traffic to Amazon Keyspaces as the primary until fully migrated.
5. **Decommissioning Cassandra**

   Once your application is fully migrated to Amazon Keyspaces and data consistency is validated, you can plan to decommission your Cassandra cluster based on data retention policies.

By planning an online migration strategy with these components, you can transition smoothly to the fully managed Amazon Keyspaces service with minimal downtime or disruption. The following sections go into each component in more detail.

Topics

- Writing new data during an online migration

- Uploading historical data during an online migration
- Validating data consistency during an online migration
- Migrating the application during an online migration
- Decommissioning Cassandra after an online migration

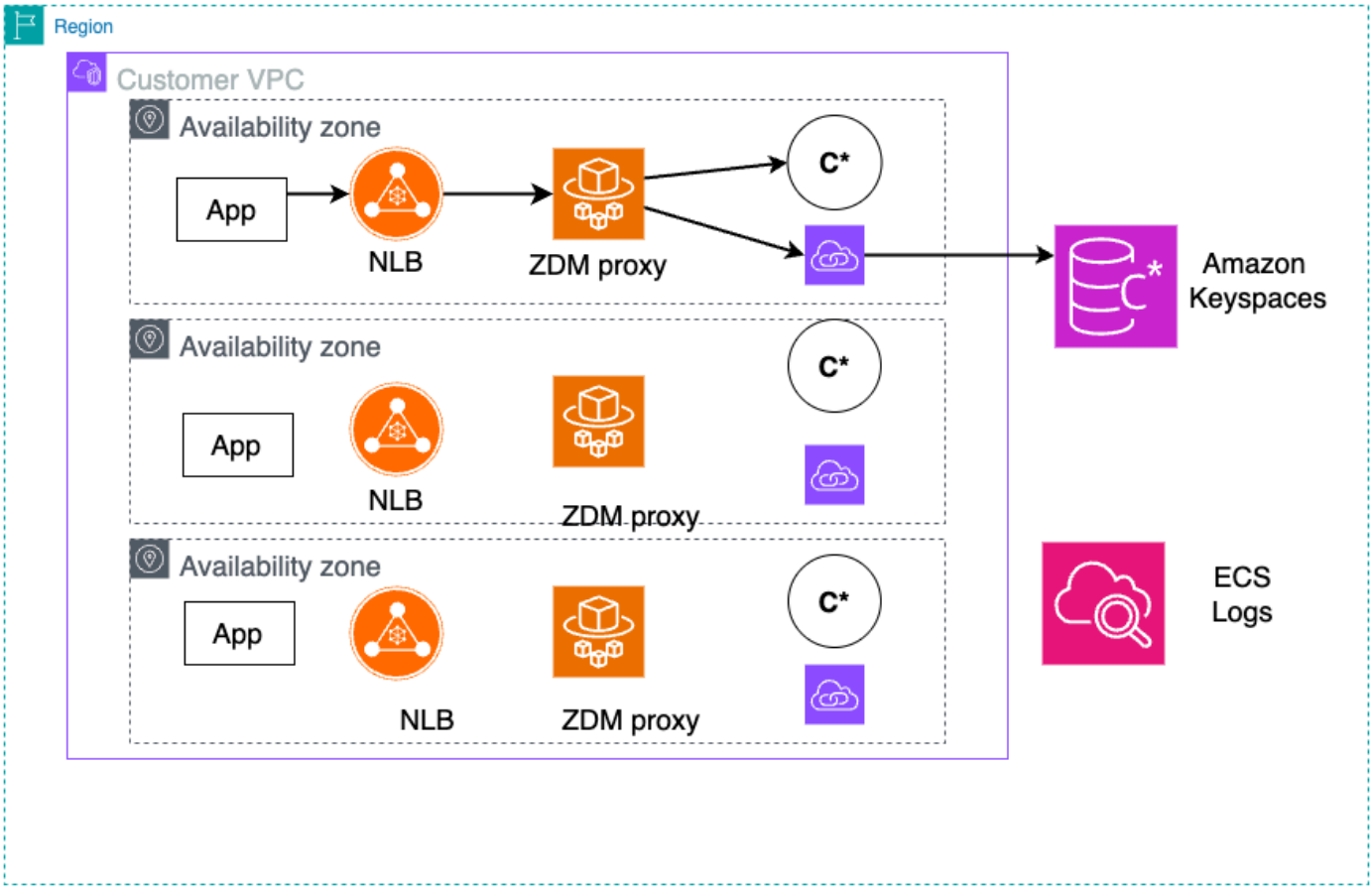
Writing new data during an online migration

The first step in an online migration plan is to ensure that any new data written by the application is stored in both databases, your existing Cassandra cluster and Amazon Keyspaces. The goal is to provide a consistent view across the two data stores. You can do this by applying all new writes to both databases. To implement dual writes, consider one of the following three options.

- **ZDM Dual Write Proxy for Amazon Keyspaces Migration** – Using the ZDM Proxy for Amazon Keyspaces available on Github, you can migrate your Apache Cassandra workloads to Amazon Keyspaces without application downtime. This enhanced solution implements AWS best practices and extends the official ZDM Proxy capabilities.
  - Perform online migrations between Apache Cassandra and Amazon Keyspaces.
  - Write data to both source and target tables simultaneously without refactoring applications.
  - Validate queries through dual-read operations.

  The solution offers the following enhancements to work with AWS and Amazon Keyspaces.
  - **Container deployment** – Use a pre-configured Docker image from Amazon Elastic Container Registry (Amazon ECR) for VPC-accessible deployments.
  - **Infrastructure as code** – Deploy using AWS CloudFormation templates for automated setup on AWS Fargate.
  - **Amazon Keyspaces compatibility** – Access system tables with custom adaptations for Amazon Keyspaces.

  The solution runs on Amazon ECS with Fargate, providing serverless scalability based on your workload demands. A network load balancer distributes incoming application traffic across multiple Amazon ECS tasks for high availability.



- **Application dual writes** – You can implement dual writes with minimal changes to your application code by leveraging the existing Cassandra client libraries and drivers. You can either implement dual writes in your existing application, or create a new layer in the architecture to handle dual writes. For more information and a customer case study that shows how dual writes were implemented in an existing application, see Cassandra migration case study.

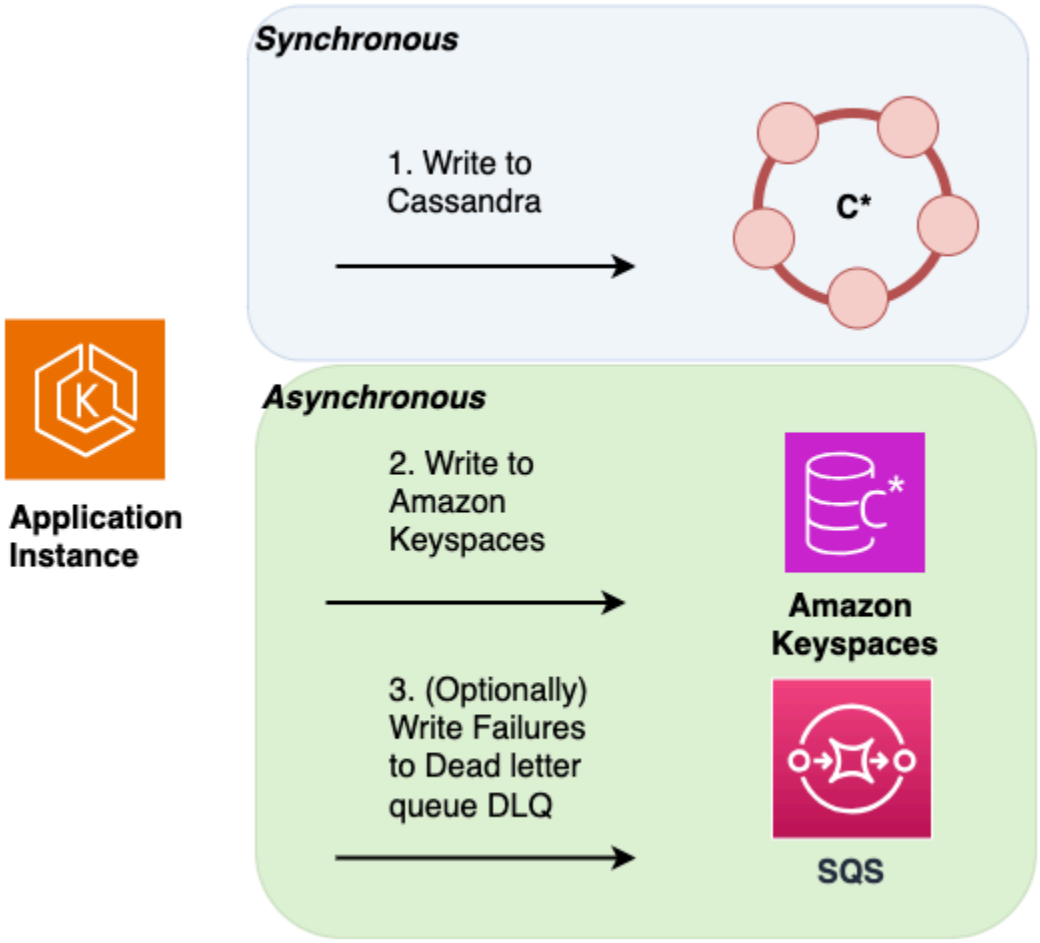
  When implementing dual writes, you can designate one database as the leader and the other database as the follower. This allows you to keep writing to your original source, or leader database without letting write failures to the follower, or destination database disrupt the critical path of your application.

  Instead of retrying failed writes to the follower, you can use Amazon Simple Queue Service to record failed writes in a dead letter queue (DLQ). The DLQ lets you analyze the failed writes to the follower and determine why processing did not succeed in the destination database.

  For a more sophisticated dual write implementation, you can follow AWS best practices for designing a sequence of local transactions using the saga pattern. A saga pattern ensures that

if a transaction fails, the saga runs compensating transactions to revert the database changes made by the previous transactions.

When using dual-writes for an online migration, you can configure the dual-writes following the saga pattern so that each write is a local transaction to ensure atomic operations across heterogeneous databases. For more information about designing distributed application using recommended design patterns for the AWS Cloud, see Cloud design patterns, architectures, and implementations.



- **Messaging tier dual writes** – Instead of implementing dual writes at the application layer, you can use your existing messaging tier to perform dual writes to Cassandra and Amazon Keyspaces.

  To do this you can configure an additional consumer to your messaging platform to send writes to both data stores. This approach provides a simple low code strategy using the messaging tier to create two views across both databases that are eventually consistent.

Uploading historical data during an online migration

After implementing dual writes to ensure that new data is written to both data stores in real time, the next step in the migration plan is to evaluate how much historical data you need to copy or bulk upload from Cassandra to Amazon Keyspaces. This ensures that both, new data and historical data are going to be available in the new Amazon Keyspaces database before you're migrating the application.

Depending on your data retention requirements, for example how much historical data you need to preserve based on your organizations policies, you can consider one the following two options.

- **Bulk upload of historical data** – The migration of historical data from your existing Cassandra deployment to Amazon Keyspaces can be achieved through various techniques, for example using AWS Glue or custom scripts to extract, transform, and load (ETL) the data. For more information about using AWS Glue to upload historical data, see the section called "Offline migration".

  When planning the bulk upload of historical data, you need to consider how to resolve conflicts that can occur when new writes are trying to update the same data that is in the process of being uploaded. The bulk upload is expected to be eventually consistent, which means the data is going to reach all nodes eventually.

  If an update of the same data occurs at the same time due to a new write, you want to ensure that it's not going to be overwritten by the historical data upload. To ensure that you preserve the latest updates to your data even during the bulk import, you must add conflict resolution either into the bulk upload scripts or into the application logic for dual writes.

  For example, you can use the section called "Lightweight transactions" (LWT) to compare and set operations. To do this, you can add an additional field to your data-model that represents time of modification or state.

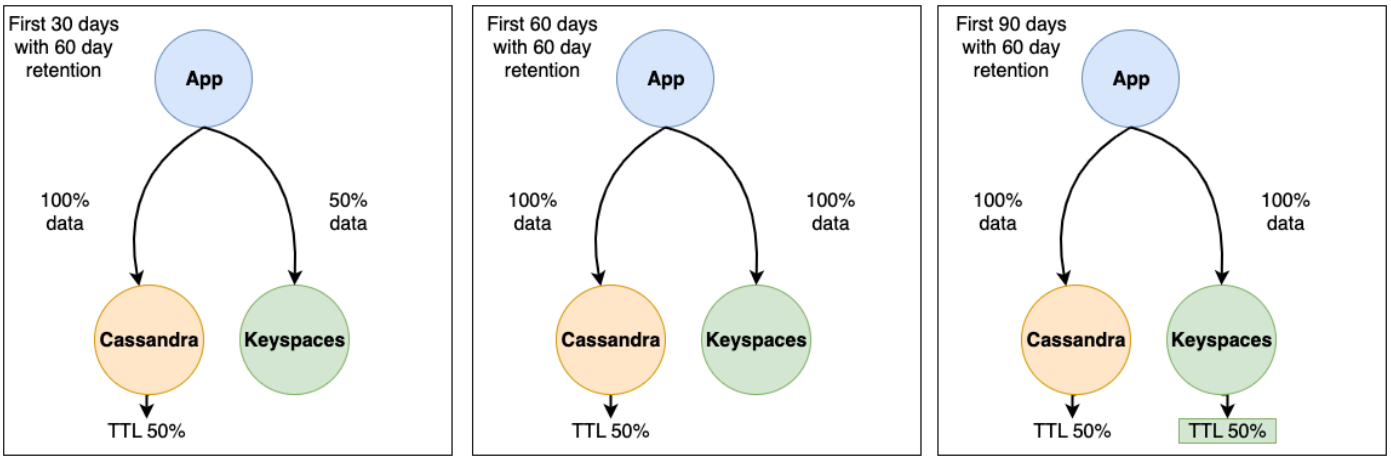
  Additionally, Amazon Keyspaces supports the Cassandra `WRITETIME` timestamp function. You can use Amazon Keyspaces client-side timestamps to preserve source database timestamps and implement last-writer-wins conflict resolution. For more information, see the section called "Client-side timestamps".
- **Using Time-to-Live (TTL)** – For data retention periods shorter than 30, 60, or 90 days, you can use TTL in Cassandra and Amazon Keyspaces during migration to avoid uploading unnecessary historical data to Amazon Keyspaces. TTL allows you to set a time period after which the data is automatically removed from the database.

During the migration phase, instead of copying historical data to Amazon Keyspaces, you can configure the TTL settings to let the historical data expire automatically in the old system (Cassandra) while only applying the new writes to Amazon Keyspaces using the dual-write method. Over time and with old data continually expiring in the Cassandra cluster and new data written using the dual-write method, Amazon Keyspaces automatically catches up to contain the same data as Cassandra.

This approach can significantly reduce the amount of data to be migrated, resulting in a more efficient and streamlined migration process. You can consider this approach when dealing with large datasets with varying data retention requirements. For more information about TTL, see the section called “Expire data with Time to Live”.

Consider the following example of a migration from Cassandra to Amazon Keyspaces using TTL data expiration. In this example we set TTL for both databases to 60 days and show how the migration process progresses over a period of 90 days. Both databases receive the same newly written data during this period using the dual writes method. We're going to look at three different phases of the migration, each phase is 30 days long.

How the migration process works for each phase is shown in the following images.



1. After the first 30 days, the Cassandra cluster and Amazon Keyspaces have been receiving new writes. The Cassandra cluster also contains historical data that has not yet reached 60 days of retention, which makes up 50% of the data in the cluster.

   Data that is older than 60 days is being automatically deleted in the Cassandra cluster using TTL. At this point Amazon Keyspaces contains 50% of the data stored in the Cassandra cluster, which is made up of the new writes minus the historical data.

2. After 60 days, both the Cassandra cluster and Amazon Keyspaces contain the same data written in the last 60 days.
3. Within 90 days, both Cassandra and Amazon Keyspaces contain the same data and are expiring data at the same rate.

This example illustrates how to avoid the step of uploading historical data by using TTL with an expiration date set to 60 days.

Validating data consistency during an online migration

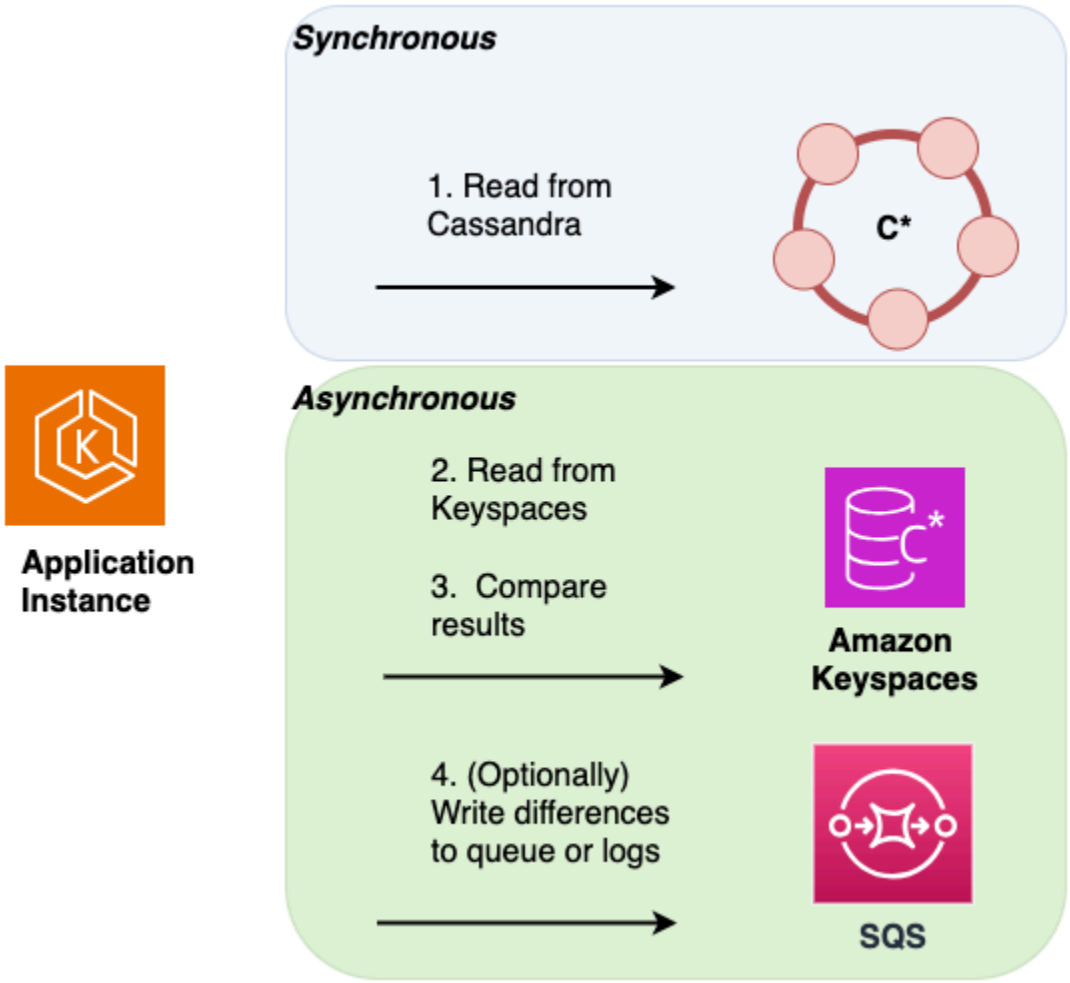
The next step in the online migration process is data validation. Dual writes are adding new data to your Amazon Keyspaces database and you have completed the migration of historical data either using bulk upload or data expiration with TTL.

Now you can use the validation phase to confirm that both data stores contain in fact the same data and return the same read results. You can choose from one of the following two options to validate that both your databases contain identical data.

- **Dual reads** – To validate that both, the source and the destination database contain the same set of newly written and historical data, you can implement dual reads. To do so you read from both your primary Cassandra and your secondary Amazon Keyspaces database similarly to the dual writes method and compare the results asynchronously.

  The results from the primary database are returned to the client, and the results from the secondary database are used to validate against the primary resultset. Differences found can be logged or sent to a dead letter queue (DLQ) for later reconciliation.

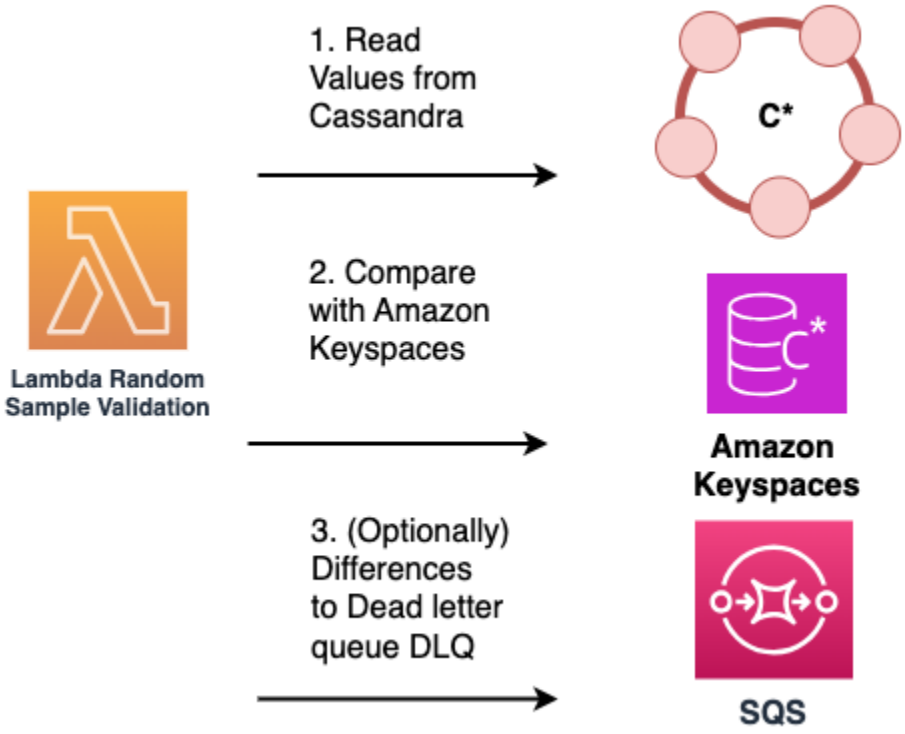
  In the following diagram, the application is performing a synchronous read from Cassandra, which is the primary data store) and an asynchronous read from Amazon Keyspaces, which is the secondary data store.



- **Sample reads** – An alternative solution that doesn't require application code changes is to use AWS Lambda functions to periodically and randomly sample data from both the source Cassandra cluster and the destination Amazon Keyspaces database.

  These Lambda functions can be configured to run at regular intervals. The Lambda function retrieves a random subset of data from both the source and destination systems, and then performs a comparison of the sampled data. Any discrepancies or mismatches between the two datasets can be recorded and sent to a dedicated dead letter queue (DLQ) for later reconciliation.

  This process is illustrated in the following diagram.



Migrating the application during an online migration

In the fourth phase of an online migration, you are migrating your application and transitioning to Amazon Keyspaces as the primary data store. This means that you switch your application to read and write directly from and to Amazon Keyspaces. To ensure minimal disruption to your users, this should be a well-planned and coordinated process.

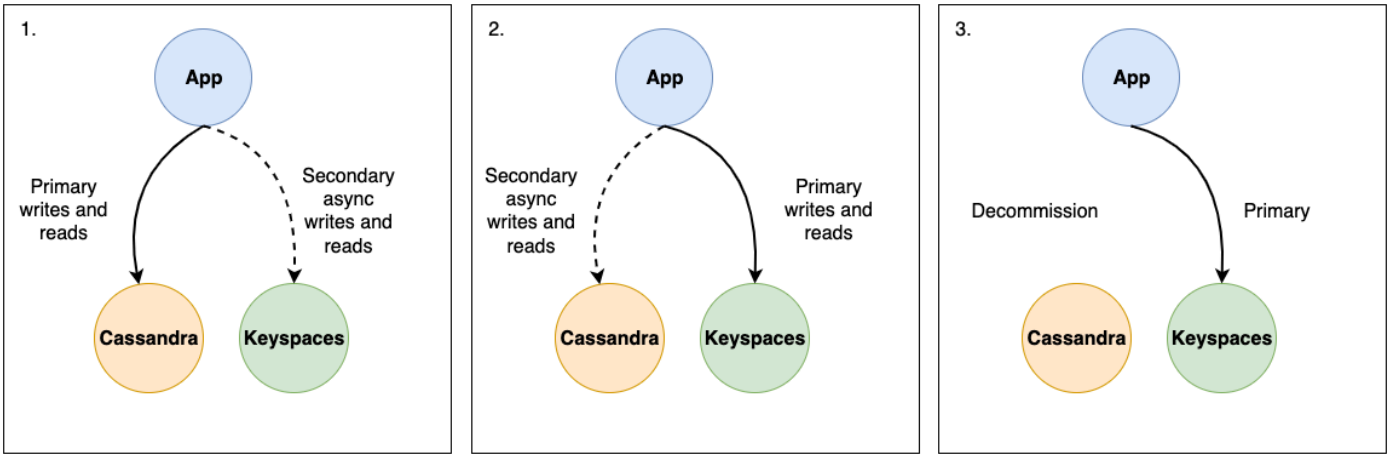
Two different recommended solution for application migration are available, the blue green cut over strategy and the canary cut over strategy. The following sections outline these strategies in more detail.

- **Blue green strategy** – Using this approach, you switch your application to treat Amazon Keyspaces as the primary data store and Cassandra as the secondary data store in a single step. You can do this using an AWS AppConfig feature flag to control the election of primary and secondary data stores across the application instance. For more information about feature flags, see Creating a feature flag configuration profile in AWS AppConfig.

  After making Amazon Keyspaces the primary data store, you monitor the application's behavior and performance, ensuring that Amazon Keyspaces meets your requirements and that the migration is successful.

For example, if you implemented dual-reads for your application, during the application migration phase you transition the primary reads going from Cassandra to Amazon Keyspaces and the secondary reads from Amazon Keyspaces to Cassandra. After the transition, you continue to monitor and compare results as described in the data validation section to ensure consistency across both databases before decommissioning Cassandra.

If you detect any issues, you can quickly roll back to the previous state by reverting to Cassandra as the primary data store. You only proceed to the decommissioning phase of the migration if Amazon Keyspaces is meeting all your needs as the primary data store.

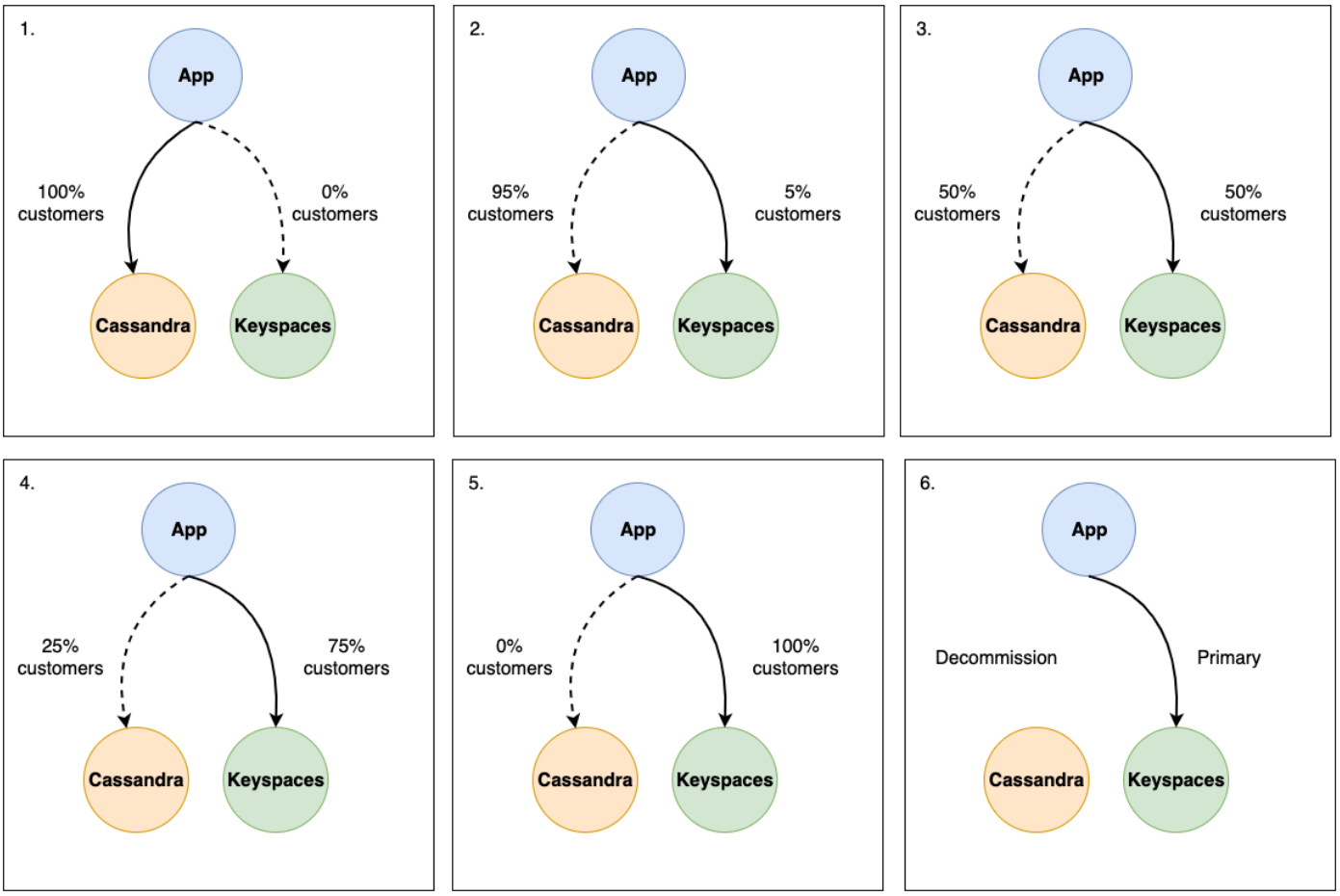


- **Canary strategy** – In this approach, you gradually roll out the migration to a subset of your users or traffic. Initially, a small percentage of your application's traffic, for example 5% of all traffic is routed to the version using Amazon Keyspaces as the primary data store, while the rest of the traffic continues to use Cassandra as the primary data store.

  This allows you to thoroughly test the migrated version with real-world traffic and monitor its performance, stability, and investigate potential issues. If you don't detect any issues, you can incrementally increase the percentage of traffic routed to Amazon Keyspaces until it becomes the primary data store for all users and traffic.

  This staged roll out minimizes the risk of widespread service disruptions and allows for a more controlled migration process. If any critical issues arise during the canary deployment, you can quickly roll back to the previous version using Cassandra as the primary data store for the affected traffic segment. You only proceed to the decommissioning phase of the migration after you have validated that Amazon Keyspaces processes 100% of your users and traffic as expected.

  The following diagram illustrates the individual steps of the canary strategy.



Decommissioning Cassandra after an online migration

After the application migration is complete with your application is fully running on Amazon Keyspaces and you have validated data consistency over a period of time, you can plan to decommission your Cassandra cluster. During this phase, you can evaluate if the data remaining in your Cassandra cluster needs to be archived or can be deleted. This depends on your organization's policies for data handling and retention.

By following this strategy and considering the recommended best practices described in this topic when planning your online migration from Cassandra to Amazon Keyspaces, you can ensure a seamless transition to Amazon Keyspaces while maintaining read-after-write consistency and availability of your application.

Migrating from Apache Cassandra to Amazon Keyspaces can provide numerous benefits, including reduced operational overhead, automatic scaling, improved security, and a framework that helps you to reach your compliance goals. By planning an online migration strategy with dual writes,

historical data upload, data validation, and a gradual roll out, you can ensure a smooth transition with minimal disruption to your application and its users.

Implementing the online migration strategy discussed in this topic allows you to validate the migration results, identify and address any issues, and ultimately decommission your existing Cassandra deployment in favor of the fully managed Amazon Keyspaces service.

Offline migration process: Apache Cassandra to Amazon Keyspaces

Offline migrations are suitable when you can afford downtime to perform the migration. It's common among enterprises to have maintenance windows for patching, large releases, or downtime for hardware upgrades or major upgrades. Offline migration can use this window to copy data and switch over the application traffic from Apache Cassandra to Amazon Keyspaces.

Offline migration reduces modifications to the application because it doesn't require communication to both Cassandra and Amazon Keyspaces simultaneously. Additionally, with the data flow paused, the exact state can be copied without maintaining mutations.

In this example, we use Amazon Simple Storage Service (Amazon S3) as a staging area for data during the offline migration to minimize downtime. You can automatically import the data you stored in Parquet format in Amazon S3 into an Amazon Keyspaces table using the Spark Cassandra connector and AWS Glue. The following section is going to show the high-level overview of the process. You can find code examples for this process on Github.

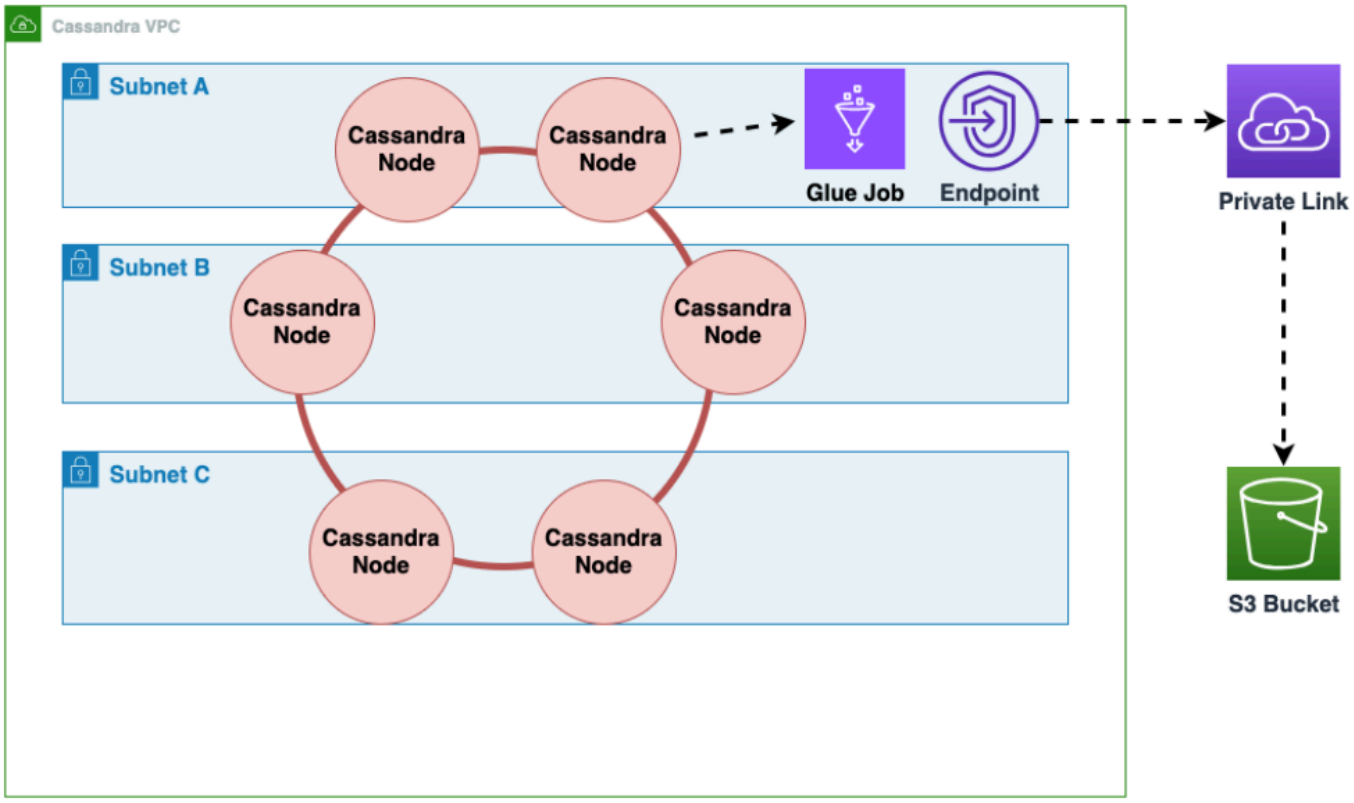
The offline migration process from Apache Cassandra to Amazon Keyspaces using Amazon S3 and AWS Glue requires the following AWS Glue jobs.

1. An ETL job that extracts and transforms CQL data and stores it in an Amazon S3 bucket.
2. A second job that imports the data from the bucket to Amazon Keyspaces.
3. A third job to import incremental data.

How to perform an offline migration to Amazon Keyspaces from Cassandra running on Amazon EC2 in a Amazon Virtual Private Cloud

1. First you use AWS Glue to export table data from Cassandra in Parquet format and save it to an Amazon S3 bucket. You need to run an AWS Glue job using a AWS Glue connector to a VPC where the Amazon EC2 instance running Cassandra resides. Then, using the Amazon S3 private endpoint, you can save data to the Amazon S3 bucket.

The following diagram illustrates these steps.



2. Shuffle the data in the Amazon S3 bucket to improve data randomization. Evenly imported data allows for more distributed traffic in the target table.

   This step is required when exporting data from Cassandra with large partitions (partitions with more than 1000 rows) to avoid hot key patterns when inserting the data into Amazon Keyspaces. Hot key issues cause `WriteThrottleEvents` in Amazon Keyspaces and result in increased load time.



3. Use another AWS Glue job to import data from the Amazon S3 bucket into Amazon Keyspaces. The shuffled data in the Amazon S3 bucket is stored in Parquet format.



For more information about the offline migration process, see the workshop Amazon Keyspaces with AWS Glue

Using a hybrid migration solution: Apache Cassandra to Amazon Keyspaces

The following migration solution can be considered a hybrid between online and offline migration. With this hybrid approach, data is written to the destination database in near real time without providing read after write consistency. This means that newly written data won't be immediately available and delays are to be expected. If you need read after write consistency, see the section called "Online migration".

For a near real time migration from Apache Cassandra to Amazon Keyspaces, you can choose between two available methods.

- **CQLReplicator** – (Recommended) CQLReplicator is an open source utility available on Github that helps you to migrate data from Apache Cassandra to Amazon Keyspaces in near real time.

  To determine the writes and updates to propagate to the destination database, CQLReplicator scans the Apache Cassandra token range and uses an AWS Glue job to remove duplicate events and apply writes and updates directly to Amazon Keyspaces.
- **Change data capture (CDC)** – If you are familiar with Cassandra CDC, the Apache Cassandra built-in CDC feature that allows capturing changes by copying the commit log to a separate CDC directory is another option for implementing a hybrid migration.

  You can do this by replicating the data changes to Amazon Keyspaces, making CDC an alternative option for data migration scenarios.

If you don't need read after write consistency, you can use either the CQLReplicator or a CDC pipeline to migrate data from Apache Cassandra to Amazon Keyspaces based on your preferences

and familiarity with the tools and AWS services used in each solution. Using these methods to migrate data in near real time can be considered a hybrid approach to migration that offers an alternative to online migration.

This strategy is considered a hybrid approach, because in addition to the options outlined in this topic, you have to implement some steps of the online migration progress, for example historical data copy and the application migration strategies discussed in the online migration topic.

The following sections go over the hybrid migration options in more detail.

Topics

- Migrate data using CQLReplicator
- Migrate data using change data capture (CDC)

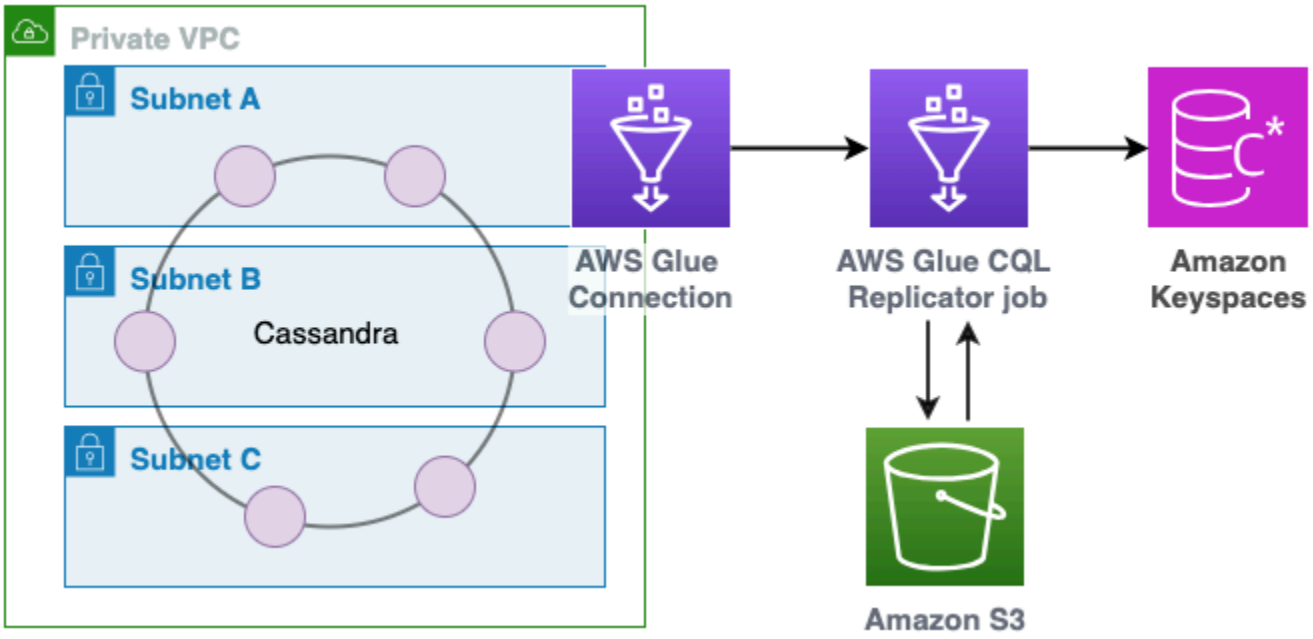
Migrate data using CQLReplicator

With CQLReplicator, you can read data from Apache Cassandra in near real time through intelligently scanning the Cassandra token ring using CQL queries. CQLReplicator doesn't use Cassandra CDC and instead implements a caching strategy to reduce the performance penalties of full scans.

To reduce the number of writes to the destination, CQLReplicator automatically removes duplicate replication events. With CQLReplicator, you can tune the replication of changes from the source database to the destination database, allowing for a near real time migration of data from Apache Cassandra to Amazon Keyspaces.

The following diagram shows the typical architecture of a CQLReplicator job using AWS Glue.

1. To allow access to Apache Cassandra running in a private VPC, configure an AWS Glue connection with the connection type **Network**.
2. To remove duplicates and enable key caching with the CQLReplicator job, configure Amazon Simple Storage Service (Amazon S3).
3. The CQLReplicator job streams verified source database changes directly to Amazon Keyspaces.



For more information about the migration process using CQLReplicator, see the following post on the AWS Database blog Migrate Cassandra workloads to Amazon Keyspaces using CQLReplicator and the AWS prescriptive guidance Migrate Apache Cassandra workloads to Amazon Keyspaces by using AWS Glue.

Migrate data using change data capture (CDC)

If you're already familiar with configuring a change data capture (CDC) pipeline with Debezium, you can use this option to migrate data to Amazon Keyspaces as an alternative to using CQLReplicator. Debezium is an open-source, distributed platform for CDC, designed to monitor a database and capture row-level changes reliably.

The Debezium connector for Apache Cassandra uploads changes to Amazon Managed Streaming for Apache Kafka (Amazon MSK) so that they can be consumed and processed by downstream consumers which in turn write the data to Amazon Keyspaces. For more information, see Guidance for continuous data migration from Apache Cassandra to Amazon Keyspaces.

To address any potential data consistency issues, you can implement a process with Amazon MSK where a consumer compares the keys or partitions in Cassandra with those in Amazon Keyspaces.

To implement this solution successfully, we recommend to consider the following.

- How to parse the CDC commit log, for example how to remove duplicate events.
- How to maintain the CDC directory, for example how to delete old logs.

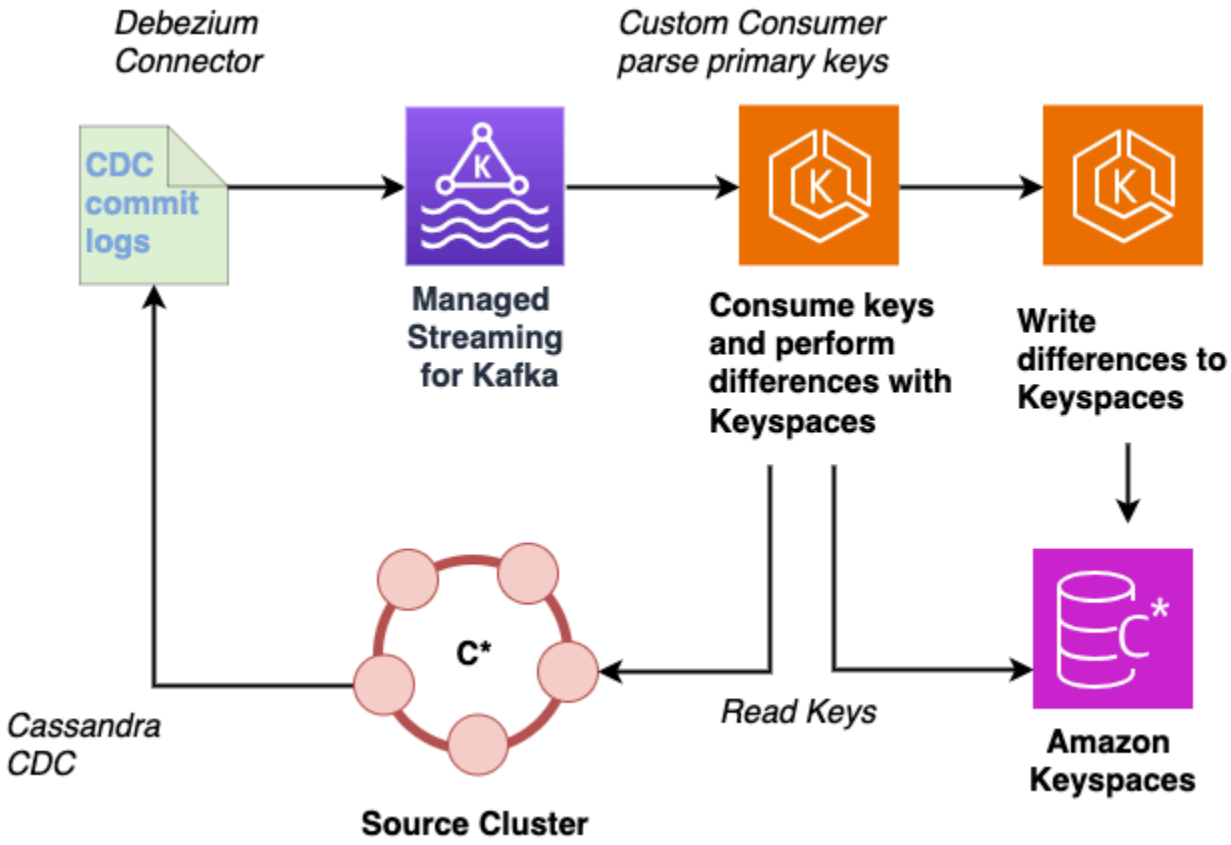
- How to handle partial failures in Apache Cassandra, for example if a write only succeeds in one out of three replicas.
- How to handle resource allocation, for example increasing the size of the instance to account for additional CPU, memory, DISK, and IO requirements for the CDC process that occurs on a node.

This pattern treats changes from Cassandra as a "hint" that a key may have changed from its previous state. To determine if there are changes to propagate to the destination database, you must first read from the source Cassandra cluster using a `LOCAL_QUORUM` operation to receive the latest records and then write them to Amazon Keyspaces.

In the case of range deletes or range updates, you may need to perform a comparison against the entire partition to determine which write or update events need to be written to your destination database.

In cases where writes are not idempotent, you also need to compare your writes with what is already in the destination database before writing to Amazon Keyspaces.

The following diagram shows the typical architecture of a CDC pipeline using Debezium and Amazon MSK.



How to select the right tool for bulk uploading or migrating data to Amazon Keyspaces

In this section you can review the different tools that you can use to bulk upload or migrate data to Amazon Keyspaces, and learn how to select the correct tool based on your needs. In addition, this section provides an overview and use cases for the available step-by-step tutorials that demonstrate how to import data into Amazon Keyspaces.

To review the available strategies to migrate workloads from Apache Cassandra to Amazon Keyspaces, see the section called "Migrating from Cassandra".

- **Migration tools**
  - With the pricing calculator for Amazon Keyspaces (for Apache Cassandra) available on Github, you can estimate your monthly costs for Amazon Keyspaces based on your existing Apache Cassandra workload. Enter metrics from your Cassandra nodetool status output and intended serverless configuration for Amazon Keyspaces to compare direct costs between the two solutions. Note that this calculator focuses only on the operational costs of Amazon Keyspaces compared to your existing Cassandra deployment. It doesn't include total cost of ownership (TCO) factors like infrastructure maintenance, operational overhead, or support costs for Cassandra.
  - **ZDM Dual Write Proxy for Amazon Keyspaces Migration** – ZDM Dual Write Proxy available on Github supports zero-downtime migration from Apache Cassandra to Amazon Keyspaces.
  - **CQLReplicator** – CQLReplicator is an open source utility available on Github that helps you to migrate data from Apache Cassandra to Amazon Keyspaces in near real time.

    For more information, see the section called "CQLReplicator".
  - To learn more about how to use Amazon Managed Streaming for Apache Kafka to implement an online migration process with dual-writes, see Guidance for continuous data migration from Apache Cassandra to Amazon Keyspaces.
  - For large migrations, consider using an extract, transform, and load (ETL) tool. You can use AWS Glue to quickly and effectively perform data transformation migrations. For more information, see the section called "Offline migration".
  - To learn how to use the Apache Cassandra Spark connector to write data to Amazon Keyspaces, see the section called "Integrating with Apache Spark".
  - Get started quickly with loading data into Amazon Keyspaces by using the cqlsh `COPY FROM` command. cqlsh is included with Apache Cassandra and is best suited for loading small

datasets or test data. For step-by-step instructions, see the section called "Loading data using cqlsh".

- You can also use the DataStax Bulk Loader for Apache Cassandra to load data into Amazon Keyspaces using the `dsbulk` command. DSBulk provides more robust import capabilities than cqlsh and is available from the GitHub repository. For step-by-step instructions, see the section called "Loading data using DSBulk".

General considerations for data uploads to Amazon Keyspaces

- **Break the data upload down into smaller components.**

  Consider the following units of migration and their potential footprint in terms of raw data size. Uploading smaller amounts of data in one or more phases may help simplify your migration.

  - **By cluster** – Migrate all of your Cassandra data at once. This approach may be fine for smaller clusters.
  - **By keyspace or table** – Break up your migration into groups of keyspaces or tables. This approach can help you migrate data in phases based on your requirements for each workload.
  - **By data** – Consider migrating data for a specific group of users or products, to bring the size of data down even more.
- **Prioritize what data to upload first based on simplicity.**

  Consider if you have data that could be migrated first more easily—for example, data that does not change during specific times, data from nightly batch jobs, data not used during offline hours, or data from internal apps.

Topics

- Tutorial: Loading data into Amazon Keyspaces using cqlsh
- Tutorial: Loading data into Amazon Keyspaces using DSBulk

Tutorial: Loading data into Amazon Keyspaces using cqlsh

This tutorial guides you through the process of migrating data from Apache Cassandra to Amazon Keyspaces using the `cqlsh COPY FROM` command. The `cqlsh COPY FROM` command is useful to quickly and easily upload small datasets to Amazon Keyspaces for academic or test purposes.

For more information about how to migrate production workloads, see the section called "Offline migration". In this tutorial, you'll complete the following steps:

Prerequisites – Set up an AWS account with credentials, create a JKS trust store file for the certificate, and configure `cqlsh` to connect to Amazon Keyspaces.

1. **Create source CSV and target table** – Prepare a CSV file as the source data and create the target keyspace and table in Amazon Keyspaces.
2. **Prepare the data** – Randomize the data in the CSV file and analyze it to determine the average and maximum row sizes.
3. **Set throughput capacity** – Calculate the required write capacity units (WCUs) based on the data size and desired load time, and configure the table's provisioned capacity.
4. **Configure cqlsh parameters** – Determine optimal values for `cqlsh COPY FROM` parameters like `INGESTRATE`, `NUMPROCESSES`, `MAXBATCHSIZE`, and `CHUNKSIZE` to distribute the workload evenly.
5. **Run the `cqlsh COPY FROM` command** – Run the `cqlsh COPY FROM` command to upload the data from the CSV file to the Amazon Keyspaces table, and monitor the progress.

Troubleshooting – Resolve common issues like invalid requests, parser errors, capacity errors, and cqlsh errors during the data upload process.

Topics

- Prerequisites: Steps to complete before you can upload data using cqlsh COPY FROM
- Step 1: Create the source CSV file and a target table for the data upload
- Step 2: Prepare the source data for a successful data upload
- Step 3: Set throughput capacity for the table
- Step 4: Configure cqlsh COPY FROM settings
- Step 5: Run the cqlsh COPY FROM command to upload data from the CSV file to the target table
- Troubleshooting

Prerequisites: Steps to complete before you can upload data using `cqlsh COPY FROM`

You must complete the following tasks before you can start this tutorial.

1. If you have not already done so, sign up for an AWS account by following the steps at the section called “Setting up Amazon Keyspaces”.
2. Create service-specific credentials by following the steps at the section called “Create service-specific credentials”.
3. Set up the Cassandra Query Language shell (cqlsh) connection and confirm that you can connect to Amazon Keyspaces by following the steps at the section called “Using `cqlsh`”.

Step 1: Create the source CSV file and a target table for the data upload

For this tutorial, we use a comma-separated values (CSV) file with the name `keyspaces_sample_table.csv` as the source file for the data migration. The provided sample file contains a few rows of data for a table with the name `book_awards`.

1. Create the source file. You can choose one of the following options:
   - Download the sample CSV file (`keyspaces_sample_table.csv`) contained in the following archive file samplemigration.zip. Unzip the archive and take note of the path to `keyspaces_sample_table.csv`.
   - To populate a CSV file with your own data stored in an Apache Cassandra database, you can populate the source CSV file by using the `cqlsh COPY TO` statement as shown in the following example.

     ```
     cqlsh localhost 9042 -u "username" -p "password" --execute
      "COPY mykeyspace.mytable TO 'keyspaces_sample_table.csv' WITH HEADER=true";
     ```

     Make sure the CSV file you create meets the following requirements:

     - The first row contains the column names.
     - The column names in the source CSV file match the column names in the target table.
     - The data is delimited with a comma.
     - All data values are valid Amazon Keyspaces data types. See the section called “Data types”.
2. Create the target keyspace and table in Amazon Keyspaces.

   a. Connect to Amazon Keyspaces using `cqlsh`, replacing the service endpoint, user name, and password in the following example with your own values.

```
cqlsh cassandra.us-east-1.amazonaws.com 9142 -u "111122223333" -p
 "wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY" --ssl
```

b. Create a new keyspace with the name `catalog` as shown in the following example.

```
CREATE KEYSPACE catalog WITH REPLICATION = {'class': 'SingleRegionStrategy'};
```

c. When the new keyspace is available, use the following code to create the target table `book_awards`.

```
CREATE TABLE "catalog.book_awards" (
   year int,
   award text,
   rank int,
   category text,
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank)
   );
```

If Apache Cassandra is your original data source, a simple way to create the Amazon Keyspaces target table with matching headers is to generate the `CREATE TABLE` statement from the source table, as shown in the following statement.

```
cqlsh localhost 9042  -u "username" -p "password" --execute "DESCRIBE
 TABLE mykeyspace.mytable;"
```

Then create the target table in Amazon Keyspaces with the column names and data types matching the description from the Cassandra source table.

Step 2: Prepare the source data for a successful data upload

Preparing the source data for an efficient transfer is a two-step process. First, you randomize the data. In the second step, you analyze the data to determine the appropriate `cqlsh` parameter values and required table settings to ensure that the data upload is successful.

Randomize the data

The `cqlsh COPY FROM` command reads and writes data in the same order that it appears in the CSV file. If you use the `cqlsh COPY TO` command to create the source file, the data is written in key-sorted order in the CSV. Internally, Amazon Keyspaces partitions data using partition keys. Although Amazon Keyspaces has built-in logic to help load balance requests for the same partition key, loading the data is faster and more efficient if you randomize the order. This is because you can take advantage of the built-in load balancing that occurs when Amazon Keyspaces is writing to different partitions.

To spread the writes across the partitions evenly, you must randomize the data in the source file. You can write an application to do this or use an open-source tool, such as Shuf. Shuf is freely available on Linux distributions, on macOS (by installing coreutils in homebrew), and on Windows (by using Windows Subsystem for Linux (WSL)). One extra step is required to prevent the header row with the column names to get shuffled in this step.

To randomize the source file while preserving the header, enter the following code.

```
tail -n +2 keyspaces_sample_table.csv | shuf -o keyspace.table.csv && (head
 -1 keyspaces_sample_table.csv && cat keyspace.table.csv ) > keyspace.table.csv1 &&
 mv keyspace.table.csv1 keyspace.table.csv
```

Shuf rewrites the data to a new CSV file called `keyspace.table.csv`. You can now delete the `keyspaces_sample_table.csv` file—you no longer need it.

Analyze the data

Determine the average and maximum row size by analyzing the data.

You do this for the following reasons:

- The average row size helps to estimate the total amount of data to be transferred.
- You need the average row size to provision the write capacity needed for the data upload.
- You can make sure that each row is less than 1 MB in size, which is the maximum row size in Amazon Keyspaces.

> **Note**
>
> This quota refers to row size, not partition size. Unlike Apache Cassandra partitions, Amazon Keyspaces partitions can be virtually unbound in size. Partition keys and clustering

columns require additional storage for metadata, which you must add to the raw size of rows. For more information, see the section called “Estimate row size”.

The following code uses AWK to analyze a CSV file and print the average and maximum row size.

```
awk -F, 'BEGIN {samp=10000;max=-1;}{if(NR>1){len=length($0);t+=len;avg=t/
NR;max=(len>max ? len : max)}}NR==samp{exit}END{printf("{lines: %d, average: %d bytes,
 max: %d bytes}\n",NR,avg,max);}' keyspace.table.csv
```

Running this code results in the following output.

```
using 10,000 samples:
{lines: 10000, avg: 123 bytes, max: 225 bytes}
```

You use the average row size in the next step of this tutorial to provision the write capacity for the table.

Step 3: Set throughput capacity for the table

This tutorial shows you how to tune cqlsh to load data within a set time range. Because you know how many reads and writes you perform in advance, use provisioned capacity mode. After you finish the data transfer, you should set the capacity mode of the table to match your application's traffic patterns. To learn more about capacity management, see *Managing serverless resources*.

With provisioned capacity mode, you specify how much read and write capacity you want to provision to your table in advance. Write capacity is billed hourly and metered in write capacity units (WCUs). Each WCU is enough write capacity to support writing 1 KB of data per second. When you load the data, the write rate must be under the max WCUs (parameter: `write_capacity_units`) that are set on the target table.

By default, you can provision up to 40,000 WCUs to a table and 80,000 WCUs across all the tables in your account. If you need additional capacity, you can request a quota increase in the Service Quotas console. For more information about quotas, see *Quotas*.

Calculate the average number of WCUs required for an insert

Inserting 1 KB of data per second requires 1 WCU. If your CSV file has 360,000 rows and you want to load all the data in 1 hour, you must write 100 rows per second (360,000 rows / 60 minutes / 60 seconds = 100 rows per second). If each row has up to 1 KB of data, to insert 100 rows per second,

you must provision 100 WCUs to your table. If each row has 1.5 KB of data, you need two WCUs to insert one row per second. Therefore, to insert 100 rows per second, you must provision 200 WCUs.

To determine how many WCUs you need to insert one row per second, divide the average row size in bytes by 1024 and round up to the nearest whole number.

For example, if the average row size is 3000 bytes, you need three WCUs to insert one row per second.

```
ROUNDUP(3000 / 1024) = ROUNDUP(2.93) = 3 WCUs
```

Calculate data load time and capacity

Now that you know the average size and number of rows in your CSV file, you can calculate how many WCUs you need to load the data in a given amount of time, and the approximate time it takes to load all the data in your CSV file using different WCU settings.

For example, if each row in your file is 1 KB and you have 1,000,000 rows in your CSV file, to load the data in 1 hour, you need to provision at least 278 WCUs to your table for that hour.

```
1,000,000 rows * 1 KBs = 1,000,000 KBs
1,000,000 KBs / 3600 seconds =277.8 KBs / second = 278 WCUs
```

Configure provisioned capacity settings

You can set a table's write capacity settings when you create the table or by using the `ALTER TABLE` CQL command. The following is the syntax for altering a table's provisioned capacity settings with the `ALTER TABLE` CQL statement.

```
ALTER TABLE mykeyspace.mytable WITH custom_properties={'capacity_mode':
{'throughput_mode': 'PROVISIONED', 'read_capacity_units': 100,
 'write_capacity_units': 278}} ;
```

For the complete language reference, see the section called "ALTER TABLE".

Step 4: Configure `cqlsh COPY FROM` settings

This section outlines how to determine the parameter values for `cqlsh COPY FROM`. The `cqlsh COPY FROM` command reads the CSV file that you prepared earlier and inserts the data into Amazon Keyspaces using CQL. The command divides up the rows and distributes the `INSERT`

operations among a set of workers. Each worker establishes a connection with Amazon Keyspaces and sends INSERT requests along this channel.

The cqlsh COPY command doesn't have internal logic to distribute work evenly among its workers. However, you can configure it manually to make sure that the work is distributed evenly. Start by reviewing these key cqlsh parameters:

- **DELIMITER** – If you used a delimiter other than a comma, you can set this parameter, which defaults to comma.
- **INGESTRATE** – The target number of rows that cqlsh COPY FROM attempts to process per second. If unset, it defaults to 100,000.
- **NUMPROCESSES** – The number of child worker processes that cqlsh creates for COPY FROM tasks. The maximum for this setting is 16, the default is num_cores - 1, where num_cores is the number of processing cores on the host running cqlsh.
- **MAXBATCHSIZE** – The batch size determines the maximal number of rows inserted into the destination table in a single batch. If unset, cqlsh uses batches of 20 inserted rows.
- **CHUNKSIZE** – The size of the work unit that passes to the child worker. By default, it is set to 5,000.
- **MAXATTEMPTS** – The maximum number of times to retry a failed worker chunk. After the maximum attempt is reached, the failed records are written to a new CSV file that you can run again later after investigating the failure.

Set INGESTRATE based on the number of WCUs that you provisioned to the target destination table. The INGESTRATE of the cqlsh COPY FROM command isn't a limit—it's a target average. This means it can (and often does) burst above the number you set. To allow for bursts and make sure that enough capacity is in place to handle the data load requests, set INGESTRATE to 90% of the table's write capacity.

```
INGESTRATE = WCUs * .90
```

Next, set the NUMPROCESSES parameter to equal to one less than the number of cores on your system. To find out what the number of cores of your system is, you can run the following code.

```
python -c "import multiprocessing; print(multiprocessing.cpu_count())"
```

For this tutorial, we use the following value.

```
NUMPROCESSES = 4
```

Each process creates a worker, and each worker establishes a connection to Amazon Keyspaces. Amazon Keyspaces can support up to 3,000 CQL requests per second on every connection. This means that you have to make sure that each worker is processing fewer than 3,000 requests per second.

As with INGESTRATE, the workers often burst above the number you set and aren't limited by clock seconds. Therefore, to account for bursts, set your cqlsh parameters to target each worker to process 2,500 requests per second. To calculate the amount of work distributed to a worker, use the following guideline.

- Divide INGESTRATE by NUMPROCESSES.
- If INGESTRATE / NUMPROCESSES > 2,500, lower the INGESTRATE to make this formula true.

```
INGESTRATE / NUMPROCESSES <= 2,500
```

Before you configure the settings to optimize the upload of our sample data, let's review the cqlsh default settings and see how using them impacts the data upload process. Because cqlsh COPY FROM uses the CHUNKSIZE to create chunks of work (INSERT statements) to distribute to workers, the work is not automatically distributed evenly. Some workers might sit idle, depending on the INGESTRATE setting.

To distribute work evenly among the workers and keep each worker at the optimal 2,500 requests per second rate, you must set CHUNKSIZE, MAXBATCHSIZE, and INGESTRATE by changing the input parameters. To optimize network traffic utilization during the data load, choose a value for MAXBATCHSIZE that is close to the maximum value of 30. By changing CHUNKSIZE to 100 and MAXBATCHSIZE to 25, the 10,000 rows are spread evenly among the four workers (10,000 / 2500 = 4).

The following code example illustrates this.

```
INGESTRATE = 10,000
NUMPROCESSES = 4
CHUNKSIZE = 100
MAXBATCHSIZE. = 25
Work Distribution:
```

```
Connection 1 / Worker 1 : 2,500 Requests per second
Connection 2 / Worker 2 : 2,500 Requests per second
Connection 3 / Worker 3 : 2,500 Requests per second
Connection 4 / Worker 4 : 2,500 Requests per second
```

To summarize, use the following formulas when setting `cqlsh COPY FROM` parameters:

- **INGESTRATE** = write_capacity_units * .90
- **NUMPROCESSES** = num_cores -1 (default)
- **INGESTRATE / NUMPROCESSES** = 2,500 (This must be a true statement.)
- **MAXBATCHSIZE** = 30 (Defaults to 20. Amazon Keyspaces accepts batches up to 30.)
- **CHUNKSIZE** = (INGESTRATE / NUMPROCESSES) / MAXBATCHSIZE

Now that you have calculated `NUMPROCESSES`, `INGESTRATE`, and `CHUNKSIZE`, you're ready to load your data.

Step 5: Run the `cqlsh COPY FROM` command to upload data from the CSV file to the target table

To run the `cqlsh COPY FROM` command, complete the following steps.

1. Connect to Amazon Keyspaces using cqlsh.
2. Choose your keyspace with the following code.

   ```
   USE catalog;
   ```

3. Set write consistency to `LOCAL_QUORUM`. To ensure data durability, Amazon Keyspaces doesn't allow other write consistency settings. See the following code.

   ```
   CONSISTENCY LOCAL_QUORUM;
   ```

4. Prepare your `cqlsh COPY FROM` syntax using the following code example.

   ```
   COPY book_awards FROM './keyspace.table.csv' WITH HEADER=true
   AND INGESTRATE=calculated ingestrate
   AND NUMPROCESSES=calculated numprocess
   AND MAXBATCHSIZE=20
   AND CHUNKSIZE=calculated chunksize;
   ```

5. Run the statement prepared in the previous step. cqlsh echoes back all the settings that you've configured.

   a. Make sure that the settings match your input. See the following example.

   ```
   Reading options from the command line: {'chunksize': '120', 'header': 'true',
    'ingestrate': '36000', 'numprocesses': '15', 'maxbatchsize': '20'}
   Using 15 child processes
   ```

   b. Review the number of rows transferred and the current average rate, as shown in the following example.

   ```
   Processed: 57834 rows; Rate: 6561 rows/s; Avg. rate: 31751 rows/s
   ```

   c. When cqlsh has finished uploading the data, review the summary of the data load statistics (the number of files read, runtime, and skipped rows) as shown in the following example.

   ```
   15556824 rows imported from 1 files in 8 minutes and 8.321 seconds (0 skipped).
   ```

In this final step of the tutorial, you have uploaded the data to Amazon Keyspaces.

> **Important**
>
> Now that you have transferred your data, adjust the capacity mode settings of your target table to match your application's regular traffic patterns. You incur charges at the hourly rate for your provisioned capacity until you change it.

Troubleshooting

After the data upload has completed, check to see if rows were skipped. To do so, navigate to the source directory of the source CSV file and search for a file with the following name.

```
import_yourcsvfilename.err.timestamp.csv
```

cqlsh writes any skipped rows of data into a file with that name. If the file exists in your source directory and has data in it, these rows didn't upload to Amazon Keyspaces. To retry these rows,

first check for any errors that were encountered during the upload and adjust the data accordingly. To retry these rows, you can rerun the process.

Common errors

The most common reasons why rows aren't loaded are capacity errors and parsing errors.

Invalid request errors when uploading data to Amazon Keyspaces

In the following example, the source table contains a counter column, which results in logged batch calls from the cqlsh `COPY` command. Logged batch calls are not supported by Amazon Keyspaces.

```
Failed to import 10 rows: InvalidRequest - Error from server: code=2200 [Invalid query]
 message="Only UNLOGGED Batches are supported at this time.",  will retry later,
 attempt 22 of 25
```

To resolve this error, use DSBulk to migrate the data. For more information, see the section called "Loading data using DSBulk".

Parser errors when uploading data to Amazon Keyspaces

The following example shows a skipped row due to a `ParseError`.

```
Failed to import 1 rows: ParseError - Invalid ... –
```

To resolve this error, you need to make sure that the data to be imported matches the table schema in Amazon Keyspaces. Review the import file for parsing errors. You can try using a single row of data using an `INSERT` statement to isolate the error.

Capacity errors when uploading data to Amazon Keyspaces

```
Failed to import 1 rows: WriteTimeout - Error from server: code=1100 [Coordinator node
 timed out waiting for replica nodes' responses]
 message="Operation timed out - received only 0 responses." info={'received_responses':
 0, 'required_responses': 2, 'write_type': 'SIMPLE', 'consistency':
 'LOCAL_QUORUM'}, will retry later, attempt 1 of 100
```

Amazon Keyspaces uses the `ReadTimeout` and `WriteTimeout` exceptions to indicate when a write request fails due to insufficient throughput capacity. To help diagnose insufficient capacity exceptions, Amazon Keyspaces publishes `WriteThrottleEvents` and `ReadThrottledEvents`

metrics in Amazon CloudWatch. For more information, see the section called “Monitoring with CloudWatch”.

cqlsh errors when uploading data to Amazon Keyspaces

To help troubleshoot cqlsh errors, rerun the failing command with the `--debug` flag.

When using an incompatible version of cqlsh, you see the following error.

```
AttributeError: 'NoneType' object has no attribute 'is_up'
Failed to import 3 rows: AttributeError - 'NoneType' object has no attribute 'is_up',
 given up after 1 attempts
```

Confirm that the correct version of cqlsh is installed by running the following command.

```
cqlsh --version
```

You should see something like the following for output.

```
cqlsh 5.0.1
```

If you're using Windows, replace all instances of `cqlsh` with `cqlsh.bat`. For example, to check the version of cqlsh in Windows, run the following command.

```
cqlsh.bat --version
```

The connection to Amazon Keyspaces fails after the cqlsh client receives three consecutive errors of any type from the server. The cqlsh client fails with the following message.

```
Failed to import 1 rows: NoHostAvailable - , will retry later, attempt 3 of 100
```

To resolve this error, you need to make sure that the data to be imported matches the table schema in Amazon Keyspaces. Review the import file for parsing errors. You can try using a single row of data by using an INSERT statement to isolate the error.

The client automatically attempts to reestablish the connection.

Tutorial: Loading data into Amazon Keyspaces using DSBulk

This step-by-step tutorial guides you through migrating data from Apache Cassandra to Amazon Keyspaces using the DataStax Bulk Loader (DSBulk) available on GitHub. Using DSBulk is useful to

upload datasets to Amazon Keyspaces for academic or test purposes. For more information about how to migrate production workloads, see the section called "Offline migration". In this tutorial, you complete the following steps.

Prerequisites – Set up an AWS account with credentials, create a JKS trust store file for the certificate, configure `cqlsh`, download and install DSBulk, and configure an `application.conf` file.

1. **Create source CSV and target table** – Prepare a CSV file as the source data and create the target keyspace and table in Amazon Keyspaces.
2. **Prepare the data** – Randomize the data in the CSV file and analyze it to determine the average and maximum row sizes.
3. **Set throughput capacity** – Calculate the required write capacity units (WCUs) based on the data size and desired load time, and configure the table's provisioned capacity.
4. **Configure DSBulk settings** – Create a DSBulk configuration file with settings like authentication, SSL/TLS, consistency level, and connection pool size.
5. **Run the DSBulk load command** – Run the DSBulk load command to upload the data from the CSV file to the Amazon Keyspaces table, and monitor the progress.

Topics

- Prerequisites: Steps you have to complete before you can upload data with DSBulk
- Step 1: Create the source CSV file and a target table for the data upload using DSBulk
- Step 2: Prepare the data to upload using DSBulk
- Step 3: Set the throughput capacity for the target table
- Step 4: Configure DSBulk settings to upload data from the CSV file to the target table
- Step 5: Run the DSBulk load command to upload data from the CSV file to the target table

Prerequisites: Steps you have to complete before you can upload data with DSBulk

You must complete the following tasks before you can start this tutorial.

1. If you have not already done so, sign up for an AWS account by following the steps at the section called "Setting up Amazon Keyspaces".

2. Create credentials by following the steps at the section called "Create IAM credentials for AWS authentication".
3. Create a JKS trust store file.

   a. Download the following digital certificates and save the files locally or in your home directory.

      1. AmazonRootCA1
      2. AmazonRootCA2
      3. AmazonRootCA3
      4. AmazonRootCA4
      5. Starfield Class 2 Root (optional – for backward compatibility)

      To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

      Note

      Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

   b. Convert the digital certificates into trustStore files and add them to the keystore.

```
openssl x509 -outform der -in AmazonRootCA1.pem -out temp_file.der
keytool -import -alias amazon-root-ca-1 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in AmazonRootCA2.pem -out temp_file.der
keytool -import -alias amazon-root-ca-2 -keystore cassandra_truststore.jks -
file temp_file.der
```

```
openssl x509 -outform der -in AmazonRootCA3.pem -out temp_file.der
keytool -import -alias amazon-root-ca-3 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in AmazonRootCA4.pem -out temp_file.der
keytool -import -alias amazon-root-ca-4 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in sf-class2-root.crt -out temp_file.der
keytool -import -alias cassandra -keystore cassandra_truststore.jks -file
 temp_file.der
```

In the last step, you need to create a password for the keystore and trust each certificate. The interactive command looks like this.

```
Enter keystore password:
Re-enter new password:
Owner: CN=Amazon Root CA 1, O=Amazon, C=US
Issuer: CN=Amazon Root CA 1, O=Amazon, C=US
Serial number: 66c9fcf99bf8c0a39e2f0788a43e696365bca
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sun Jan 17 00:00:00 UTC 2038
Certificate fingerprints:
     SHA1: 8D:A7:F9:65:EC:5E:FC:37:91:0F:1C:6E:59:FD:C1:CC:6A:6E:DE:16
     SHA256:
 8E:CD:E6:88:4F:3D:87:B1:12:5B:A3:1A:C3:FC:B1:3D:70:16:DE:7F:57:CC:90:4F:E1:CB:97:C6:AE
Signature algorithm name: SHA256withRSA
Subject Public Key Algorithm: 2048-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
```

```
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: 84 18 CC 85 34 EC BC 0C   94 94 2E 08 59 9C C7 B2  ....4.......Y...
0010: 10 4E 0A 08                                        .N..
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: CN=Amazon Root CA 2, O=Amazon, C=US
Issuer: CN=Amazon Root CA 2, O=Amazon, C=US
Serial number: 66c9fd29635869f0a0fe58678f85b26bb8a37
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: 5A:8C:EF:45:D7:A6:98:59:76:7A:8C:8B:44:96:B5:78:CF:47:4B:1A
     SHA256:
 1B:A5:B2:AA:8C:65:40:1A:82:96:01:18:F8:0B:EC:4F:62:30:4D:83:CE:C4:71:3A:19:C3:9C:01:1E
Signature algorithm name: SHA384withRSA
Subject Public Key Algorithm: 4096-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: B0 0C F0 4C 30 F4 05 58   02 48 FD 33 E5 52 AF 4B  ...L0..X.H.3.R.K
```

```
0010: 84 E3 66 52                                        ..fR
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: CN=Amazon Root CA 3, O=Amazon, C=US
Issuer: CN=Amazon Root CA 3, O=Amazon, C=US
Serial number: 66c9fd5749736663f3b0b9ad9e89e7603f24a
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: 0D:44:DD:8C:3C:8C:1A:1A:58:75:64:81:E9:0F:2E:2A:FF:B3:D2:6E
     SHA256:
 18:CE:6C:FE:7B:F1:4E:60:B2:E3:47:B8:DF:E8:68:CB:31:D0:2E:BB:3A:DA:27:15:69:F5:03:43:B4
Signature algorithm name: SHA256withECDSA
Subject Public Key Algorithm: 256-bit EC (secp256r1) key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: AB B6 DB D7 06 9E 37 AC   30 86 07 91 70 C7 9C C4  ......7.0...p...
0010: 19 B1 78 C0                                        ..x.
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
```

```
Enter keystore password:
Owner: CN=Amazon Root CA 4, O=Amazon, C=US
Issuer: CN=Amazon Root CA 4, O=Amazon, C=US
Serial number: 66c9fd7c1bb104c2943e5717b7b2cc81ac10e
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: F6:10:84:07:D6:F8:BB:67:98:0C:C2:E2:44:C2:EB:AE:1C:EF:63:BE
     SHA256:
 E3:5D:28:41:9E:D0:20:25:CF:A6:90:38:CD:62:39:62:45:8D:A5:C6:95:FB:DE:A3:C2:2B:0B:FB:25
Signature algorithm name: SHA384withECDSA
Subject Public Key Algorithm: 384-bit EC (secp384r1) key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: D3 EC C7 3A 65 6E CC E1   DA 76 9A 56 FB 9C F3 86  ...:en...v.V....
0010: 6D 57 E5 81                                        mW..
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: OU=Starfield Class 2 Certification Authority, O="Starfield Technologies,
 Inc.", C=US
Issuer: OU=Starfield Class 2 Certification Authority, O="Starfield
 Technologies, Inc.", C=US
Serial number: 0
```

```
Valid from: Tue Jun 29 17:39:16 UTC 2004 until: Thu Jun 29 17:39:16 UTC 2034
Certificate fingerprints:
     SHA1: AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:B5:8A
     SHA256:
 14:65:FA:20:53:97:B8:76:FA:A6:F0:A9:95:8E:55:90:E4:0F:CC:7F:AA:4F:B7:C2:C8:67:75:21:FB
Signature algorithm name: SHA1withRSA (weak)
Subject Public Key Algorithm: 2048-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.35 Criticality=false
AuthorityKeyIdentifier [
KeyIdentifier [
0000: BF 5F B7 D1 CE DD 1F 86   F4 5B 55 AC DC D7 10 C2  ._.......[U.....
0010: 0E A9 88 E7                                        ....
]
[OU=Starfield Class 2 Certification Authority, O="Starfield Technologies,
 Inc.", C=US]
SerialNumber: [    00]
]

#2: ObjectId: 2.5.29.19 Criticality=false
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: BF 5F B7 D1 CE DD 1F 86   F4 5B 55 AC DC D7 10 C2  ._.......[U.....
0010: 0E A9 88 E7                                        ....
]
]


Warning:
The input uses the SHA1withRSA signature algorithm which is considered a
 security risk. This algorithm will be disabled in a future update.

Trust this certificate? [no]:  yes
Certificate was added to keystore
```

4. Set up the Cassandra Query Language shell (cqlsh) connection and confirm that you can connect to Amazon Keyspaces by following the steps at the section called "Using `cqlsh`".
5. Download and install DSBulk.

> **Note**
>
> The version shown in this tutorial might not be the latest version available. Before you download DSBulk, check the DataStax Bulk Loader download page for the latest version, and update the version number in the following commands accordingly.

a. To download DSBulk, you can use the following code.

```
curl -OL https://downloads.datastax.com/dsbulk/dsbulk-1.8.0.tar.gz
```

b. Then unpack the tar file and add DSBulk to your PATH as shown in the following example.

```
tar -zxvf dsbulk-1.8.0.tar.gz
# add the DSBulk directory to the path
export PATH=$PATH:./dsbulk-1.8.0/bin
```

c. Create an `application.conf` file to store settings to be used by DSBulk. You can save the following example as `./dsbulk_keyspaces.conf`. Replace `localhost` with the contact point of your local Cassandra cluster if you are not on the local node, for example the DNS name or IP address. Take note of the file name and path, as you're going to need to specify this later in the `dsbulk load` command.

```
datastax-java-driver {
  basic.contact-points = [ "localhost"]
  advanced.auth-provider {
        class = software.aws.mcs.auth.SigV4AuthProvider
        aws-region = us-east-1
  }
}
```

d. To enable SigV4 support, download the shaded `jar` file from GitHub and place it in the DSBulk `lib` folder as shown in the following example.

```
curl -O -L https://github.com/aws/aws-sigv4-auth-cassandra-java-driver-plugin/
releases/download/4.0.6-shaded-v2/aws-sigv4-auth-cassandra-java-driver-
plugin-4.0.6-shaded.jar
```

Step 1: Create the source CSV file and a target table for the data upload using DSBulk

For this tutorial, we use a comma-separated values (CSV) file with the name `keyspaces_sample_table.csv` as the source file for the data migration. The provided sample file contains a few rows of data for a table with the name `book_awards`.

1. Create the source file. You can choose one of the following options:
   - Download the sample CSV file (`keyspaces_sample_table.csv`) contained in the following archive file samplemigration.zip. Unzip the archive and take note of the path to `keyspaces_sample_table.csv`.
   - To populate a CSV file with your own data stored in an Apache Cassandra database, you can populate the source CSV file by using `dsbulk unload` as shown in the following example.

     ```
     dsbulk unload -k mykeyspace -t mytable -f ./my_application.conf
      > keyspaces_sample_table.csv
     ```

     Make sure the CSV file you create meets the following requirements:

     - The first row contains the column names.
     - The column names in the source CSV file match the column names in the target table.
     - The data is delimited with a comma.
     - All data values are valid Amazon Keyspaces data types. See the section called “Data types”.
2. Create the target keyspace and table in Amazon Keyspaces.

   a. Connect to Amazon Keyspaces using `cqlsh`, replacing the service endpoint, user name, and password in the following example with your own values.

```
cqlsh cassandra.us-east-1.amazonaws.com 9142 -u "111122223333" -p
 "wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY" --ssl
```

b. Create a new keyspace with the name `catalog` as shown in the following example.

```
CREATE KEYSPACE catalog WITH REPLICATION = {'class': 'SingleRegionStrategy'};
```

c. After the new keyspace has a status of available, use the following code to create the target table book_awards. To learn more about asynchronous resource creation and how to check if a resource is available, see the section called “Check keyspace creation status”.

```
CREATE TABLE catalog.book_awards (
   year int,
   award text,
   rank int,
   category text,
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank)
   );
```

If Apache Cassandra is your original data source, a simple way to create the Amazon Keyspaces target table with matching headers is to generate the `CREATE TABLE` statement from the source table as shown in the following statement.

```
cqlsh localhost 9042  -u "username" -p "password" --execute "DESCRIBE
 TABLE mykeyspace.mytable;"
```

Then create the target table in Amazon Keyspaces with the column names and data types matching the description from the Cassandra source table.

Step 2: Prepare the data to upload using DSBulk

Preparing the source data for an efficient transfer is a two-step process. First, you randomize the data. In the second step, you analyze the data to determine the appropriate `dsbulk` parameter values and required table settings.

Randomize the data

The `dsbulk` command reads and writes data in the same order that it appears in the CSV file. If you use the `dsbulk` command to create the source file, the data is written in key-sorted order in the CSV. Internally, Amazon Keyspaces partitions data using partition keys. Although Amazon Keyspaces has built-in logic to help load balance requests for the same partition key, loading the data is faster and more efficient if you randomize the order. This is because you can take advantage of the built-in load balancing that occurs when Amazon Keyspaces is writing to different partitions.

To spread the writes across the partitions evenly, you must randomize the data in the source file. You can write an application to do this or use an open-source tool, such as Shuf. Shuf is freely available on Linux distributions, on macOS (by installing coreutils in homebrew), and on Windows (by using Windows Subsystem for Linux (WSL)). One extra step is required to prevent the header row with the column names to get shuffled in this step.

To randomize the source file while preserving the header, enter the following code.

```
tail -n +2 keyspaces_sample_table.csv | shuf -o keyspace.table.csv && (head
 -1 keyspaces_sample_table.csv && cat keyspace.table.csv ) > keyspace.table.csv1 &&
 mv keyspace.table.csv1 keyspace.table.csv
```

Shuf rewrites the data to a new CSV file called `keyspace.table.csv`. You can now delete the `keyspaces_sample_table.csv` file—you no longer need it.

Analyze the data

Determine the average and maximum row size by analyzing the data.

You do this for the following reasons:

- The average row size helps to estimate the total amount of data to be transferred.
- You need the average row size to provision the write capacity needed for the data upload.
- You can make sure that each row is less than 1 MB in size, which is the maximum row size in Amazon Keyspaces.

> **Note**
>
> This quota refers to row size, not partition size. Unlike Apache Cassandra partitions, Amazon Keyspaces partitions can be virtually unbound in size. Partition keys and clustering

columns require additional storage for metadata, which you must add to the raw size of rows. For more information, see the section called “Estimate row size”.

The following code uses AWK to analyze a CSV file and print the average and maximum row size.

```
awk -F, 'BEGIN {samp=10000;max=-1;}{if(NR>1){len=length($0);t+=len;avg=t/
NR;max=(len>max ? len : max)}}NR==samp{exit}END{printf("{lines: %d, average: %d bytes,
 max: %d bytes}\n",NR,avg,max);}' keyspace.table.csv
```

Running this code results in the following output.

```
using 10,000 samples:
{lines: 10000, avg: 123 bytes, max: 225 bytes}
```

Make sure that your maximum row size doesn't exceed 1 MB. If it does, you have to break up the row or compress the data to bring the row size below 1 MB. In the next step of this tutorial, you use the average row size to provision the write capacity for the table.

Step 3: Set the throughput capacity for the target table

This tutorial shows you how to tune DSBulk to load data within a set time range. Because you know how many reads and writes you perform in advance, use provisioned capacity mode. After you finish the data transfer, you should set the capacity mode of the table to match your application’s traffic patterns. To learn more about capacity management, see *Managing serverless resources*.

With provisioned capacity mode, you specify how much read and write capacity you want to provision to your table in advance. Write capacity is billed hourly and metered in write capacity units (WCUs). Each WCU is enough write capacity to support writing 1 KB of data per second. When you load the data, the write rate must be under the max WCUs (parameter: `write_capacity_units`) that are set on the target table.

By default, you can provision up to 40,000 WCUs to a table and 80,000 WCUs across all the tables in your account. If you need additional capacity, you can request a quota increase in the Service Quotas console. For more information about quotas, see *Quotas*.

Calculate the average number of WCUs required for an insert

Inserting 1 KB of data per second requires 1 WCU. If your CSV file has 360,000 rows and you want to load all the data in 1 hour, you must write 100 rows per second (360,000 rows / 60 minutes / 60

seconds = 100 rows per second). If each row has up to 1 KB of data, to insert 100 rows per second, you must provision 100 WCUs to your table. If each row has 1.5 KB of data, you need two WCUs to insert one row per second. Therefore, to insert 100 rows per second, you must provision 200 WCUs.

To determine how many WCUs you need to insert one row per second, divide the average row size in bytes by 1024 and round up to the nearest whole number.

For example, if the average row size is 3000 bytes, you need three WCUs to insert one row per second.

```
ROUNDUP(3000 / 1024) = ROUNDUP(2.93) = 3 WCUs
```

Calculate data load time and capacity

Now that you know the average size and number of rows in your CSV file, you can calculate how many WCUs you need to load the data in a given amount of time, and the approximate time it takes to load all the data in your CSV file using different WCU settings.

For example, if each row in your file is 1 KB and you have 1,000,000 rows in your CSV file, to load the data in 1 hour, you need to provision at least 278 WCUs to your table for that hour.

```
1,000,000 rows * 1 KBs = 1,000,000 KBs
1,000,000 KBs / 3600 seconds =277.8 KBs / second = 278 WCUs
```

Configure provisioned capacity settings

You can set a table's write capacity settings when you create the table or by using the ALTER TABLE command. The following is the syntax for altering a table's provisioned capacity settings with the ALTER TABLE command.

```
ALTER TABLE catalog.book_awards WITH custom_properties={'capacity_mode':
{'throughput_mode': 'PROVISIONED', 'read_capacity_units': 100, 'write_capacity_units':
 278}} ;
```

For the complete language reference, see the section called "CREATE TABLE" and the section called "ALTER TABLE".

Step 4: Configure DSBulk settings to upload data from the CSV file to the target table

This section outlines the steps required to configure DSBulk for data upload to Amazon Keyspaces. You configure DSBulk by using a configuration file. You specify the configuration file directly from the command line.

1. Create a DSBulk configuration file for the migration to Amazon Keyspaces, in this example we use the file name `dsbulk_keyspaces.conf`. Specify the following settings in the DSBulk configuration file.

   a. *`PlainTextAuthProvider`* – Create the authentication provider with the `PlainTextAuthProvider` class. `ServiceUserName` and `ServicePassword` should match the user name and password you obtained when you generated the service-specific credentials by following the steps at the section called "Create programmatic access credentials".

   b. *`local-datacenter`* – Set the value for `local-datacenter` to the AWS Region that you're connecting to. For example, if the application is connecting to `cassandra.us-east-1.amazonaws.com`, then set the local data center to `us-east-1`. For all available AWS Regions, see the section called "Service endpoints". To avoid replicas, set `slow-replica-avoidance` to `false`.

   c. *`SSLEngineFactory`* – To configure SSL/TLS, initialize the `SSLEngineFactory` by adding a section in the configuration file with a single line that specifies the class with `class = DefaultSslEngineFactory`. Provide the path to `cassandra_truststore.jks` and the password that you created previously.

   d. *`consistency`* – Set the consistency level to `LOCAL_QUORUM`. Other write consistency levels are not supported, for more information see the section called "Supported Cassandra consistency levels".

   e. The number of connections per pool is configurable in the Java driver. For this example, set `advanced.connection.pool.local.size` to 3.

   The following is the complete sample configuration file.

```
datastax-java-driver {
basic.contact-points = [ "cassandra.us-east-1.amazonaws.com:9142"]
advanced.auth-provider {
    class = PlainTextAuthProvider
```

```
    username = "ServiceUserName"
    password = "ServicePassword"
}

basic.load-balancing-policy {
    local-datacenter = "us-east-1"
    slow-replica-avoidance = false
}

basic.request {
    consistency = LOCAL_QUORUM
    default-idempotence = true
}
advanced.ssl-engine-factory {
    class = DefaultSslEngineFactory
    truststore-path = "./cassandra_truststore.jks"
    truststore-password = "my_password"
    hostname-validation = false
  }
advanced.connection.pool.local.size = 3
}
```

2. Review the parameters for the DSBulk `load` command.

   a. *`executor.maxPerSecond`* – The maximum number of rows that the load command attempts to process concurrently per second. If unset, this setting is disabled with -1.

      Set `executor.maxPerSecond` based on the number of WCUs that you provisioned to the target destination table. The `executor.maxPerSecond` of the `load` command isn't a limit – it's a target average. This means it can (and often does) burst above the number you set. To allow for bursts and make sure that enough capacity is in place to handle the data load requests, set `executor.maxPerSecond` to 90% of the table's write capacity.

      ```
      executor.maxPerSecond = WCUs * .90
      ```

      In this tutorial, we set `executor.maxPerSecond` to 5.

      > **Note**
      >
      > If you are using DSBulk 1.6.0 or higher, you can use `dsbulk.engine.maxConcurrentQueries` instead.

b. Configure these additional parameters for the DSBulk `load` command.

- *`batch-mode`* – This parameter tells the system to group operations by partition key. We recommend to disable batch mode, because it can result in hot key scenarios and cause `WriteThrottleEvents`.
- *`driver.advanced.retry-policy-max-retries`* – This determines how many times to retry a failed query. If unset, the default is 10. You can adjust this value as needed.
- *`driver.basic.request.timeout`* – The time in minutes the system waits for a query to return. If unset, the default is "5 minutes". You can adjust this value as needed.

Step 5: Run the DSBulk `load` command to upload data from the CSV file to the target table

In the final step of this tutorial, you upload the data into Amazon Keyspaces.

To run the DSBulk `load` command, complete the following steps.

1. Run the following code to upload the data from your csv file to your Amazon Keyspaces table. Make sure to update the path to the application configuration file you created earlier.

```
dsbulk load -f ./dsbulk_keyspaces.conf  --connector.csv.url keyspace.table.csv
 -header true --batch.mode DISABLED --executor.maxPerSecond 5 --
driver.basic.request.timeout "5 minutes" --driver.advanced.retry-policy.max-
retries 10 -k catalog -t book_awards
```

2. The output includes the location of a log file that details successful and unsuccessful operations. The file is stored in the following directory.

```
Operation directory: /home/user_name/logs/UNLOAD_20210308-202317-801911
```

3. The log file entries will include metrics, as in the following example. Check to make sure that the number of rows is consistent with the number of rows in your csv file.

```
total | failed | rows/s | p50ms | p99ms | p999ms
   200 |      0 |    200 | 21.63 | 21.89 |  21.89
```

Important

Now that you have transferred your data, adjust the capacity mode settings of your target table to match your application's regular traffic patterns. You incur charges at the hourly rate for your provisioned capacity until you change it. For more information, see the section called "Configure read/write capacity modes".

Accessing Amazon Keyspaces (for Apache Cassandra)

You can access Amazon Keyspaces using the console, AWS CloudShell, programmatically by running a `cqlsh` client, the AWS SDK, or by using an Apache 2.0 licensed Cassandra driver. Amazon Keyspaces supports drivers and clients that are compatible with Apache Cassandra 3.11.2. Before accessing Amazon Keyspaces, you must complete setting up AWS Identity and Access Management and then grant an IAM identity access permissions to Amazon Keyspaces.

Sign up for an AWS account

To get started with AWS, you need an AWS account. There are two ways to sign up for AWS. If you want complete control over account configuration and where your content is stored, or if you have regulated workloads such as HIPAA or FedRAMP, use Sign up for AWS (advanced). If you are a new user and want to use a login you already own to sign in to AWS and create an AWS environment with preconfigured defaults in select AWS Regions, use Sign up for AWS.

Setting up Amazon Keyspaces

Access to Amazon Keyspaces resources is managed using IAM. Using IAM, you can attach policies to IAM users, roles, and federated identities that grant read and write permissions to specific resources in Amazon Keyspaces.

To get started with granting permissions to an IAM identity, you can use one of the AWS managed policies for Amazon Keyspaces:

- AmazonKeyspacesFullAccess – this policy grants permissions to access all resources in Amazon Keyspaces with full access to all features.
- AmazonKeyspacesReadOnlyAccess_v2 – this policy grants read-only permissions to Amazon Keyspaces.

For a detailed explanation of the actions defined in the managed policies, see the section called "AWS managed policies".

To limit the scope of actions that an IAM identity can perform or limit the resources that the identity can access, you can create a custom policy that uses the `AmazonKeyspacesFullAccess`

managed policy as a template and remove all permissions that you don't need. You can also limit access to specific keyspaces or tables. For more information about how to restrict actions or limit access to specific resources in Amazon Keyspaces, see the section called “How Amazon Keyspaces works with IAM”.

To access Amazon Keyspaces after you have created the AWS account and created a policy that grants an IAM identity access to Amazon Keyspaces, continue to one of the following sections:

- Using the console
- Using AWS CloudShell

Accessing Amazon Keyspaces using the console

You can access the console for Amazon Keyspaces at https://console.aws.amazon.com/keyspaces/home. For more information about AWS Management Console access, see Controlling IAM users access to the AWS Management Console in the IAM User Guide.

You can use the console to do the following in Amazon Keyspaces:

- Create, delete, and manage keyspaces and tables.
- Monitor important table metrics on a table's **Monitor** tab:
  - Billable table size (Bytes)
  - Capacity metrics
- Run queries using the CQL editor or through the integrated AWS CloudShell experience, for example insert, update, and delete data.
- Connect to Amazon Keyspaces directly through AWS CloudShell with integrated CQLSH support.
- Change the partitioner configuration of the account.
- View performance and error metrics for the account on the dashboard.

Connect to Amazon Keyspaces using AWS CloudShell from the console

AWS CloudShell provides a streamlined way to connect to Amazon Keyspaces directly from the console. The AWS CloudShell integration automatically initializes the `cqlsh-expansion` for you and establishes a connection to a specific keyspace.

Getting started with AWS CloudShell integration

1. **Access the AWS CloudShell integration** – From the Amazon Keyspaces console, navigate to the keyspace you want to connect to and choose the **Connect to Keyspaces** AWS CloudShell button.
2. **Pre-filled setup command** – When you choose the AWS CloudShell button, the system provides a pre-filled command that includes the necessary initialization and connection parameters:

   ```
   cqlsh-expansion.init ; cqlsh-expansion cassandra.region.amazonaws.com 9142 --ssl
    -my_keyspace
   ```
3. **Click Run**
4. **Wait for Amazon Keyspaces to establish the connection** – Allow time for the setup process to complete and the connection to your selected keyspace to be established.
5. **Execute commands** – When connected, you can write and execute CQL commands directly against the selected keyspace.

Available CQLSH commands

The AWS CloudShell integration provides access to standard CQLSH functionality, including support for commands beyond basic CQL.

- **Describe** – List and view detailed descriptions of keyspaces and tables.
- **Copy** – Export query output to a file for later processing.
- **Source** – Execute CQL statements from a file.
- **Command history navigation** – Scroll through previous commands using keyboard shortcuts.
- **Query execution** – Run queries directly from the keyboard interface.
- **Output copying** – Copy results as simple text for use in other applications.

Feature considerations

When using the AWS CloudShell integration, consider the following trade-offs.

The following features are not supported:

- CQL syntax suggestions and auto-complete functionality.

- Editor tools such as show autocomplete, show tooltip, find, find and replace, redo, toggle block comments, toggle code folding, toggle line comment, and undo.

Modified functionality:

- **CSV downloads** – To download results as CSV format, specify the > operator to pipe command output:

```
SELECT * FROM my_table > file_name.csv
```

- **JSON viewing** - You can view items in JSON format without requiring data conversion.
- **Terminal-style interface** - The experience operates as a terminal interface rather than a full-featured code editor.

The AWS CloudShell integration simplifies the connection process while providing essential CQL functionality for managing your Amazon Keyspaces data directly from the AWS Management Console.

To learn how to create an Amazon Keyspaces keyspace and table and set it up with sample application data, see Getting started with Amazon Keyspaces (for Apache Cassandra).

Using AWS CloudShell to access Amazon Keyspaces

AWS CloudShell is a browser-based, pre-authenticated shell that you can launch directly from the AWS Management Console. You can run AWS CLI commands against AWS services using your preferred shell (Bash, PowerShell or Z shell). AWS CloudShell comes pre-authenticated with your console credentials and includes common tools for working with AWS services, including the AWS CLI, Python, and Node.js.

You launch AWS CloudShell from the AWS Management Console, and the AWS credentials you used to sign in to the console are automatically available in a new shell session. This pre-authentication of AWS CloudShell users allows you to skip configuring credentials when interacting with AWS services such as Amazon Keyspaces using `cqlsh` or AWS CLI version 2 (pre-installed on the shell's compute environment).

AWS CloudShell integration options

Amazon Keyspaces offers two ways to use AWS CloudShell:

1. **Integrated AWS CloudShell experience** - A streamlined connection method available directly from the Amazon Keyspaces console that automatically initializes the `cqlsh-expansion` and connects to a specific keyspace. For complete instructions on using this integrated experience, see the section called “CloudShell console integration”.
2. **Manual AWS CloudShell setup** - Manually install and configure `cqlsh` in AWS CloudShell. The steps are described in the following sections and provides more control over the setup process and enable custom configurations.

Prerequisites

Before using Amazon Keyspaces with AWS CloudShell, ensure you have:

- An AWS account with access to Amazon Keyspaces and AWS CloudShell
- Appropriate IAM permissions to use both services
- Basic familiarity with Cassandra Query Language (CQL)

Getting started with AWS CloudShell

To access AWS CloudShell:

1. Sign in to the AWS Management Console
2. Launch AWS CloudShell by choosing the AWS CloudShell icon in the navigation bar at the top of the console, or by navigating to https://console.aws.amazon.com/cloudshell/
3. Wait for the AWS CloudShell environment to initialize

Obtaining IAM permissions for AWS CloudShell

Using the access management resources provided by AWS Identity and Access Management, administrators can grant permissions to IAM users so they can access AWS CloudShell and use the environment's features.

The quickest way for an administrator to grant access to users is through an AWS managed policy. An AWS managed policy is a standalone policy that's created and administered by AWS. The following AWS managed policy for CloudShell can be attached to IAM identities:

- `AWSCloudShellFullAccess`: Grants permission to use AWS CloudShell with full access to all features.

If you want to limit the scope of actions that an IAM user can perform with AWS CloudShell, you can create a custom policy that uses the `AWSCloudShellFullAccess` managed policy as a template. For more information about limiting the actions that are available to users in CloudShell, see Managing AWS CloudShell access and usage with IAM policies in the *AWS CloudShell User Guide*.

> **Note**
>
> Your IAM identity also requires a policy that grants permission to make calls to Amazon Keyspaces.

You can use an AWS managed policy to give your IAM identity access you Amazon Keyspaces, or start with the managed policy as a template and remove the permissions that you don't need. You can also limit access to specific keyspaces and tables to create a custom policy. The following managed policy for Amazon Keyspaces can be attached to IAM identities:

- AmazonKeyspacesFullAccess – This policy grants permission to use Amazon Keyspaces with full access to all features.

For a detailed explanation of the actions defined in the managed policy, see the section called "AWS managed policies".

For more information about how to restrict actions or limit access to specific resources in Amazon Keyspaces, see the section called "How Amazon Keyspaces works with IAM".

Installing the cqlsh client

AWS CloudShell does not come with `cqlsh` pre-installed. You need to install it to interact with Amazon Keyspaces. You can install the Amazon Keyspaces-specific version of `cqlsh`. For `cqlsh-expansion` installation instructions, see the section called "Using the `cqlsh-expansion`".

Configuring TLS certificates

To connect to Amazon Keyspaces using a TLS connection, you need to download the required Amazon digital certificates. For detailed instructions on downloading and configuring the SSL certificate, see the section called “How to manually configure cqlsh connections for TLS”.

Connecting to Amazon Keyspaces

You can connect to Amazon Keyspaces using either IAM credentials (recommended) or service-specific credentials.

Connecting with IAM credentials (recommended)

AWS CloudShell is already authenticated with your IAM credentials. To connect using these credentials, you can use the SigV4 authentication plugin. For detailed instructions on using IAM credentials with `cqlsh`, see the section called “Using the cqlsh-expansion”.

Connecting with service-specific credentials

If you have created service-specific credentials for Amazon Keyspaces, you can use them to connect. For information about creating and using service-specific credentials, see the section called “Create service-specific credentials”.

Using CQLSH with Amazon Keyspaces

When connected, you can use standard CQL commands to interact with your keyspaces and tables. For detailed information about supported CQL commands and operations, see the section called “Using the cqlsh-expansion”.

Persisting data in AWS CloudShell

AWS CloudShell provides 1 GB of persistent storage in your home directory. This means scripts, certificates, and configuration files you create remain available across sessions. You can create a configuration file for `cqlsh` to simplify connections.

With a configuration file, you can run `cqlsh` without specifying additional parameters. For more information about creating and using `cqlsh` configuration files, see the section called “Using the cqlsh-expansion”.

Best practices

When using Amazon Keyspaces with AWS CloudShell, we recommend the following best practices:

- Create scripts for repetitive tasks and store them in your persistent home directory.
- Use environment variables for sensitive information rather than hardcoding them.
- Remember that AWS CloudShell sessions may time out after inactivity.
- Be mindful of the AWS CloudShell service quotas and limitations.
- Consider using the AWS CLI for automated operations with Amazon Keyspaces.

Troubleshooting

If you encounter issues when connecting to Amazon Keyspaces from AWS CloudShell:

- Verify your IAM permissions include the necessary Amazon Keyspaces actions.
- Ensure that you are using the correct endpoint for your Region.
- Check that the SSL certificates are correctly downloaded and referenced.
- Verify that your service-specific credentials are correct and not expired.
- If using a cqlshrc file, check its formatting and permissions.

Example: How to interact with Amazon Keyspaces using AWS CloudShell

After you launch AWS CloudShell from the AWS Management Console, you can immediately start to interact with Amazon Keyspaces using `cqlsh` or the command line interface. If you haven't already installed the `cqlsh-expansion`, see the section called “Using the `cqlsh-expansion`” for detailed steps.

> **Note**
>
> When using the `cqlsh-expansion` in AWS CloudShell, you don't need to configure credentials before making calls, because you're already authenticated within the shell.

Connect to Amazon Keyspaces and create a new keyspace. Then read from a system table to confirm that the keyspace was created using AWS CloudShell

1. From the AWS Management Console, you can launch CloudShell by choosing the following options available on the navigation bar:

   - Choose the CloudShell icon.
   - Start typing `cloudshell` in the search box and then choose the CloudShell option.

2. You can establish a connection to Amazon Keyspaces using the following command. Make sure to replace `cassandra.us-east-1.amazonaws.com` with the correct endpoint for your Region.

   ```
   cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
   ```

   If the connection is successful, you should see output similar to the following example.

   ```
   Connected to Amazon Keyspaces at cassandra.us-east-1.amazonaws.com:9142
   [cqlsh 6.1.0 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
   Use HELP for help.
   cqlsh current consistency level is ONE.
   cqlsh>
   ```

3. Create a new keyspace with the name `mykeyspace`. You can use the following command to do that.

   ```
   CREATE KEYSPACE mykeyspace WITH REPLICATION = {'class': 'SingleRegionStrategy'};
   ```

4. To confirm that the keyspace was created, you can read from a system table using the following command.

   ```
   SELECT * FROM system_schema_mcs.keyspaces WHERE keyspace_name = 'mykeyspace';
   ```

   If the call is successful, the command line displays a response from the service similar to the following output:

   ```
    keyspace_name  | durable_writes | replication
   ----------------+----------------
   +-------------------------------------------------------------------------------
   ```

```
 mykeyspace     |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}

(1 rows)
```

Create credentials for programmatic access to Amazon Keyspaces

To provide users and applications with credentials for programmatic access to Amazon Keyspaces resources, you can do either of the following:

- Create service-specific credentials that are similar to the traditional username and password that Cassandra uses for authentication and access management. AWS service-specific credentials are associated with a specific AWS Identity and Access Management (IAM) user and can only be used for the service they were created for. For more information, see Using IAM with Amazon Keyspaces (for Apache Cassandra) in the IAM User Guide.

  > **Warning**
  >
  > IAM users have long-term credentials, which presents a security risk. To help mitigate this risk, we recommend that you provide these users with only the permissions they require to perform the task and that you remove these users when they are no longer needed.

- For enhanced security, we recommend to create IAM identities that are used across all AWS services and use temporary credentials. The Amazon Keyspaces SigV4 authentication plugin for Cassandra client drivers enables you to authenticate calls to Amazon Keyspaces using IAM access keys instead of user name and password. To learn more about how the Amazon Keyspaces SigV4 plugin enables IAM users, roles, and federated identities to authenticate in Amazon Keyspaces API requests, see AWS Signature Version 4 process (SigV4).

  You can download the SigV4 plugins from the following locations.

  - Java: https://github.com/aws/aws-sigv4-auth-cassandra-java-driver-plugin.
  - Node.js: https://github.com/aws/aws-sigv4-auth-cassandra-nodejs-driver-plugin.
  - Python: https://github.com/aws/aws-sigv4-auth-cassandra-python-driver-plugin.
  - Go: https://github.com/aws/aws-sigv4-auth-cassandra-gocql-driver-plugin.

For code samples that show how to establish connections using the SigV4 authentication plugin, see the section called “Using a Cassandra client driver”.

Topics

- Create service-specific credentials for programmatic access to Amazon Keyspaces
- Create and configure AWS credentials for Amazon Keyspaces

Create service-specific credentials for programmatic access to Amazon Keyspaces

Service-specific credentials are similar to the traditional username and password that Cassandra uses for authentication and access management. Service-specific credentials enable IAM users to access a specific AWS service. These long-term credentials can't be used to access other AWS services. They are associated with a specific IAM user and can't be used by other IAM users.

> **Important**
>
> Service-specific credentials are long-term credentials associated with a specific IAM user and can only be used for the service they were created for. To give IAM roles or federated identities permissions to access all your AWS resources using temporary credentials, you should use AWS authentication with the SigV4 authentication plugin for Amazon Keyspaces.

Use one of the following procedures to generate service-specific credentials.

Console

Create service-specific credentials using the console

1. Sign in to the AWS Management Console and open the AWS Identity and Access Management console at https://console.aws.amazon.com/iam/home.
2. In the navigation pane, choose **Users**, and then choose the user that you created earlier that has Amazon Keyspaces permissions (policy attached).
3. Choose **Security Credentials**. Under **Credentials for Amazon Keyspaces**, choose **Generate credentials** to generate the service-specific credentials.

Your service-specific credentials are now available. This is the only time you can download or view the password. You cannot recover it later. However, you can reset your password at any time. Save the user and password in a secure location, because you'll need them later.

CLI

Create service-specific credentials using the AWS CLI

Before generating service-specific credentials, you need to download, install, and configure the AWS Command Line Interface (AWS CLI):

1. Download the AWS CLI at http://aws.amazon.com/cli.

   Note

   The AWS CLI runs on Windows, macOS, or Linux.

2. Follow the instructions for Installing the AWS CLI and Configuring the AWS CLI in the *AWS Command Line Interface User Guide*.
3. Using the AWS CLI, run the following command to generate service-specific credentials for the user `alice`, so that she can access Amazon Keyspaces.

```
aws iam create-service-specific-credential \
    --user-name alice \
    --service-name cassandra.amazonaws.com
```

The output looks like the following.

```
{
    "ServiceSpecificCredential": {
        "CreateDate": "2019-10-09T16:12:04Z",
        "ServiceName": "cassandra.amazonaws.com",
        "ServiceUserName": "alice-at-111122223333",
        "ServicePassword": "wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY",
        "ServiceSpecificCredentialId": "ACCAYFI33SINPGJEBYESF",
        "UserName": "alice",
        "Status": "Active"
    }
```

```
}
```

In the output, note the values for `ServiceUserName` and `ServicePassword`. Save these values in a secure location, because you'll need them later.

> **Important**
>
> This is the only time that the `ServicePassword` will be available to you.

Create and configure AWS credentials for Amazon Keyspaces

To access Amazon Keyspaces programmatically with the AWS CLI, the AWS SDK, or with Cassandra client drivers and the SigV4 plugin, you need an IAM user with access keys. When you use Amazon Keyspaces programmatically, you provide your AWS access keys so that AWS can verify your identity in programmatic calls. Your access keys consist of an access key ID (for example, AKIAIOSFODNN7EXAMPLE) and a secret access key (for example, wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY). This topic walks you through the required steps in this process.

Security best practices recommend that you create IAM users with limited permissions and instead associate IAM roles with the permissions needed to perform specific tasks. IAM users can then temporarily assume IAM roles to perform the required tasks. For example, IAM users in your account using the Amazon Keyspaces console can switch to a role to temporarily use the permissions of the role in the console. The users give up their original permissions and take on the permissions assigned to the role. When the users exit the role, their original permissions are restored. The credentials the users use to assume the role are temporary. On the contrary, IAM users have long-term credentials, which presents a security risk if instead of assuming roles they have permissions directly assigned to them. To help mitigate this risk, we recommend that you provide these users with only the permissions they require to perform the task and that you remove these users when they are no longer needed. For more information about roles, see Common scenarios for roles: Users, applications, and services in the *IAM User Guide*.

Topics

- Credentials required by the AWS CLI, the AWS SDK, or the Amazon Keyspaces SigV4 plugin for Cassandra client drivers
- Create temporary credentials to connect to Amazon Keyspaces using an IAM role and the SigV4 plugin

- Create an IAM user for programmatic access to Amazon Keyspaces in your AWS account
- Create new access keys for an IAM user
- Store access keys for programmatic access

Credentials required by the AWS CLI, the AWS SDK, or the Amazon Keyspaces SigV4 plugin for Cassandra client drivers

The following credentials are required to authenticate the IAM user or role:

`AWS_ACCESS_KEY_ID`

Specifies an AWS access key associated with an IAM user or role.

The access key `aws_access_key_id` is required to connect to Amazon Keyspaces programmatically.

`AWS_SECRET_ACCESS_KEY`

Specifies the secret key associated with the access key. This is essentially the "password" for the access key.

The `aws_secret_access_key` is required to connect to Amazon Keyspaces programmatically.

`AWS_SESSION_TOKEN` – Optional

Specifies the session token value that is required if you are using temporary security credentials that you retrieved directly from AWS Security Token Service operations. For more information, see the section called “Create temporary credentials to connect to Amazon Keyspaces”.

If you are connecting with an IAM user, the `aws_session_token` is not required.

Create temporary credentials to connect to Amazon Keyspaces using an IAM role and the SigV4 plugin

The recommended way to access Amazon Keyspaces programmatically is by using temporary credentials to authenticate with the SigV4 plugin. In many scenarios, you don't need long-term access keys that never expire (as you have with an IAM user). Instead, you can create an IAM role and generate temporary security credentials. Temporary security credentials consist of an access key ID and a secret access key, but they also include a security token that indicates when the

credentials expire. To learn more about how to use IAM roles instead of long-term access keys, see Switching to an IAM role (AWS API).

To get started with temporary credentials, you first need to create an IAM role.

Create an IAM role that grants read-only access to Amazon Keyspaces

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, choose **Roles**, then **Create role**.
3. On the **Create role** page, under **Select type of trusted entity**, choose **AWS service**. Under **Choose a use case**, choose **Amazon EC2**, then choose **Next**.
4. On the **Add permissions** page, under **Permissions policies**, choose **Amazon Keyspaces Read Only Access** from the policy list, then choose **Next**.
5. On the **Name, review, and create** page, enter a name for the role, and review the **Select trusted entities** and **Add permissions** sections. You can also add optional tags for the role on this page. When you are done, select **Create role**. Remember this name because you'll need it when you launch your Amazon EC2 instance.

To use temporary security credentials in code, you programmatically call an AWS Security Token Service API like `AssumeRole` and extract the resulting credentials and session token from your IAM role that you created in the previous step. You then use those values as credentials for subsequent calls to AWS. The following example shows pseudocode for how to use temporary security credentials:

```
assumeRoleResult = AssumeRole(role-arn);
tempCredentials = new SessionAWSCredentials(
   assumeRoleResult.AccessKeyId,
   assumeRoleResult.SecretAccessKey,
   assumeRoleResult.SessionToken);
cassandraRequest = CreateAmazoncassandraClient(tempCredentials);
```

For an example that implements temporary credentials using the Python driver to access Amazon Keyspaces, see ???.

For details about how to call `AssumeRole`, `GetFederationToken`, and other API operations, see the AWS Security Token Service API Reference. For information on getting the temporary

security credentials and session token from the result, see the documentation for the SDK that you're working with. You can find the documentation for all the AWS SDKs on the main AWS documentation page, in the **SDKs and Toolkits** section.

Create an IAM user for programmatic access to Amazon Keyspaces in your AWS account

To obtain credentials for programmatic access to Amazon Keyspaces with the AWS CLI, the AWS SDK, or the SigV4 plugin, you need to first create an IAM user or role. The process of creating a IAM user and configuring that IAM user to have programmatic access to Amazon Keyspaces is shown in the following steps:

1. Create the user in the AWS Management Console, the AWS CLI, Tools for Windows PowerShell, or using an AWS API operation. If you create the user in the AWS Management Console, then the credentials are created automatically.
2. If you create the user programmatically, then you must create an access key (access key ID and a secret access key) for that user in an additional step.
3. Give the user permissions to access Amazon Keyspaces.

For information about the permissions that you need in order to create an IAM user, see Permissions required to access IAM resources.

Console

Create an IAM user with programmatic access (console)

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Users** and then choose **Add users**.
3. Type the user name for the new user. This is the sign-in name for AWS.

> **Note**
>
> User names can be a combination of up to 64 letters, digits, and these characters: plus (+), equal (=), comma (,), period (.), at sign (@), underscore (_), and hyphen (-). Names must be unique within an account. They are not distinguished by case. For example, you cannot create two users named *TESTUSER* and *testuser*.

4. Select **Access key - Programmatic access** to create an access key for the new user. You can view or download the access key when you get to the **Final** page.

   Choose **Next: Permissions**.

5. On the **Set permissions** page, choose **Attach existing policies directly** to assign permissions to the new user.

   This option displays the list of AWS managed and customer managed policies available in your account. You can enter `keyspaces` into the search field to display only the policies that are related to Amazon Keyspaces.

   For Amazon Keyspaces, the available managed policies are `AmazonKeyspacesFullAccess` and `AmazonKeyspacesReadOnlyAccess`. For more information about each policy, see the section called “AWS managed policies”.

   For testing purposes and to follow the connection tutorials, select the `AmazonKeyspacesReadOnlyAccess` policy for the new IAM user. **Note:** As a best practice, we recommend that you follow the principle of least privilege and create custom policies that limit access to specific resources and only allow the required actions. For more information about IAM policies and to view example policies for Amazon Keyspaces, see the section called “Amazon Keyspaces identity-based policies”. After you have created custom permission policies, attach your policies to roles and then let users assume the appropriate roles temporarily.

   Choose **Next: Tags**.

6. On the **Add tags (optional)** page you can add tags for the user, or choose **Next: Review**.

7. On the **Review** page you can see all of the choices you made up to this point. When you're ready to proceed, choose **Create user**.

8. To view the user's access keys (access key IDs and secret access keys), choose **Show** next to the password and access key. To save the access keys, choose **Download .csv** and then save the file to a safe location.

   > **Important**
   >
   > This is your only opportunity to view or download the secret access keys, and you need this information before they can use the SigV4 plugin. Save the user's new

access key ID and secret access key in a safe and secure place. You will not have access to the secret keys again after this step.

CLI

Create an IAM user with programmatic access (AWS CLI)

1. Create a user with the following AWS CLI code.
   - aws iam create-user
2. Give the user programmatic access. This requires access keys, that can be generated in the following ways.
   - AWS CLI: aws iam create-access-key
   - Tools for Windows PowerShell: New-IAMAccessKey
   - IAM API: CreateAccessKey

   Important

   This is your only opportunity to view or download the secret access keys, and you need this information before they can use the SigV4 plugin. Save the user's new access key ID and secret access key in a safe and secure place. You will not have access to the secret keys again after this step.
3. Attach the `AmazonKeyspacesReadOnlyAccess` policy to the user that defines the user's permissions. **Note:** As a best practice, we recommend that you manage user permissions by adding the user to a group and attaching a policy to the group instead of attaching directly to a user.
   - AWS CLI: aws iam attach-user-policy

Create new access keys for an IAM user

If you already have an IAM user, you can create new access keys at any time. For more information about key management, for example how to update access keys, see Managing access keys for IAM users.

To create access keys for an IAM user (console)

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Users**.
3. Choose the name of the user whose access keys you want to create.
4. On the **Summary** page of the user, choose the **Security credentials** tab.
5. In the **Access keys** section under **Access key best practices & alternatives**, choose the use case **Other**. Click **Next**, enter optional information as needed, and choose **Create access key**.

   To view the new access key pair, choose **Show**. Your credentials will look something like this:

   - Access key ID: AKIAIOSFODNN7EXAMPLE
   - Secret access key: wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY

   > **Note**
   >
   > You will not have access to the secret access key again after this dialog box closes.

   Consider the following best practices for the key pair that you've created.

   - Never store your access key in plain text, in a code repository, or in code.
   - Disable or delete access keys when no longer needed.
   - Enable least-privilege permissions.
   - Rotate access keys regularly.
6. To download the key pair, choose **Download .csv file**. Store the keys in a secure location.
7. After you download the .csv file, choose **Close**.

When you create an access key, the key pair is active by default, and you can use the pair right away.

Store access keys for programmatic access

As a best practice, we recommend that you don't embed access keys directly into code. The AWS SDKs and the AWS Command Line Tools enable you to put access keys in known locations so that you do not have to keep them in code. Put access keys in one of the following locations:

- **Environment variables** – On a multitenant system, choose user environment variables, not system environment variables.
- **CLI credentials file** – The `credentials` and `config` file are updated when you run the command `aws configure`. The `credentials` file is located at `~/.aws/credentials` on Linux, macOS, or Unix, or at `C:\Users\`*`USERNAME`*`\.aws\credentials` on Windows. This file can contain the credential details for the `default` profile and any named profiles.
- **CLI configuration file** – The `credentials` and `config` file are updated when you run the command `aws configure`. The `config` file is located at `~/.aws/config` on Linux, macOS, or Unix, or at `C:\Users\`*`USERNAME`*`\.aws\config` on Windows. This file contains the configuration settings for the default profile and any named profiles.

Storing access keys as environment variables is a prerequisite for the the section called "Authentication plugin for Java 4.x". Note that this includes the default AWS Region. The client searches for credentials using the default credentials provider chain, and access keys stored as environment variables take precedent over all other locations, for example configuration files. For more information, see Configuration settings and precedence.

The following examples show how you can configure environment variables for the default user.

Linux, macOS, or Unix

```
$ export AWS_ACCESS_KEY_ID=AKIAIOSFODNN7EXAMPLE
$ export AWS_SECRET_ACCESS_KEY=wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
$ export AWS_SESSION_TOKEN=AQoDYXdzEJr...<remainder of security token>
$ export AWS_DEFAULT_REGION=us-east-1
```

Setting the environment variable changes the value used until the end of your shell session, or until you set the variable to a different value. You can make the variables persistent across future sessions by setting them in your shell's startup script.

Windows Command Prompt

```
C:\> setx AWS_ACCESS_KEY_ID AKIAIOSFODNN7EXAMPLE
```

```
C:\> setx AWS_SECRET_ACCESS_KEY wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
C:\> setx AWS_SESSION_TOKEN AQoDYXdzEJr...<remainder of security token>
C:\> setx AWS_DEFAULT_REGION us-east-1
```

Using `set` to set an environment variable changes the value used until the end of the current command prompt session, or until you set the variable to a different value. Using `setx` to set an environment variable changes the value used in both the current command prompt session and all command prompt sessions that you create after running the command. It does ***not*** affect other command shells that are already running at the time you run the command.

PowerShell

```
PS C:\> $Env:AWS_ACCESS_KEY_ID="AKIAIOSFODNN7EXAMPLE"
PS C:\> $Env:AWS_SECRET_ACCESS_KEY="wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY"
PS C:\> $Env:AWS_SESSION_TOKEN="AQoDYXdzEJr...<remainder of security token>"
PS C:\> $Env:AWS_DEFAULT_REGION="us-east-1"
```

If you set an environment variable at the PowerShell prompt as shown in the previous examples, it saves the value for only the duration of the current session. To make the environment variable setting persistent across all PowerShell and Command Prompt sessions, store it by using the **System** application in **Control Panel**. Alternatively, you can set the variable for all future PowerShell sessions by adding it to your PowerShell profile. See the PowerShell documentation for more information about storing environment variables or persisting them across sessions.

Service endpoints for Amazon Keyspaces

Topics

- Ports and protocols
- Global endpoints
- AWS GovCloud (US) Region FIPS endpoints
- China Regions endpoints
- Streams endpoints
- Connecting to dual-stack endpoints

Ports and protocols

You can access Amazon Keyspaces programmatically by running a `cqlsh` client, with an Apache 2.0 licensed Cassandra driver, or by using the AWS CLI and the AWS SDK.

The following table shows the ports and protocols for the different access mechanisms.

Programmatic Access	Port	Protocol
CQLSH	9142	TLS
Cassandra Driver	9142	TLS
AWS CLI	443	HTTPS
AWS SDK	443	HTTPS

For TLS connections, Amazon Keyspaces uses certificates issued under Amazon Trust Services (Amazon Root CAs 1–4) to authenticate against the server. For more information, see the section called "How to manually configure `cqlsh` connections for TLS" or the Before you begin section of your driver in the the section called "Using a Cassandra client driver" chapter.

Global endpoints

Amazon Keyspaces supports both IPv4 and IPv6 public endpoints. You can choose between IPv4 endpoints and dual-stack endpoints. The endpoints use the following naming convention, where you can replace *`us-east-1`* with another available AWS Region from the table.

- **IPv4 endpoints** – `cassandra.`*`us-east-1`*`.amazonaws.com`
- **Dual-stack endpoints** – `cassandra.`*`us-east-1`*`.api.aws`

For more information about dual-stack endpoints and how to configure connections, see the section called "Connecting to dual-stack endpoints".

Amazon Keyspaces is available in the following Regions.

Region Name	Region	Endpoint	Protocol	
US East (Ohio)	us-east-2	cassandra.us-east-2.amazonaws.com cassandra.us-east-2.api.aws	HTTPS and TLS HTTPS and TLS	
US East (N. Virginia)	us-east-1	cassandra.us-east-1.amazonaws.com cassandra-fips.us-east-1.api.aws cassandra-fips.us-east-1.amazonaws.com cassandra.us-east-1.api.aws	HTTPS and TLS HTTPS and TLS HTTPS and TLS HTTPS and TLS	
US West (N. California)	us-west-1	cassandra.us-west-1.amazonaws.com cassandra.us-west-1.api.aws	HTTPS and TLS HTTPS and TLS	
US West (Oregon)	us-west-2	cassandra.us-west-2.amazonaws.com cassandra-fips.us-west-2.api.aws cassandra-fips.us-west-2.amazonaws.com cassandra.us-west-2.api.aws	HTTPS and TLS HTTPS and TLS HTTPS and TLS HTTPS and TLS	

Region Name	Region	Endpoint	Protocol
Africa (Cape Town)	af-south-1	cassandra.af-south-1.amazonaws.com cassandra.af-south-1.api.aws	HTTPS and TLS HTTPS and TLS
Asia Pacific (Hong Kong)	ap-east-1	cassandra.ap-east-1.amazonaws.com cassandra.ap-east-1.api.aws	HTTPS and TLS HTTPS and TLS
Asia Pacific (Hyderabad)	ap-south-2	cassandra.ap-south-2.api.aws	HTTPS and TLS
Asia Pacific (Jakarta)	ap-southeast-3	cassandra.ap-southeast-3.api.aws	HTTPS and TLS
Asia Pacific (Malaysia)	ap-southeast-5	cassandra.ap-southeast-5.amazonaws.com cassandra.ap-southeast-5.api.aws	HTTPS and TLS HTTPS and TLS
Asia Pacific (Melbourne)	ap-southeast-4	cassandra.ap-southeast-4.api.aws	HTTPS and TLS

Region Name	Region	Endpoint	Protocol	
Asia Pacific (Mumbai)	ap-south-1	cassandra.ap-south-1.amazonaws.com cassandra.ap-south-1.api.aws	HTTPS and TLS HTTPS and TLS	
Asia Pacific (New Zealand)	ap-southeast-6	cassandra.ap-southeast-6.api.aws	HTTPS and TLS	
Asia Pacific (Osaka)	ap-northeast-3	cassandra.ap-northeast-3.api.aws	HTTPS and TLS	
Asia Pacific (Seoul)	ap-northeast-2	cassandra.ap-northeast-2.amazonaws.com cassandra.ap-northeast-2.api.aws	HTTPS and TLS HTTPS and TLS	
Asia Pacific (Singapore)	ap-southeast-1	cassandra.ap-southeast-1.amazonaws.com cassandra.ap-southeast-1.api.aws	HTTPS and TLS HTTPS and TLS	
Asia Pacific (Sydney)	ap-southeast-2	cassandra.ap-southeast-2.amazonaws.com cassandra.ap-southeast-2.api.aws	HTTPS and TLS HTTPS and TLS	
Asia Pacific (Taipei)	ap-east-2	cassandra.ap-east-2.api.aws	HTTPS and TLS	

Region Name	Region	Endpoint	Protocol	
Asia Pacific (Thailand)	ap-southeast-7	cassandra.ap-southeast-7.amazonaws.com cassandra.ap-southeast-7.api.aws	HTTPS and TLS HTTPS and TLS	
Asia Pacific (Tokyo)	ap-northeast-1	cassandra.ap-northeast-1.amazonaws.com cassandra.ap-northeast-1.api.aws	HTTPS and TLS HTTPS and TLS	
Canada (Central)	ca-central-1	cassandra.ca-central-1.amazonaws.com cassandra.ca-central-1.api.aws	HTTPS and TLS HTTPS and TLS	
Canada West (Calgary)	ca-west-1	cassandra.ca-west-1.amazonaws.com cassandra.ca-west-1.api.aws	HTTPS and TLS HTTPS and TLS	
Europe (Frankfurt)	eu-central-1	cassandra.eu-central-1.amazonaws.com cassandra.eu-central-1.api.aws	HTTPS and TLS HTTPS and TLS	
Europe (Ireland)	eu-west-1	cassandra.eu-west-1.amazonaws.com cassandra.eu-west-1.api.aws	HTTPS and TLS HTTPS and TLS	

Region Name	Region	Endpoint	Protocol	
Europe (London)	eu-west-2	cassandra.eu-west-2.amazonaws.com cassandra.eu-west-2.api.aws	HTTPS and TLS HTTPS and TLS	
Europe (Milan)	eu-south-1	cassandra.eu-south-1.api.aws	HTTPS and TLS	
Europe (Paris)	eu-west-3	cassandra.eu-west-3.amazonaws.com cassandra.eu-west-3.api.aws	HTTPS and TLS HTTPS and TLS	
Europe (Spain)	eu-south-2	cassandra.eu-south-2.api.aws	HTTPS and TLS	
Europe (Stockholm)	eu-north-1	cassandra.eu-north-1.amazonaws.com cassandra.eu-north-1.api.aws	HTTPS and TLS HTTPS and TLS	
Europe (Zurich)	eu-central-2	cassandra.eu-central-2.api.aws	HTTPS and TLS	
Israel (Tel Aviv)	il-central-1	cassandra.il-central-1.api.aws	HTTPS and TLS	
Mexico (Central)	mx-central-1	cassandra.mx-central-1.api.aws	HTTPS and TLS	

Region Name	Region	Endpoint	Protocol	
Middle East (Bahrain)	me-south-1	cassandra.me-south-1.amazonaws.com cassandra.me-south-1.api.aws	HTTPS and TLS HTTPS and TLS	
Middle East (UAE)	me-central-1	cassandra.me-central-1.amazonaws.com cassandra.me-central-1.api.aws	HTTPS and TLS HTTPS and TLS	
South America (São Paulo)	sa-east-1	cassandra.sa-east-1.amazonaws.com cassandra.sa-east-1.api.aws	HTTPS and TLS HTTPS and TLS	
AWS GovCloud (US-East)	us-gov-east-1	cassandra.us-gov-east-1.amazonaws.com cassandra.us-gov-east-1.api.aws	HTTPS and TLS HTTPS and TLS	
AWS GovCloud (US-West)	us-gov-west-1	cassandra.us-gov-west-1.amazonaws.com cassandra.us-gov-west-1.api.aws	HTTPS and TLS HTTPS and TLS	

AWS GovCloud (US) Region FIPS endpoints

Available FIPS endpoints in the AWS GovCloud (US) Region. Amazon Keyspaces supports both IPv4 and IPv6 FIPS endpoints. You can choose between IPv4 endpoints and dual-stack endpoints. For more information, see Amazon Keyspaces in the *AWS GovCloud (US) User Guide*.

Region name	Region	FIPS endpoint IPv4	FIPS endpoint dual-stack	Protocol
AWS GovClou (US-East)	us-gov-east-1	cassandra.us-gov-east-1.amazonaws.com	cassandra.us-gov-east-1.api.aws	HTTPS and TLS
AWS GovClou (US-West)	us-gov-west-1	cassandra.us-gov-west-1.amazonaws.com	cassandra.us-gov-west-1.api.aws	HTTPS and TLS

China Regions endpoints

Amazon Keyspaces supports IPv4 endpoints in the AWS China Regions.

To access these endpoints, you have to sign up for a separate set of account credentials unique to the China Regions. For more information, see China Signup, Accounts, and Credentials.

Region name	Region	Endpoint	Protocol
China (Beijing)	cn-north-1	cassandra.cn-north-1.amazonaws.com.cn	HTTPS and TLS
China (Ningxia)	cn-northwest-1	cassandra.cn-northwest-1.amazonaws.com.cn	HTTPS and TLS

Streams endpoints

Amazon Keyspaces CDC streams is available in the following AWS Regions. This table shows the available dual-stack service endpoint for each Region. For more information about Amazon Keyspaces CDC streams, see the section called “Access CDC stream endpoints”.

Region Name	Region	Endpoint	Protocol	
US East (Ohio)	us-east-2	cassandra-streams.us-east-2.api.aws	HTTPS	
US East (N. Virginia)	us-east-1	cassandra-streams.us-east-1.api.aws	HTTPS	
US West (N. California)	us-west-1	cassandra-streams.us-west-1.api.aws	HTTPS	
US West (Oregon)	us-west-2	cassandra-streams.us-west-2.api.aws	HTTPS	
Africa (Cape Town)	af-south-1	cassandra-streams.af-south-1.api.aws	HTTPS	
Asia Pacific (Hong Kong)	ap-east-1	cassandra-streams.ap-east-1.api.aws	HTTPS	
Asia Pacific (Hyderabad)	ap-south-2	cassandra-streams.ap-south-2.api.aws	HTTPS	
Asia Pacific (Jakarta)	ap-southeast-3	cassandra-streams.ap-southeast-3.api.aws	HTTPS	
Asia Pacific	ap-southeast-5	cassandra-streams.ap-southeast-5.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
(Malaysia)				
Asia Pacific (Melbourne)	ap-southeast-4	cassandra-streams.ap-southeast-4.api.aws	HTTPS	
Asia Pacific (Mumbai)	ap-south-1	cassandra-streams.ap-south-1.api.aws	HTTPS	
Asia Pacific (New Zealand)	ap-southeast-6	cassandra-streams.ap-southeast-6.api.aws	HTTPS	
Asia Pacific (Osaka)	ap-northeast-3	cassandra-streams.ap-northeast-3.api.aws	HTTPS	
Asia Pacific (Seoul)	ap-northeast-2	cassandra-streams.ap-northeast-2.api.aws	HTTPS	
Asia Pacific (Singapore)	ap-southeast-1	cassandra-streams.ap-southeast-1.api.aws	HTTPS	
Asia Pacific (Sydney)	ap-southeast-2	cassandra-streams.ap-southeast-2.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
Asia Pacific (Taipei)	ap-east-2	cassandra-streams.ap-east-2.api.aws	HTTPS	
Asia Pacific (Thailand)	ap-southeast-7	cassandra-streams.ap-southeast-7.api.aws	HTTPS	
Asia Pacific (Tokyo)	ap-northeast-1	cassandra-streams.ap-northeast-1.api.aws	HTTPS	
Canada (Central)	ca-central-1	cassandra-streams.ca-central-1.api.aws	HTTPS	
Canada West (Calgary)	ca-west-1	cassandra-streams.ca-west-1.api.aws	HTTPS	
Europe (Frankfurt)	eu-central-1	cassandra-streams.eu-central-1.api.aws	HTTPS	
Europe (Ireland)	eu-west-1	cassandra-streams.eu-west-1.api.aws	HTTPS	
Europe (London)	eu-west-2	cassandra-streams.eu-west-2.api.aws	HTTPS	
Europe (Milan)	eu-south-1	cassandra-streams.eu-south-1.api.aws	HTTPS	
Europe (Paris)	eu-west-3	cassandra-streams.eu-west-3.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
Europe (Spain)	eu-south-2	cassandra-streams.eu-south-2.api.aws	HTTPS	
Europe (Stockholm)	eu-north-1	cassandra-streams.eu-north-1.api.aws	HTTPS	
Europe (Zurich)	eu-central-2	cassandra-streams.eu-central-2.api.aws	HTTPS	
Israel (Tel Aviv)	il-central-1	cassandra-streams.il-central-1.api.aws	HTTPS	
Mexico (Central)	mx-central-1	cassandra-streams.mx-central-1.api.aws	HTTPS	
Middle East (Bahrain)	me-south-1	cassandra-streams.me-south-1.api.aws	HTTPS	
Middle East (UAE)	me-central-1	cassandra-streams.me-central-1.api.aws	HTTPS	
South America (São Paulo)	sa-east-1	cassandra-streams.sa-east-1.api.aws	HTTPS	
AWS GovCloud (US-East)	us-gov-east-1	cassandra-streams.us-gov-east-1.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
AWS GovCloud (US-West)	us-gov-west-1	cassandra-streams.us-gov-west-1.api.aws	HTTPS	

Connecting to dual-stack endpoints

Amazon Keyspaces global endpoints are dual-stack endpoints that accept IPv4 and IPv6 requests.

When connecting to Amazon Keyspaces using IPv6, the service automatically adapts system table responses to match your connection protocol. This ensures that your applications receive consistent network address information matching their connection type. This provides accurate network topology information to the client while maintaining backward compatibility for existing CQL applications.

Amazon Keyspaces detects the network protocol (IPv4 or IPv6) used by your client connection automatically and adjusts the system table responses accordingly. This detection happens transparently during the initial connection handshake, requiring no additional configuration from the client application.

Amazon Keyspaces returns IP addresses based on your connection protocol. For example, a request from an IPv4 network returns the following response.

```
SELECT * FROM system.peers;
-- Returns IPv4 addresses in peer column
-- Example: 172.31.1.1, 172.31.1.2, etc.
```

A connection from an IPv6 network to a dual-stack endpoint, for example `cassandra.us-east-1.api.aws`, returns the following response.

```
SELECT * FROM system.peers;
-- Returns IPv6 addresses in peer column
-- Example: 2001:db8::1, 2001:db8::2, etc.
```

For more information about IPv6 support in Amazon Keyspaces, see the section called “IPv6 support in Amazon Keyspaces”.

IPv6 support in Amazon Keyspaces

IPv6 support in Amazon Keyspaces allows applications to establish connections using Internet Protocol version 6, the next-generation internet protocol that provides a vastly expanded address space compared to IPv4. The implementation uses dual-stack endpoints that support both IPv4 and IPv6 simultaneously, ensuring backward compatibility while enabling future-ready connectivity. For a list of endpoints, see the section called “Global endpoints”.

Amazon Keyspaces implements IPv6 support through a dual-stack architecture that maintains complete backward compatibility while enabling IPv6 connectivity.

DNS resolution in Amazon Keyspaces

When applications connect to dual-stack endpoints, the DNS resolution process returns both address types:

A Records (IPv4)

Traditional IPv4 addresses for backward compatibility

AAAA Records (IPv6)

New IPv6 addresses for modern connectivity

The client's operating system and network stack automatically select the most appropriate protocol based on local configuration, network availability, and system preferences.

The Cassandra Query Language (CQL) protocol seamlessly supports IPv6 connectivity without requiring application code changes.

Automatic protocol selection

- Applications specify the dual-stack endpoint
- Network stack chooses IPv4 or IPv6 based on availability
- No code modifications required for existing CQL applications

Driver compatibility

- All major CQL drivers support IPv6 transparently

- DataStax drivers handle IPv6 addresses natively
- Open-source drivers work without modification

Connection consistency

- System tables reflect the connection protocol used
- IPv6 connections show IPv6 addresses in `system.peers`
- IPv4 connections continue showing IPv4 addresses

Using `cqlsh` to connect to Amazon Keyspaces

To connect to Amazon Keyspaces using `cqlsh`, you can use the `cqlsh-expansion`. This is a toolkit that contains common Apache Cassandra tooling like `cqlsh` and helpers that are preconfigured for Amazon Keyspaces while maintaining full compatibility with Apache Cassandra. The `cqlsh-expansion` integrates the SigV4 authentication plugin and allows you to connect using IAM access keys instead of user name and password. You only need to install the `cqlsh` scripts to make a connection and not the full Apache Cassandra distribution, because Amazon Keyspaces is serverless. This lightweight install package includes the `cqlsh-expansion` and the classic `cqlsh` scripts that you can install on any platform that supports Python.

> **Note**
>
> `Murmur3Partitioner` is the recommended partitioner for Amazon Keyspaces and the `cqlsh-expansion`. The `cqlsh-expansion` doesn't support the Amazon Keyspaces `DefaultPartitioner`. For more information, see the section called “Working with partitioners”.

For general information about `cqlsh`, see `cqlsh: the CQL shell`.

Topics

- Using the cqlsh-expansion to connect to Amazon Keyspaces
- How to manually configure cqlsh connections for TLS

Using the `cqlsh-expansion` to connect to Amazon Keyspaces

Installing and configuring the `cqlsh-expansion`

1. To install the `cqlsh-expansion` Python package, you can run a `pip` command. This installs the `cqlsh-expansion` scripts on your machine using a *pip install* along with a file containing a list of dependencies. The `--user flag` tells `pip` to use the Python user install directory for your platform. On a Unix based system, that should be the `~/.local/` directory.

   You need Python 3 to install the `cqlsh-expansion`, to find out your Python version, use `Python --version`. To install, you can run the following command.

   ```
   python3 -m pip install --user cqlsh-expansion
   ```

   The output should look similar to this.

   ```
   Collecting cqlsh-expansion
     Downloading cqlsh_expansion-0.9.6-py3-none-any.whl (153 kB)
        ######################################## 153.7/153.7 KB 3.3 MB/s eta 0:00:00
   Collecting cassandra-driver
     Downloading cassandra_driver-3.28.0-cp310-cp310-
   manylinux_2_17_x86_64.manylinux2014_x86_64.whl (19.1 MB)
        ######################################## 19.1/19.1 MB 44.5 MB/s eta 0:00:00
   Requirement already satisfied: six>=1.12.0 in /usr/lib/python3/dist-packages (from
    cqlsh-expansion) (1.16.0)
   Collecting boto3
     Downloading boto3-1.29.2-py3-none-any.whl (135 kB)
        ######################################## 135.8/135.8 KB 17.2 MB/s eta 0:00:00
   Collecting cassandra-sigv4>=4.0.2
     Downloading cassandra_sigv4-4.0.2-py2.py3-none-any.whl (9.8 kB)
   Collecting botocore<1.33.0,>=1.32.2
     Downloading botocore-1.32.2-py3-none-any.whl (11.4 MB)
        ######################################## 11.4/11.4 MB 60.9 MB/s eta 0:00:00
   Collecting s3transfer<0.8.0,>=0.7.0
     Downloading s3transfer-0.7.0-py3-none-any.whl (79 kB)
        ######################################## 79.8/79.8 KB 13.1 MB/s eta 0:00:00
   Collecting jmespath<2.0.0,>=0.7.1
     Downloading jmespath-1.0.1-py3-none-any.whl (20 kB)
   Collecting geomet<0.3,>=0.1
     Downloading geomet-0.2.1.post1-py3-none-any.whl (18 kB)
   Collecting python-dateutil<3.0.0,>=2.1
   ```

```
  Downloading python_dateutil-2.8.2-py2.py3-none-any.whl (247 kB)
     ######################################## 247.7/247.7 KB 33.1 MB/s eta 0:00:00
Requirement already satisfied: urllib3<2.1,>=1.25.4 in /usr/lib/python3/dist-
packages (from botocore<1.33.0,>=1.32.2->boto3->cqlsh-expansion) (1.26.5)
Requirement already satisfied: click in /usr/lib/python3/dist-packages (from
 geomet<0.3,>=0.1->cassandra-driver->cqlsh-expansion) (8.0.3)
Installing collected packages: python-dateutil, jmespath, geomet, cassandra-driver,
 botocore, s3transfer, boto3, cassandra-sigv4, cqlsh-expansion
  WARNING: The script geomet is installed in '/home/ubuntu/.local/bin' which is not
 on PATH.
  Consider adding this directory to PATH or, if you prefer to suppress this
 warning, use --no-warn-script-location.
  WARNING: The scripts cqlsh, cqlsh-expansion and cqlsh-expansion.init are
 installed in '/home/ubuntu/.local/bin' which is not on PATH.
  Consider adding this directory to PATH or, if you prefer to suppress this
 warning, use --no-warn-script-location.
Successfully installed boto3-1.29.2 botocore-1.32.2 cassandra-driver-3.28.0
 cassandra-sigv4-4.0.2 cqlsh-expansion-0.9.6 geomet-0.2.1.post1 jmespath-1.0.1
 python-dateutil-2.8.2 s3transfer-0.7.0
```

If the install directory is not in the PATH, you need to add it following the instructions of your operating system. Below is one example for Ubuntu Linux.

```
export PATH="$PATH:/home/ubuntu/.local/bin"
```

To confirm that the package is installed, you can run the following command.

```
cqlsh-expansion --version
```

The output should look like this.

```
cqlsh 6.1.0
```

2. To configure the `cqlsh-expansion`, you can run a post-install script to automatically complete the following steps:

   1. Create the `.cassandra` directory in the user home directory if it doesn't already exist.
   2. Copy a preconfigured `cqlshrc` configuration file into the `.cassandra` directory.
   3. Copy the combined certificate file into the `.cassandra` directory. Amazon Keyspaces uses this certificate to configure the secure connection with Transport Layer Security (TLS).

Encryption in transit provides an additional layer of data protection by encrypting your data as it travels to and from Amazon Keyspaces. For more information about certificates, see the section called "How to manually configure `cqlsh` connections for TLS".

To review the script first, you can access it in the Github repo at `post_install.py`.

To use the script, you can run the following command.

```
cqlsh-expansion.init
```

> **Note**
>
> The directory and file created by the post-install script are not removed when you uninstall the `cqlsh-expansion` using `pip uninstall`, and have to be deleted manually.

Connecting to Amazon Keyspaces using the `cqlsh-expansion`

1. Configure your AWS Region and add it as a user environment variable.

   To add your default Region as an environment variable on a Unix based system, you can run the following command. For this example, we use `us-east-1`.

   ```
   export AWS_DEFAULT_REGION=us-east-1
   ```

   For more information about how to set environment variables, including for other platforms, see How to set environment variables.

2. Find your service endpoint.

   Choose the appropriate service endpoint for your Region. To review the available endpoints for Amazon Keyspaces, see the section called "Service endpoints". For this example, we use the endpoint `cassandra.us-east-1.amazonaws.com`.

3. Configure the authentication method.

   Connecting with IAM access keys (IAM users, roles, and federated identities) is the recommended method for enhanced security.

Before you can connect with IAM access keys, you need to complete the following steps:

a. Create an IAM user, or follow the best practice and create an IAM role that IAM users can assume. For more information on how to create IAM access keys, see the section called "Create IAM credentials for AWS authentication".

b. Create an IAM policy that grants the role (or IAM user) at least read-only access to Amazon Keyspaces. For more information about the permissions required for the IAM user or role to connect to Amazon Keyspaces, see the section called "Accessing Amazon Keyspaces tables".

c. Add the access keys of the IAM user to the user's environment variables as shown in the following example.

```
export AWS_ACCESS_KEY_ID=AKIAIOSFODNN7EXAMPLE
export AWS_SECRET_ACCESS_KEY=wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
```

For more information about how to set environment variables, including for other platforms, see How to set environment variables.

> **Note**
>
> If you're connecting from an Amazon EC2 instance, you also need to configure an outbound rule in the security group that allows traffic from the instance to Amazon Keyspaces. For more information about how to view and edit EC2 outbound rules, see Add rules to a security group in the Amazon EC2 User Guide.

4. Connect to Amazon Keyspaces using the `cqlsh-expansion` and SigV4 authentication.

To connect to Amazon Keyspaces with the `cqlsh-expansion`, you can use the following command. Make sure to replace the service endpoint with the correct endpoint for your Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

If the connection is successful, you should see output similar to the following example.

```
Connected to Amazon Keyspaces at cassandra.us-east-1.amazonaws.com:9142
[cqlsh 6.1.0 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
```

```
Use HELP for help.
cqlsh current consistency level is ONE.
cqlsh>
```

If you encounter a connection error, see the section called “Cqlsh connection errors” for troubleshooting information.

- Connect to Amazon Keyspaces with service-specific credentials.

  To connect with the traditional username and password combination that Cassandra uses for authentication, you must first create service-specific credentials for Amazon Keyspaces as described in the section called “Create service-specific credentials”. You also have to give that user permissions to access Amazon Keyspaces, for more information see the section called “Accessing Amazon Keyspaces tables”.

  After you have created service-specific credentials and permissions for the user, you must update the `cqlshrc` file, typically found in the user directory path `~/.cassandra/`. In the `cqlshrc` file, go to the Cassandra `[authentication]` section and comment out the SigV4 module and class under `[auth_provider]` using the ";" character as shown in the following example.

  ```
  [auth_provider]

  ; module = cassandra_sigv4.auth

  ; classname = SigV4AuthProvider
  ```

  After you have updated the `cqlshrc` file, you can connect to Amazon Keyspaces with service-specific credentials using the following command.

  ```
  cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 -u myUserName -
  p myPassword --ssl
  ```

Cleanup

- To remove the `cqlsh-expansion` package you can use the `pip uninstall` command.

  ```
  pip3 uninstall cqlsh-expansion
  ```

The `pip3 uninstall` command doesn't remove the directory and related files created by the post-install script. To remove the folder and files created by the post-install script, you can delete the `.cassandra` directory.

How to manually configure `cqlsh` connections for TLS

Amazon Keyspaces only accepts secure connections using Transport Layer Security (TLS). You can use the `cqlsh-expansion` utility that automatically downloads the certificates for you and installs a preconfigured `cqlshrc` configuration file. For more information, see the section called "Using the `cqlsh-expansion`" on this page.

If you want to download the certificates and configure the connection manually, you can do so using the following steps.

1. Download the following digital certificates and save the files locally or in your home directory.
   a. AmazonRootCA1
   b. AmazonRootCA2
   c. AmazonRootCA3
   d. AmazonRootCA4
   e. Starfield Class 2 Root (optional – for backward compatibility)

   To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

> **Note**
>
> Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

2. Combine all downloaded certificates into a single pem file with the name *keyspaces-bundle.pem* in our examples. You can do this by running the following command. Take note of the path to the file, you need this later.

```
cat AmazonRootCA1.pem \
 AmazonRootCA2.pem \
 AmazonRootCA3.pem \
 AmazonRootCA4.pem \
 sf-class2-root.crt \
 > keyspaces-bundle.pem
```

3. Open the `cqlshrc` configuration file in the Cassandra home directory, for example `${HOME}/.cassandra/cqlshrc` and add the following lines.

```
[connection]
port = 9142
factory = cqlshlib.ssl.ssl_transport_factory

[ssl]
validate = true
certfile =  path_to_file/keyspaces-bundle.pem
```

Using the AWS CLI to connect to Amazon Keyspaces

You can use the AWS Command Line Interface (AWS CLI) to control multiple AWS services from the command line and automate them through scripts. With Amazon Keyspaces you can use the AWS CLI for data definition language (DDL) operations, such as creating a table. In addition, you can use infrastructure as code (IaC) services and tools such as AWS CloudFormation and Terraform.

Before you can use the AWS CLI with Amazon Keyspaces, you must get an access key ID and secret access key. For more information, see the section called “Create IAM credentials for AWS authentication”.

For a complete listing of all the commands available for Amazon Keyspaces in the AWS CLI, see the *AWS CLI Command Reference*.

Topics

- Downloading and Configuring the AWS CLI
- Using the AWS CLI with Amazon Keyspaces

Downloading and Configuring the AWS CLI

The AWS CLI is available at https://aws.amazon.com/cli. It runs on Windows, macOS, or Linux. After downloading the AWS CLI, follow these steps to install and configure it:

1. Go to the AWS Command Line Interface User Guide
2. Follow the instructions for Installing the AWS CLI and Configuring the AWS CLI

Using the AWS CLI with Amazon Keyspaces

The command line format consists of a Amazon Keyspaces operation name followed by the parameters for that operation. The AWS CLI supports a shorthand syntax for the parameter values, as well as JSON. The following Amazon Keyspaces examples use AWS CLI shorthand syntax. For more information, see Using shorthand syntax with the AWS CLI.

The following command creates a keyspace with the name *catalog*.

```
aws keyspaces create-keyspace --keyspace-name 'catalog'
```

The command returns the resource Amazon Resource Name (ARN) in the output.

```
{
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/"
}
```

To confirm that the keyspace *catalog* exists, you can use the following command.

```
aws keyspaces get-keyspace --keyspace-name 'catalog'
```

The output of the command returns the following values.

```
{
    "keyspaceName": "catalog",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/"
}
```

The following command creates a table with the name *book_awards*. The partition key of the table consists of the columns `year` and `award` and the clustering key consists of the columns

`category` and `rank`, both clustering columns use the ascending sort order. (For easier readability, long commands in this section are broken into separate lines.)

```
aws keyspaces create-table --keyspace-name 'catalog' --table-name 'book_awards'
            --schema-definition 'allColumns=[{name=year,type=int},
{name=award,type=text},{name=rank,type=int},
            {name=category,type=text}, {name=author,type=text},
{name=book_title,type=text},{name=publisher,type=text}],
            partitionKeys=[{name=year},
{name=award}],clusteringKeys=[{name=category,orderBy=ASC},{name=rank,orderBy=ASC}]'
```

This command results in the following output.

```
{
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/table/
book_awards"
}
```

To confirm the metadata and properties of the table, you can use the following command.

```
aws keyspaces get-table --keyspace-name 'catalog' --table-name 'book_awards'
```

This command returns the following output.

```
{
    "keyspaceName": "catalog",
    "tableName": "book_awards",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/table/
book_awards",
    "creationTimestamp": 1645564368.628,
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "year",
                "type": "int"
            },
            {
                "name": "award",
                "type": "text"
            },
            {
```

```
                "name": "category",
                "type": "text"
            },
            {
                "name": "rank",
                "type": "int"
            },
            {
                "name": "author",
                "type": "text"
            },
            {
                "name": "book_title",
                "type": "text"
            },
            {
                "name": "publisher",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "year"
            },
            {
                "name": "award"
            }
        ],
        "clusteringKeys": [
            {
                "name": "category",
                "orderBy": "ASC"
            },
            {
                "name": "rank",
                "orderBy": "ASC"
            }
        ],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": 1645564368.628
    },
```

```
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    }
}
```

When creating tables with complex schemas, it can be helpful to load the table's schema definition from a JSON file. The following is an example of this. Download the schema definition example JSON file from schema_definition.zip and extract `schema_definition.json`, taking note of the path to the file. In this example, the schema definition JSON file is located in the current directory. For different file path options, see How to load parameters from a file.

```
aws keyspaces create-table --keyspace-name 'catalog'
            --table-name 'book_awards' --schema-definition 'file://
schema_definition.json'
```

The following examples show how to create a simple table with the name *myTable* with additional options. Note that the commands are broken down into separate rows to improve readability. This command shows how to create a table and:

- set the capacity mode of the table
- enable Point-in-time recovery for the table
- set the default Time to Live (TTL) value for the table to one year
- add two tags for the table

```
aws keyspaces create-table --keyspace-name 'catalog' --table-name 'myTable'
            --schema-definition 'allColumns=[{name=id,type=int},{name=name,type=text},
{name=date,type=timestamp}],partitionKeys=[{name=id}]'
            --capacity-specification
 'throughputMode=PROVISIONED,readCapacityUnits=5,writeCapacityUnits=5'
```

```
            --point-in-time-recovery 'status=ENABLED'
            --default-time-to-live '31536000'
            --tags 'key=env,value=test' 'key=dpt,value=sec'
```

This example shows how to create a new table that uses a customer managed key for encryption and has TTL enabled to allow you to set expiration dates for columns and rows. To run this sample, you must replace the resource ARN for the customer managed AWS KMS key with your own key and ensure Amazon Keyspaces has access to it.

```
aws keyspaces create-table --keyspace-name 'catalog' --table-name 'myTable'
            --schema-definition 'allColumns=[{name=id,type=int},{name=name,type=text},
{name=date,type=timestamp}],partitionKeys=[{name=id}]'
            --encryption-specification
 'type=CUSTOMER_MANAGED_KMS_KEY,kmsKeyIdentifier=arn:aws:kms:us-
east-1:111122223333:key/11111111-2222-3333-4444-555555555555'
            --ttl 'status=ENABLED'
```

Using the API to connect to Amazon Keyspaces

You can use the AWS SDK and the AWS Command Line Interface (AWS CLI) to work interactively with Amazon Keyspaces. You can use the API for data language definition (DDL) operations, such as creating a keyspace or a table. In addition, you can use infrastructure as code (IaC) services and tools such as AWS CloudFormation and Terraform.

Before you can use the AWS CLI with Amazon Keyspaces, you must get an access key ID and secret access key. For more information, see the section called “Create IAM credentials for AWS authentication”.

For a complete listing of all operations available for Amazon Keyspaces in the API, see *Amazon Keyspaces API Reference*.

Using a Cassandra client driver to access Amazon Keyspaces programmatically

You can use many third-party, open-source Cassandra drivers to connect to Amazon Keyspaces. Amazon Keyspaces is compatible with Cassandra drivers that support Apache Cassandra version 3.11.2. These are the drivers and latest versions that we’ve tested and recommend to use with Amazon Keyspaces:

- `Java v3.3`
- `Java v4.17`
- `Python Cassandra-driver 3.29.1`
- `Node.js cassandra driver -v 4.7.2`
- `GO using GOCQL v1.6`
- `.NET CassandraCSharpDriver -v 3.20.1`

For more information about Cassandra drivers, see Apache Cassandra Client drivers.

> **Note**
>
> To help you get started, you can view and download end-to-end code examples that establish connections to Amazon Keyspaces with popular drivers. See Amazon Keyspaces examples on GitHub.

The tutorials in this chapter include a simple CQL query to confirm that the connection to Amazon Keyspaces has been successfully established. To learn how to work with keyspaces and tables after you connect to an Amazon Keyspaces endpoint, see *CQL language reference*. For a step-by-step tutorial that shows how to connect to Amazon Keyspaces from an Amazon VPC endpoint, see the section called "Connecting with VPC endpoints".

Topics

- Using a Cassandra Java client driver to access Amazon Keyspaces programmatically
- Using a Cassandra Python client driver to access Amazon Keyspaces programmatically
- Using a Cassandra Node.js client driver to access Amazon Keyspaces programmatically
- Using a Cassandra .NET Core client driver to access Amazon Keyspaces programmatically
- Using a Cassandra Go client driver to access Amazon Keyspaces programmatically
- Using a Cassandra Perl client driver to access Amazon Keyspaces programmatically

Using a Cassandra Java client driver to access Amazon Keyspaces programmatically

This section shows you how to connect to Amazon Keyspaces by using a Java client driver.

> **Note**
>
> Java 17 and the DataStax Java Driver 4.17 are currently only in Beta support. For more information, see https://docs.datastax.com/en/developer/java-driver/4.17/upgrade_guide/.

To provide users and applications with credentials for programmatic access to Amazon Keyspaces resources, you can do either of the following:

- Create service-specific credentials that are associated with a specific AWS Identity and Access Management (IAM) user.
- For enhanced security, we recommend to create IAM access keys for IAM identities that are used across all AWS services. The Amazon Keyspaces SigV4 authentication plugin for Cassandra client drivers enables you to authenticate calls to Amazon Keyspaces using IAM access keys instead of user name and password. For more information, see the section called “Create IAM credentials for AWS authentication”.

> **Note**
>
> For an example how to use Amazon Keyspaces with Spring Boot, see https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/java/datastax-v4/spring.

Topics

- Before you begin
- Step-by-step tutorial to connect to Amazon Keyspaces using the DataStax Java driver for Apache Cassandra using service-specific credentials
- Step-by-step tutorial to connect to Amazon Keyspaces using the 4.x DataStax Java driver for Apache Cassandra and the SigV4 authentication plugin
- Connect to Amazon Keyspaces using the 3.x DataStax Java driver for Apache Cassandra and the SigV4 authentication plugin

Before you begin

To connect to Amazon Keyspaces, you need to complete the following tasks before you can start.

1. Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients.

   a. Download the following digital certificates and save the files locally or in your home directory.

      1. AmazonRootCA1
      2. AmazonRootCA2
      3. AmazonRootCA3
      4. AmazonRootCA4
      5. Starfield Class 2 Root (optional – for backward compatibility)

      To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

      Note

      Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

   b. Convert the digital certificates into trustStore files and add them to the keystore.

```
openssl x509 -outform der -in AmazonRootCA1.pem -out temp_file.der
keytool -import -alias amazon-root-ca-1 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in AmazonRootCA2.pem -out temp_file.der
keytool -import -alias amazon-root-ca-2 -keystore cassandra_truststore.jks -
file temp_file.der
```

```
openssl x509 -outform der -in AmazonRootCA3.pem -out temp_file.der
keytool -import -alias amazon-root-ca-3 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in AmazonRootCA4.pem -out temp_file.der
keytool -import -alias amazon-root-ca-4 -keystore cassandra_truststore.jks -
file temp_file.der

openssl x509 -outform der -in sf-class2-root.crt -out temp_file.der
keytool -import -alias cassandra -keystore cassandra_truststore.jks -file
 temp_file.der
```

In the last step, you need to create a password for the keystore and trust each certificate. The interactive command looks like this.

```
Enter keystore password:
Re-enter new password:
Owner: CN=Amazon Root CA 1, O=Amazon, C=US
Issuer: CN=Amazon Root CA 1, O=Amazon, C=US
Serial number: 66c9fcf99bf8c0a39e2f0788a43e696365bca
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sun Jan 17 00:00:00 UTC 2038
Certificate fingerprints:
     SHA1: 8D:A7:F9:65:EC:5E:FC:37:91:0F:1C:6E:59:FD:C1:CC:6A:6E:DE:16
     SHA256:
 8E:CD:E6:88:4F:3D:87:B1:12:5B:A3:1A:C3:FC:B1:3D:70:16:DE:7F:57:CC:90:4F:E1:CB:97:C6:AE
Signature algorithm name: SHA256withRSA
Subject Public Key Algorithm: 2048-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]
```

```
#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: 84 18 CC 85 34 EC BC 0C   94 94 2E 08 59 9C C7 B2  ....4.......Y...
0010: 10 4E 0A 08                                        .N..
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: CN=Amazon Root CA 2, O=Amazon, C=US
Issuer: CN=Amazon Root CA 2, O=Amazon, C=US
Serial number: 66c9fd29635869f0a0fe58678f85b26bb8a37
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: 5A:8C:EF:45:D7:A6:98:59:76:7A:8C:8B:44:96:B5:78:CF:47:4B:1A
     SHA256:
 1B:A5:B2:AA:8C:65:40:1A:82:96:01:18:F8:0B:EC:4F:62:30:4D:83:CE:C4:71:3A:19:C3:9C:01:1E
Signature algorithm name: SHA384withRSA
Subject Public Key Algorithm: 4096-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: B0 0C F0 4C 30 F4 05 58   02 48 FD 33 E5 52 AF 4B  ...L0..X.H.3.R.K
0010: 84 E3 66 52                                        ..fR
```

```
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: CN=Amazon Root CA 3, O=Amazon, C=US
Issuer: CN=Amazon Root CA 3, O=Amazon, C=US
Serial number: 66c9fd5749736663f3b0b9ad9e89e7603f24a
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: 0D:44:DD:8C:3C:8C:1A:1A:58:75:64:81:E9:0F:2E:2A:FF:B3:D2:6E
     SHA256:
 18:CE:6C:FE:7B:F1:4E:60:B2:E3:47:B8:DF:E8:68:CB:31:D0:2E:BB:3A:DA:27:15:69:F5:03:43:B4
Signature algorithm name: SHA256withECDSA
Subject Public Key Algorithm: 256-bit EC (secp256r1) key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: AB B6 DB D7 06 9E 37 AC   30 86 07 91 70 C7 9C C4  ......7.0...p...
0010: 19 B1 78 C0                                        ..x.
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
```

```
Owner: CN=Amazon Root CA 4, O=Amazon, C=US
Issuer: CN=Amazon Root CA 4, O=Amazon, C=US
Serial number: 66c9fd7c1bb104c2943e5717b7b2cc81ac10e
Valid from: Tue May 26 00:00:00 UTC 2015 until: Sat May 26 00:00:00 UTC 2040
Certificate fingerprints:
     SHA1: F6:10:84:07:D6:F8:BB:67:98:0C:C2:E2:44:C2:EB:AE:1C:EF:63:BE
     SHA256:
 E3:5D:28:41:9E:D0:20:25:CF:A6:90:38:CD:62:39:62:45:8D:A5:C6:95:FB:DE:A3:C2:2B:0B:FB:25
Signature algorithm name: SHA384withECDSA
Subject Public Key Algorithm: 384-bit EC (secp384r1) key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  DigitalSignature
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: D3 EC C7 3A 65 6E CC E1   DA 76 9A 56 FB 9C F3 86  ...:en...v.V....
0010: 6D 57 E5 81                                        mW..
]
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
Enter keystore password:
Owner: OU=Starfield Class 2 Certification Authority, O="Starfield Technologies,
 Inc.", C=US
Issuer: OU=Starfield Class 2 Certification Authority, O="Starfield
 Technologies, Inc.", C=US
Serial number: 0
Valid from: Tue Jun 29 17:39:16 UTC 2004 until: Thu Jun 29 17:39:16 UTC 2034
```

```
Certificate fingerprints:
     SHA1: AD:7E:1C:28:B0:64:EF:8F:60:03:40:20:14:C3:D0:E3:37:0E:B5:8A
     SHA256:
 14:65:FA:20:53:97:B8:76:FA:A6:F0:A9:95:8E:55:90:E4:0F:CC:7F:AA:4F:B7:C2:C8:67:75:21:FB
Signature algorithm name: SHA1withRSA (weak)
Subject Public Key Algorithm: 2048-bit RSA key
Version: 3

Extensions:

#1: ObjectId: 2.5.29.35 Criticality=false
AuthorityKeyIdentifier [
KeyIdentifier [
0000: BF 5F B7 D1 CE DD 1F 86   F4 5B 55 AC DC D7 10 C2  ._.......[U.....
0010: 0E A9 88 E7                                        ....
]
[OU=Starfield Class 2 Certification Authority, O="Starfield Technologies,
 Inc.", C=US]
SerialNumber: [    00]
]

#2: ObjectId: 2.5.29.19 Criticality=false
BasicConstraints:[
  CA:true
  PathLen:2147483647
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: BF 5F B7 D1 CE DD 1F 86   F4 5B 55 AC DC D7 10 C2  ._.......[U.....
0010: 0E A9 88 E7                                        ....
]
]


Warning:
The input uses the SHA1withRSA signature algorithm which is considered a
 security risk. This algorithm will be disabled in a future update.

Trust this certificate? [no]:  yes
Certificate was added to keystore
```

2. Attach the trustStore file in the JVM arguments:

```
-Djavax.net.ssl.trustStore=path_to_file/cassandra_truststore.jks
-Djavax.net.ssl.trustStorePassword=my_password
```

Step-by-step tutorial to connect to Amazon Keyspaces using the DataStax Java driver for Apache Cassandra using service-specific credentials

The following step-by-step tutorial walks you through connecting to Amazon Keyspaces using a Java driver for Cassandra using service-specific credentials. Specifically, you'll use the 4.0 version of the DataStax Java driver for Apache Cassandra.

Topics

- Step 1: Prerequisites
- Step 2: Configure the driver
- Step 3: Run the sample application

Step 1: Prerequisites

To follow this tutorial, you need to generate service-specific credentials and add the DataStax Java driver for Apache Cassandra to your Java project.

- Generate service-specific credentials for your Amazon Keyspaces IAM user by completing the steps in the section called “Create service-specific credentials”. If you prefer to use IAM access keys for authentication, see the section called “Authentication plugin for Java 4.x”.
- Add the DataStax Java driver for Apache Cassandra to your Java project. Ensure that you're using a version of the driver that supports Apache Cassandra 3.11.2. For more information, see the DataStax Java driver for Apache Cassandra documentation.

Step 2: Configure the driver

You can specify settings for the DataStax Java Cassandra driver by creating a configuration file for your application. This configuration file overrides the default settings and tells the driver to connect to the Amazon Keyspaces service endpoint using port 9142. For a list of available service endpoints, see the section called “Service endpoints”.

Create a configuration file and save the file in the application's resources folder—for example, `src/main/resources/application.conf`. Open `application.conf` and add the following configuration settings.

1. **Authentication provider** – Create the authentication provider with the `PlainTextAuthProvider` class. *`ServiceUserName`* and *`ServicePassword`* should match the user name and password you obtained when you generated the service-specific credentials by following the steps in Create service-specific credentials for programmatic access to Amazon Keyspaces.

   > **Note**
   >
   > You can use short-term credentials by using the authentication plugin for the DataStax Java driver for Apache Cassandra instead of hardcoding credentials in your driver configuration file. To learn more, follow the instructions for the the section called "Authentication plugin for Java 4.x".

2. **Local data center** – Set the value for `local-datacenter` to the Region you're connecting to. For example, if the application is connecting to `cassandra.us-east-2.amazonaws.com`, then set the local data center to `us-east-2`. For all available AWS Regions, see ???. Set `slow-replica-avoidance = false` to load balance against fewer nodes.
3. **SSL/TLS** – Initialize the SSLEngineFactory by adding a section in the configuration file with a single line that specifies the class with `class = DefaultSslEngineFactory`. Provide the path to the trustStore file and the password that you created previously. Amazon Keyspaces doesn't support `hostname-validation` of peers, so set this option to false.

```
datastax-java-driver {

    basic.contact-points = [ "cassandra.us-east-2.amazonaws.com:9142"]
    advanced.auth-provider{
        class = PlainTextAuthProvider
        username = "ServiceUserName"
        password = "ServicePassword"
    }
    basic.load-balancing-policy {
        local-datacenter = "us-east-2"
        slow-replica-avoidance = false
    }
```

```
    advanced.ssl-engine-factory {
        class = DefaultSslEngineFactory
        truststore-path = "./src/main/resources/cassandra_truststore.jks"
        truststore-password = "my_password"
        hostname-validation = false
      }
}
```

Note

Instead of adding the path to the trustStore in the configuration file, you can also add the trustStore path directly in the application code or you can add the path to the trustStore to your JVM arguments.

Step 3: Run the sample application

This code example shows a simple command line application that creates a connection pool to Amazon Keyspaces by using the configuration file we created earlier. It confirms that the connection is established by running a simple query.

```
package <your package>;
// add the following imports to your project
import com.datastax.oss.driver.api.core.CqlSession;
import com.datastax.oss.driver.api.core.config.DriverConfigLoader;
import com.datastax.oss.driver.api.core.cql.ResultSet;
import com.datastax.oss.driver.api.core.cql.Row;

public class App
{

    public static void main( String[] args )
    {
        //Use DriverConfigLoader to load your configuration file
        DriverConfigLoader loader =
 DriverConfigLoader.fromClasspath("application.conf");
        try (CqlSession session = CqlSession.builder()
                .withConfigLoader(loader)
                .build()) {

            ResultSet rs = session.execute("select * from system_schema.keyspaces");
```

```
            Row row = rs.one();
            System.out.println(row.getString("keyspace_name"));
        }
    }
}
```

Note

Use a `try` block to establish the connection to ensure that it's always closed. If you don't use a `try` block, remember to close your connection to avoid leaking resources.

Step-by-step tutorial to connect to Amazon Keyspaces using the 4.x DataStax Java driver for Apache Cassandra and the SigV4 authentication plugin

The following section describes how to use the SigV4 authentication plugin for the open-source 4.x DataStax Java driver for Apache Cassandra to access Amazon Keyspaces (for Apache Cassandra). The plugin is available from the GitHub repository.

The SigV4 authentication plugin allows you to use IAM credentials for users or roles when connecting to Amazon Keyspaces. Instead of requiring a user name and password, this plugin signs API requests using access keys. For more information, see the section called “Create IAM credentials for AWS authentication”.

Step 1: Prerequisites

To follow this tutorial, you need to complete the following tasks.

- If you haven't already done so, create credentials for your IAM user or role following the steps at the section called “Create IAM credentials for AWS authentication”. This tutorial assumes that the access keys are stored as environment variables. For more information, see the section called “Manage access keys”.
- Add the DataStax Java driver for Apache Cassandra to your Java project. Ensure that you're using a version of the driver that supports Apache Cassandra 3.11.2. For more information, see the DataStax Java Driver for Apache Cassandra documentation.
- Add the authentication plugin to your application. The authentication plugin supports version 4.x of the DataStax Java driver for Apache Cassandra. If you’re using Apache Maven, or a build system that can use Maven dependencies, add the following dependencies to your `pom.xml` file.

Important

Replace the version of the plugin with the latest version as shown at GitHub repository.

```
<dependency>
        <groupId>software.aws.mcs</groupId>
        <artifactId>aws-sigv4-auth-cassandra-java-driver-plugin</artifactId>
        <version>4.0.9</version>
</dependency>
```

Step 2: Configure the driver

You can specify settings for the DataStax Java Cassandra driver by creating a configuration file for your application. This configuration file overrides the default settings and tells the driver to connect to the Amazon Keyspaces service endpoint using port 9142. For a list of available service endpoints, see the section called "Service endpoints".

Create a configuration file and save the file in the application's resources folder—for example, `src/main/resources/application.conf`. Open `application.conf` and add the following configuration settings.

1. **Authentication provider** – Set the `advanced.auth-provider.class` to a new instance of `software.aws.mcs.auth.SigV4AuthProvider`. The SigV4AuthProvider is the authentication handler provided by the plugin for performing SigV4 authentication.
2. **Local data center** – Set the value for `local-datacenter` to the Region you're connecting to. For example, if the application is connecting to `cassandra.us-east-2.amazonaws.com`, then set the local data center to `us-east-2`. For all available AWS Regions, see ???. Set `slow-replica-avoidance = false` to load balance against all available nodes.
3. **Idempotence** – Set the default `idempotence` for the application to `true` to configure the driver to always retry failed read/write/prepare/execute requests. This is a best practice for distributed applications that helps to handle transient failures by retrying failed requests.
4. **SSL/TLS** – Initialize the SSLEngineFactory by adding a section in the configuration file with a single line that specifies the class with `class = DefaultSslEngineFactory`. Provide the path to the trustStore file and the password that you created previously. Amazon Keyspaces doesn't support `hostname-validation` of peers, so set this option to false.

5. **Connections** – Create at least 3 local connections per endpoint by setting `local.size = 3`. This is a best practice that helps your application to handle overhead and traffic bursts. For more information about how to calculate how many local connections per endpoint your application needs based on expected traffic patterns, see the section called “How to configure connections”.
6. **Retry policy** – Implement the Amazon Keyspaces retry policy `AmazonKeyspacesExponentialRetryPolicy` instead of the `DefaultRetryPolicy` that comes with the Cassandra driver. This allows you to configure the number of retry attempts for the `AmazonKeyspacesExponentialRetryPolicy` that meets your needs. By default, the number of retry attempts for the `AmazonKeyspacesExponentialRetryPolicy` is set to 3. For more information, see the section called “How to configure retry policies”.
7. **Prepared statements** – Set `prepare-on-all-nodes` to false to optimize network usage.

```
datastax-java-driver {
    basic {
        contact-points = [ "cassandra.us-east-2.amazonaws.com:9142"]
        request {
            timeout = 2 seconds
            consistency = LOCAL_QUORUM
            page-size = 1024
            default-idempotence = true
        }
        load-balancing-policy {
            local-datacenter = "us-east-2"
            class = DefaultLoadBalancingPolicy
            slow-replica-avoidance = false
        }
    }
    advanced {
        auth-provider {
            class = software.aws.mcs.auth.SigV4AuthProvider
            aws-region = us-east-2
        }
        ssl-engine-factory {
            class = DefaultSslEngineFactory
            truststore-path = "./src/main/resources/cassandra_truststore.jks"
            truststore-password = "my_password"
            hostname-validation = false
        }
        connection {
```

```
      connect-timeout = 5 seconds
      max-requests-per-connection = 512
      pool {
                local.size = 3
      }
        }
       retry-policy {
           class =  com.aws.ssa.keyspaces.retry.AmazonKeyspacesExponentialRetryPolicy
     max-attempts = 3
     min-wait = 10 mills
     max-wait = 100 mills
       }
       prepared-statements {
     prepare-on-all-nodes = false
       }
    }
}
```

> **Note**
>
> Instead of adding the path to the trustStore in the configuration file, you can also add the trustStore path directly in the application code or you can add the path to the trustStore to your JVM arguments.

Step 3: Run the application

This code example shows a simple command line application that creates a connection pool to Amazon Keyspaces by using the configuration file we created earlier. It confirms that the connection is established by running a simple query.

```
package <your package>;
// add the following imports to your project
import com.datastax.oss.driver.api.core.CqlSession;
import com.datastax.oss.driver.api.core.config.DriverConfigLoader;
import com.datastax.oss.driver.api.core.cql.ResultSet;
import com.datastax.oss.driver.api.core.cql.Row;

public class App
{

    public static void main( String[] args )
```

```
    {
        //Use DriverConfigLoader to load your configuration file
        DriverConfigLoader loader =
 DriverConfigLoader.fromClasspath("application.conf");
        try (CqlSession session = CqlSession.builder()
                .withConfigLoader(loader)
                .build()) {

            ResultSet rs = session.execute("select * from system_schema.keyspaces");
            Row row = rs.one();
            System.out.println(row.getString("keyspace_name"));
        }
    }
}
```

> **Note**
>
> Use a `try` block to establish the connection to ensure that it's always closed. If you don't use a `try` block, remember to close your connection to avoid leaking resources.

Connect to Amazon Keyspaces using the 3.x DataStax Java driver for Apache Cassandra and the SigV4 authentication plugin

The following section describes how to use the SigV4 authentication plugin for the 3.x open-source DataStax Java driver for Apache Cassandra to access Amazon Keyspaces. The plugin is available from the GitHub repository.

The SigV4 authentication plugin allows you to use IAM credentials for users and roles when connecting to Amazon Keyspaces. Instead of requiring a user name and password, this plugin signs API requests using access keys. For more information, see the section called “Create IAM credentials for AWS authentication”.

Step 1: Prerequisites

To run this code sample, you first need to complete the following tasks.

- Create credentials for your IAM user or role following the steps at the section called “Create IAM credentials for AWS authentication”. This tutorial assumes that the access keys are stored as environment variables. For more information, see the section called “Manage access keys”.

- Follow the steps at the section called "Before you begin" to download the digital certificates, convert them to trustStore files, and attach the keystore in the JVM arguments to your application.
- Add the DataStax Java driver for Apache Cassandra to your Java project. Ensure that you're using a version of the driver that supports Apache Cassandra 3.11.2. For more information, see the DataStax Java Driver for Apache Cassandra documentation.
- Add the authentication plugin to your application. The authentication plugin supports version 3.x of the DataStax Java driver for Apache Cassandra. If you're using Apache Maven, or a build system that can use Maven dependencies, add the following dependencies to your `pom.xml` file. Replace the version of the plugin with the latest version as shown at GitHub repository.

```
<dependency>
        <groupId>software.aws.mcs</groupId>
        <artifactId>aws-sigv4-auth-cassandra-java-driver-plugin_3</artifactId>
        <version>3.0.3</version>
</dependency>
```

Step 2: Run the application

This code example shows a simple command line application that creates a connection pool to Amazon Keyspaces. It confirms that the connection is established by running a simple query.

```
package <your package>;
// add the following imports to your project

import software.aws.mcs.auth.SigV4AuthProvider;
import com.datastax.driver.core.Cluster;
import com.datastax.driver.core.ResultSet;
import com.datastax.driver.core.Row;
import com.datastax.driver.core.Session;

public class App
{

    public static void main( String[] args )
    {
        String endPoint = "cassandra.us-east-2.amazonaws.com";
        int portNumber = 9142;
        Session session = Cluster.builder()
                                 .addContactPoint(endPoint)
```

```
                                    .withPort(portNumber)
                                    .withAuthProvider(new SigV4AuthProvider("us-east-2"))

                                    .withSSL()
                                    .build()
                                    .connect();

        ResultSet rs = session.execute("select * from system_schema.keyspaces");
        Row row = rs.one();
        System.out.println(row.getString("keyspace_name"));
    }
}
```

Usage notes:

For a list of available endpoints, see the section called “Service endpoints”.

See the following repository for helpful Java driver policies, examples, and best practices when using the Java Driver with Amazon Keyspaces: https://github.com/aws-samples/amazon-keyspaces-java-driver-helpers.

Using a Cassandra Python client driver to access Amazon Keyspaces programmatically

In this section, we show you how to connect to Amazon Keyspaces using a Python client driver. To provide users and applications with credentials for programmatic access to Amazon Keyspaces resources, you can do either of the following:

- Create service-specific credentials that are associated with a specific AWS Identity and Access Management (IAM) user.
- For enhanced security, we recommend to create IAM access keys for IAM users or roles that are used across all AWS services. The Amazon Keyspaces SigV4 authentication plugin for Cassandra client drivers enables you to authenticate calls to Amazon Keyspaces using IAM access keys instead of user name and password. For more information, see the section called “Create IAM credentials for AWS authentication”.

Topics

- Before you begin

- Connect to Amazon Keyspaces using the Python driver for Apache Cassandra and service-specific credentials
- Connect to Amazon Keyspaces using the DataStax Python driver for Apache Cassandra and the SigV4 authentication plugin

Before you begin

You need to complete the following task before you can start.

Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients. To connect to Amazon Keyspaces using TLS, you need to download Amazon digital certificates and configure the Python driver to use TLS.

Download the following digital certificates and save the files locally or in your home directory.

1. AmazonRootCA1
2. AmazonRootCA2
3. AmazonRootCA3
4. AmazonRootCA4
5. Starfield Class 2 Root (optional – for backward compatibility)

To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

Note

Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

Combine all downloaded certificates into a single pem file with the name *keyspaces-bundle.pem* in our examples. You can do this by running the following command. Take note of the path to the file, you need this later.

```
cat AmazonRootCA1.pem \
 AmazonRootCA2.pem \
 AmazonRootCA3.pem \
 AmazonRootCA4.pem \
 sf-class2-root.crt \
 > keyspaces-bundle.pem
```

Connect to Amazon Keyspaces using the Python driver for Apache Cassandra and service-specific credentials

The following code example shows you how to connect to Amazon Keyspaces with a Python client driver and service-specific credentials.

```
from cassandra.cluster import Cluster
from ssl import SSLContext, PROTOCOL_TLSv1_2 , CERT_REQUIRED
from cassandra.auth import PlainTextAuthProvider

ssl_context = SSLContext(PROTOCOL_TLSv1_2 )

ssl_context.load_verify_locations('path_to_file/keyspaces-bundle.pem')

ssl_context.verify_mode = CERT_REQUIRED
auth_provider = PlainTextAuthProvider(username='ServiceUserName',
 password='ServicePassword')
cluster = Cluster(['cassandra.us-east-2.amazonaws.com'], ssl_context=ssl_context,
 auth_provider=auth_provider, port=9142)
session = cluster.connect()
r = session.execute('select * from system_schema.keyspaces')
print(r.current_rows)
```

Usage notes:

1. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the combined certificate file saved in the first step.
2. Ensure that the *ServiceUserName* and *ServicePassword* match the user name and password you obtained when you generated the service-specific credentials by following the steps to Create service-specific credentials for programmatic access to Amazon Keyspaces.

3. For a list of available endpoints, see the section called “Service endpoints”.

Connect to Amazon Keyspaces using the DataStax Python driver for Apache Cassandra and the SigV4 authentication plugin

The following section shows how to use the SigV4 authentication plugin for the open-source DataStax Python driver for Apache Cassandra to access Amazon Keyspaces (for Apache Cassandra).

If you haven't already done so, begin with creating credentials for your IAM role following the steps at the section called “Create IAM credentials for AWS authentication”. This tutorial uses temporary credentials, which requires an IAM role. For more information about temporary credentials, see the section called “Create temporary credentials to connect to Amazon Keyspaces”.

Then, add the Python SigV4 authentication plugin to your environment from the GitHub repository.

```
pip install cassandra-sigv4
```

The following code example shows how to connect to Amazon Keyspaces by using the open-source DataStax Python driver for Cassandra and the SigV4 authentication plugin. The plugin depends on the AWS SDK for Python (Boto3). It uses `boto3.session` to obtain temporary credentials.

```
from cassandra.cluster import Cluster
from ssl import SSLContext, PROTOCOL_TLSv1_2 , CERT_REQUIRED
from cassandra.auth import PlainTextAuthProvider
import boto3
from cassandra_sigv4.auth import SigV4AuthProvider

ssl_context = SSLContext(PROTOCOL_TLSv1_2)
ssl_context.load_verify_locations('path_to_file/keyspaces-bundle.pem')
ssl_context.verify_mode = CERT_REQUIRED

# use this if you want to use Boto to set the session parameters.
boto_session = boto3.Session(aws_access_key_id="AKIAIOSFODNN7EXAMPLE",
                             aws_secret_access_key="wJalrXUtnFEMI/K7MDENG/
bPxRfiCYEXAMPLEKEY",
                             aws_session_token="AQoDYXdzEJr...<remainder of token>",
                             region_name="us-east-2")
auth_provider = SigV4AuthProvider(boto_session)
```

```
# Use this instead of the above line if you want to use the Default Credentials and not
 bother with a session.
# auth_provider = SigV4AuthProvider()

cluster = Cluster(['cassandra.us-east-2.amazonaws.com'], ssl_context=ssl_context,
 auth_provider=auth_provider,
                  port=9142)
session = cluster.connect()
r = session.execute('select * from system_schema.keyspaces')
print(r.current_rows)
```

Usage notes:

1. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the certificate saved in the first step.
2. Ensure that the *aws_access_key_id*, *aws_secret_access_key*, and the *aws_session_token* match the `Access Key`, `Secret Access Key`, and `Session Token` you obtained using `boto3.session`. For more information, see Credentials in the *AWS SDK for Python (Boto3)*.
3. For a list of available endpoints, see the section called “Service endpoints”.

Using a Cassandra Node.js client driver to access Amazon Keyspaces programmatically

This section shows you how to connect to Amazon Keyspaces by using a Node.js client driver. To provide users and applications with credentials for programmatic access to Amazon Keyspaces resources, you can do either of the following:

- Create service-specific credentials that are associated with a specific AWS Identity and Access Management (IAM) user.
- For enhanced security, we recommend to create IAM access keys for IAM users or roles that are used across all AWS services. The Amazon Keyspaces SigV4 authentication plugin for Cassandra client drivers enables you to authenticate calls to Amazon Keyspaces using IAM access keys instead of user name and password. For more information, see the section called “Create IAM credentials for AWS authentication”.

Topics

- Before you begin
- Connect to Amazon Keyspaces using the Node.js DataStax driver for Apache Cassandra and service-specific credentials
- Connect to Amazon Keyspaces using the DataStax Node.js driver for Apache Cassandra and the SigV4 authentication plugin

Before you begin

You need to complete the following task before you can start.

Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients. To connect to Amazon Keyspaces using TLS, you need to download an Amazon digital certificate and configure the Python driver to use TLS.

Download the following digital certificates and save the files locally or in your home directory.

1. AmazonRootCA1
2. AmazonRootCA2
3. AmazonRootCA3
4. AmazonRootCA4
5. Starfield Class 2 Root (optional – for backward compatibility)

To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

> **Note**
>
> Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

Combine all downloaded certificates into a single pem file with the name *keyspaces-bundle.pem* in our examples. You can do this by running the following command. Take note of the path to the file, you need this later.

```
cat AmazonRootCA1.pem \
 AmazonRootCA2.pem \
 AmazonRootCA3.pem \
 AmazonRootCA4.pem \
 sf-class2-root.crt \
 > keyspaces-bundle.pem
```

Connect to Amazon Keyspaces using the Node.js DataStax driver for Apache Cassandra and service-specific credentials

Configure your driver to use the combined certificate file `keyspaces-bundle.pem` for TLS and authenticate using service-specific credentials. For example:

```
const cassandra = require('cassandra-driver');
const fs = require('fs');
const auth = new cassandra.auth.PlainTextAuthProvider('ServiceUserName',
 'ServicePassword');
const sslOptions1 = {
         ca: [
                    fs.readFileSync('path_to_file/keyspaces-bundle.pem', 'utf-8')],

                    host: 'cassandra.us-west-2.amazonaws.com',
                    rejectUnauthorized: true
        };
const client = new cassandra.Client({
                   contactPoints: ['cassandra.us-west-2.amazonaws.com'],
                   localDataCenter: 'us-west-2',
                   authProvider: auth,
                   sslOptions: sslOptions1,
                   protocolOptions: { port: 9142 }
        });
const query = 'SELECT * FROM system_schema.keyspaces';

client.execute(query)
                    .then( result => console.log('Row from Keyspaces %s',
 result.rows[0]))
                    .catch( e=> console.log(`${e}`));
```

Usage notes:

1. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the combined certificate file saved in the first step.
2. Ensure that the *ServiceUserName* and *ServicePassword* match the user name and password you obtained when you generated the service-specific credentials by following the steps to Create service-specific credentials for programmatic access to Amazon Keyspaces.
3. For a list of available endpoints, see the section called “Service endpoints”.

Connect to Amazon Keyspaces using the DataStax Node.js driver for Apache Cassandra and the SigV4 authentication plugin

The following section shows how to use the SigV4 authentication plugin for the open-source DataStax Node.js driver for Apache Cassandra to access Amazon Keyspaces (for Apache Cassandra).

If you haven't already done so, create credentials for your IAM user or role following the steps at the section called “Create IAM credentials for AWS authentication”.

Add the Node.js SigV4 authentication plugin to your application from the GitHub repository. The plugin supports version 4.x of the DataStax Node.js driver for Cassandra and depends on the AWS SDK for Node.js. It uses `AWSCredentialsProvider` to obtain credentials.

```
$ npm install aws-sigv4-auth-cassandra-plugin --save
```

This code example shows how to set a Region-specific instance of `SigV4AuthProvider` as the authentication provider.

```
const cassandra = require('cassandra-driver');
const fs = require('fs');
const sigV4 = require('aws-sigv4-auth-cassandra-plugin');

const auth = new sigV4.SigV4AuthProvider({
    region: 'us-west-2',
    accessKeyId:'AKIAIOSFODNN7EXAMPLE',
    secretAccessKey: 'wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY'});

const sslOptions1 = {
  ca: [
      fs.readFileSync('path_to_file/keyspaces-bundle.pem', 'utf-8')],
```

```
  host: 'cassandra.us-west-2.amazonaws.com',
  rejectUnauthorized: true
};


const client = new cassandra.Client({
  contactPoints: ['cassandra.us-west-2.amazonaws.com'],
  localDataCenter: 'us-west-2',
  authProvider: auth,
  sslOptions: sslOptions1,
  protocolOptions: { port: 9142 }
});


const query = 'SELECT * FROM system_schema.keyspaces';

client.execute(query).then(
    result => console.log('Row from Keyspaces %s', result.rows[0]))
    .catch( e=> console.log(`${e}`));
```

Usage notes:

1. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the certificate saved in the first step.
2. Ensure that the *accessKeyId* and *secretAccessKey* match the Access Key and Secret Access Key you obtained using `AWSCredentialsProvider`. For more information, see Setting Credentials in Node.js in the *AWS SDK for JavaScript in Node.js*.
3. To store access keys outside of code, see best practices at the section called “Manage access keys”.
4. For a list of available endpoints, see the section called “Service endpoints”.

Using a Cassandra .NET Core client driver to access Amazon Keyspaces programmatically

This section shows you how to connect to Amazon Keyspaces by using a .NET Core client driver. The setup steps will vary depending on your environment and operating system, you might have to modify them accordingly. Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients. To connect to Amazon Keyspaces using TLS, configure your driver to use the system trust store, which includes the Amazon Root CAs 1-4.

1. Install the CassandraCSharpDriver through nuget, using the nuget console.

```
PM> Install-Package CassandraCSharpDriver
```

2. The following example uses a .NET Core C# console project to connect to Amazon Keyspaces and run a query.

```
using Cassandra;
using System;
using System.Collections.Generic;
using System.Linq;
using System.Net.Security;
using System.Runtime.ConstrainedExecution;
using System.Security.Cryptography.X509Certificates;
using System.Text;
using System.Threading.Tasks;

namespace CSharpKeyspacesExample
{
    class Program
    {
        public Program(){}

        static void Main(string[] args)
        {
            var userName = "ServiceUserName";
            var pwd = "ServicePassword";
            certCollection.Add(amazoncert);

            var awsEndpoint =  "cassandra.us-east-2.amazonaws.com" ;

            var cluster = Cluster.Builder()
                     .AddContactPoints(awsEndpoint)
                     .WithPort(9142)
                     .WithAuthProvider(new PlainTextAuthProvider(userName, pwd))
                     .WithSSL(new
 SSLOptions().SetCertificateCollection(certCollection))
                     .Build();

            var session = cluster.Connect();
            var rs = session.Execute("SELECT * FROM system_schema.tables;");
            foreach (var row in rs)
            {
```

```
                var name = row.GetValue<String>("keyspace_name");
                Console.WriteLine(name);
            }
        }
    }
}
```

Usage notes:

1. Ensure that you use the default system trust store, which includes the Amazon Root CAs 1-4.
2. Ensure that the *ServiceUserName* and *ServicePassword* match the user name and password you obtained when you generated the service-specific credentials by following the steps to Create service-specific credentials for programmatic access to Amazon Keyspaces.
3. For a list of available endpoints, see the section called "Service endpoints".

Using a Cassandra Go client driver to access Amazon Keyspaces programmatically

This section shows you how to connect to Amazon Keyspaces by using a Go Cassandra client driver. To provide users and applications with credentials for programmatic access to Amazon Keyspaces resources, you can do either of the following:

- Create service-specific credentials that are associated with a specific AWS Identity and Access Management (IAM) user.
- For enhanced security, we recommend to create IAM access keys for IAM principals that are used across all AWS services. The Amazon Keyspaces SigV4 authentication plugin for Cassandra client drivers enables you to authenticate calls to Amazon Keyspaces using IAM access keys instead of user name and password. For more information, see the section called "Create IAM credentials for AWS authentication".

Topics

- Before you begin
- Connect to Amazon Keyspaces using the Gocql driver for Apache Cassandra and service-specific credentials

- Connect to Amazon Keyspaces using the Go driver for Apache Cassandra and the SigV4 authentication plugin

Before you begin

You need to complete the following task before you can start.

Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients. To connect to Amazon Keyspaces using TLS, you need to download an Amazon digital certificate and configure the Go driver to use TLS.

Download the following digital certificates and save the files locally or in your home directory.

1. AmazonRootCA1
2. AmazonRootCA2
3. AmazonRootCA3
4. AmazonRootCA4
5. Starfield Class 2 Root (optional – for backward compatibility)

To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

Note

Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

Combine all downloaded certificates into a single `pem` file with the name *`keyspaces-bundle.pem`* in our examples. You can do this by running the following command. Take note of the path to the file, you need this later.

```
cat AmazonRootCA1.pem \
 AmazonRootCA2.pem \
 AmazonRootCA3.pem \
 AmazonRootCA4.pem \
 sf-class2-root.crt \
 > keyspaces-bundle.pem
```

Connect to Amazon Keyspaces using the Gocql driver for Apache Cassandra and service-specific credentials

1. Create a directory for your application.

```
mkdir ./gocqlexample
```

2. Navigate to the new directory.

```
cd gocqlexample
```

3. Create a file for your application.

```
touch cqlapp.go
```

4. Download the Go driver.

```
go get github.com/gocql/gocql
```

5. Add the following sample code to the cqlapp.go file.

```
package main

import (
     "fmt"
     "github.com/gocql/gocql"
     "log"
)

func main() {

    // add the Amazon Keyspaces service endpoint
    cluster := gocql.NewCluster("cassandra.us-east-2.amazonaws.com")
    cluster.Port=9142
```

```
    // add your service specific credentials
    cluster.Authenticator = gocql.PasswordAuthenticator{
            Username: "ServiceUserName",
            Password: "ServicePassword"}

    // provide the path to the keyspaces-bundle.pem
    cluster.SslOpts = &gocql.SslOptions{
            CaPath: "path_to_file/keyspaces-bundle.pem",
            EnableHostVerification: false,
     }

     // Override default Consistency to LocalQuorum
     cluster.Consistency = gocql.LocalQuorum
     cluster.DisableInitialHostLookup = false

     session, err := cluster.CreateSession()
     if err != nil {
            fmt.Println("err>", err)
     }
     defer session.Close()

     // run a sample query from the system keyspace
     var text string
     iter := session.Query("SELECT keyspace_name FROM system_schema.tables;").Iter()
     for iter.Scan(&text) {
            fmt.Println("keyspace_name:", text)
     }
     if err := iter.Close(); err != nil {
            log.Fatal(err)
     }
     session.Close()
}
```

Usage notes:

a. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the combined certificate file saved in the first step.

b. Ensure that the *ServiceUserName* and *ServicePassword* match the user name and password you obtained when you generated the service-specific credentials by following the steps to Create service-specific credentials for programmatic access to Amazon Keyspaces.

c. For a list of available endpoints, see the section called “Service endpoints”.

6. Build the program.

```
go build cqlapp.go
```

7. Run the program.

```
./cqlapp
```

Connect to Amazon Keyspaces using the Go driver for Apache Cassandra and the SigV4 authentication plugin

The following code sample shows how to use the SigV4 authentication plugin for the open-source Go driver to access Amazon Keyspaces (for Apache Cassandra).

If you haven't already done so, create credentials for your IAM principal following the steps at the section called “Create IAM credentials for AWS authentication”. If an application is running on Lambda or an Amazon EC2 instance, your application is automatically using the credentials of the instance. To run this tutorial locally, you can store the credentials as local environment variables.

Add the Go SigV4 authentication plugin to your application from the GitHub repository. The plugin supports version 1.2.x of the open-source Go driver for Cassandra and depends on the AWS SDK for Go.

```
$ go mod init
$ go get github.com/aws/aws-sigv4-auth-cassandra-gocql-driver-plugin
```

In this code example, the Amazon Keyspaces endpoint is represented by the `Cluster` class. It uses the `AwsAuthenticator` for the authenticator property of the cluster to obtain credentials.

```
package main

import (
        "fmt"
        "github.com/aws/aws-sigv4-auth-cassandra-gocql-driver-plugin/sigv4"
        "github.com/gocql/gocql"
        "log"
)

func main() {
    // configuring the cluster options
```

```
    cluster := gocql.NewCluster("cassandra.us-west-2.amazonaws.com")
    cluster.Port=9142

    // the authenticator uses the default credential chain to find AWS credentials
    cluster.Authenticator = sigv4.NewAwsAuthenticator()

    cluster.SslOpts = &gocql.SslOptions{

            CaPath: "path_to_file/keyspaces-bundle.pem",
            EnableHostVerification: false,
    }
    cluster.Consistency = gocql.LocalQuorum
    cluster.DisableInitialHostLookup = false

    session, err := cluster.CreateSession()
    if err != nil {
     fmt.Println("err>", err)
     return
    }
    defer session.Close()

    // doing the query
    var text string
    iter := session.Query("SELECT keyspace_name FROM system_schema.tables;").Iter()
    for iter.Scan(&text) {
     fmt.Println("keyspace_name:", text)
    }
    if err := iter.Close(); err != nil {
     log.Fatal(err)
    }
}
```

Usage notes:

1. Replace "*path_to_file/keyspaces-bundle.pem*" with the path to the certificate file saved in the first step.
2. For this example to run locally, you need to define the following variables as environment variables:
   - `AWS_ACCESS_KEY_ID`
   - `AWS_SECRET_ACCESS_KEY`
   - `AWS_DEFAULT_REGION`

3. To store access keys outside of code, see best practices at the section called “Manage access keys”.
4. For a list of available endpoints, see the section called “Service endpoints”.

Using a Cassandra Perl client driver to access Amazon Keyspaces programmatically

This section shows you how to connect to Amazon Keyspaces by using a Perl client driver. For this code sample, we used Perl 5. Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients.

> **Important**
>
> Amazon Keyspacescertificates are transitioning to the Amazon Trust Services (ATS) hierarchy. Ensure your environment trusts the Amazon Root CAs 1–4 to avoid connection errors during this rotation. The Perl driver doesn't validate the server's Amazon SSL certificate, which means that you can't confirm that you are connecting to Amazon Keyspaces. The second step, to configure the driver to use TLS when connecting to Amazon Keyspaces is still required, and ensures that data transferred between the client and server is encrypted.

1. Download the Cassandra DBI driver from https://metacpan.org/pod/DBD::Cassandra and install the driver to your Perl environment. The exact steps depend on the environment. The following is a common example.

```
cpanm DBD::Cassandra
```

2. Create a file for your application.

```
touch cqlapp.pl
```

3. Add the following sample code to the cqlapp.pl file.

```
use DBI;
my $user = "ServiceUserName";
my $password = "ServicePassword";
```

```
my $db = DBI->connect("dbi:Cassandra:host=cassandra.us-
east-2.amazonaws.com;port=9142;tls=1;",
$user, $password);

my $rows = $db->selectall_arrayref("select * from system_schema.keyspaces");
print "Found the following Keyspaces...\n";
for my $row (@$rows) {
      print join(" ",@$row['keyspace_name']),"\n";
}

$db->disconnect;
```

Important

Ensure that the *ServiceUserName* and *ServicePassword* match the user name and password you obtained when you generated the service-specific credentials by following the steps to Create service-specific credentials for programmatic access to Amazon Keyspaces.

Note

For a list of available endpoints, see the section called “Service endpoints”.

4. Run the application.

```
perl cqlapp.pl
```

Configure cross-account access to Amazon Keyspaces with VPC endpoints

You can create and use separate AWS accounts to isolate resources and for use in different environments, for example development and production. This topic walks you through cross-account access for Amazon Keyspaces using interface VPC endpoints in an Amazon Virtual Private Cloud. For more information about IAM cross-account access configuration, see Example scenario using separate development and production accounts in the IAM User Guide.

For more information about Amazon Keyspaces and private VPC endpoints, see the section called "Using interface VPC endpoints".

Topics

- Configure cross-account access to Amazon Keyspaces using VPC endpoints in a shared VPC
- Configuring cross-account access to Amazon Keyspaces without a shared VPC

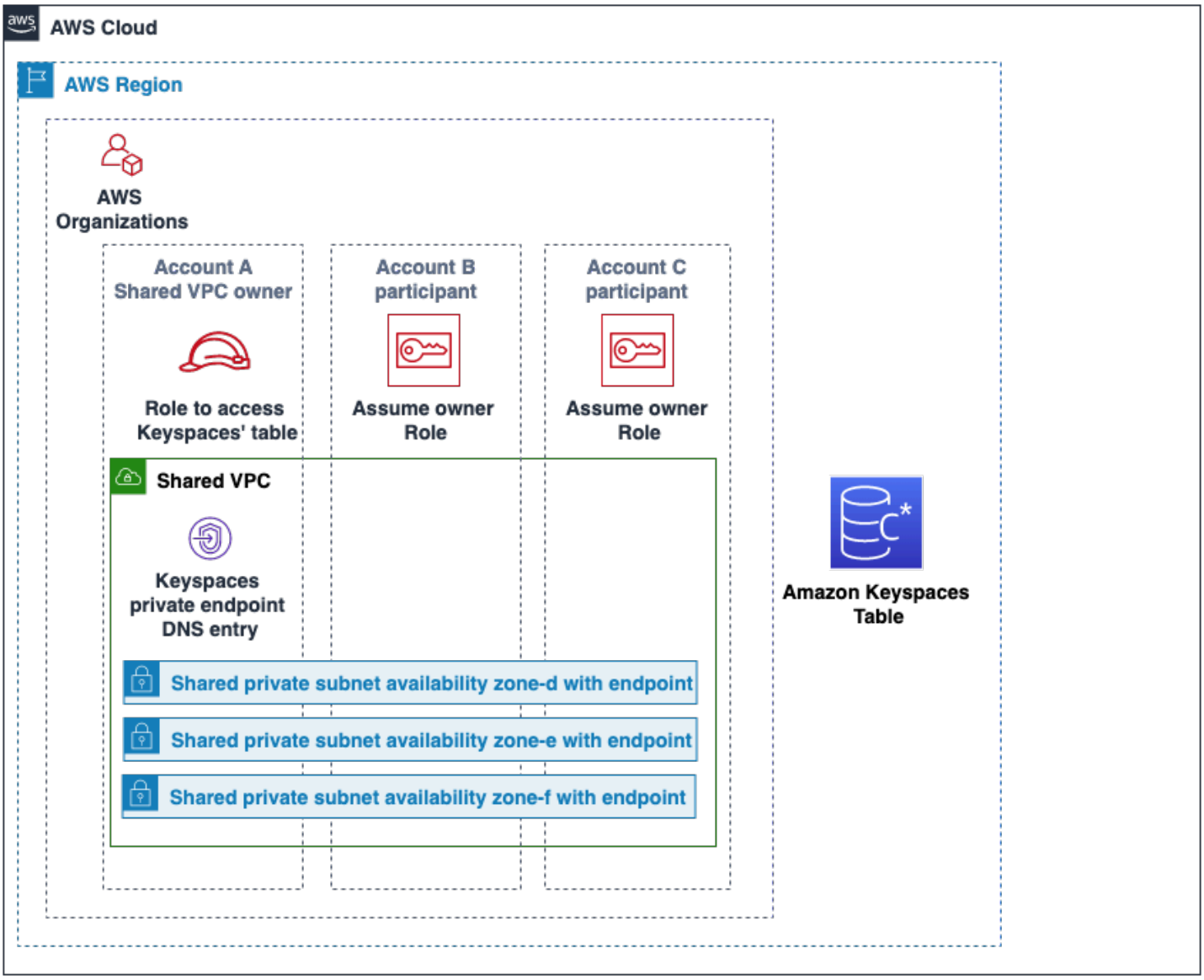
Configure cross-account access to Amazon Keyspaces using VPC endpoints in a shared VPC

You can create different AWS accounts to separate resources from applications. For example, you can create one account for your Amazon Keyspaces tables, a different account for applications in a development environment, and another account for applications in a production environment. This topic walks you through the configuration steps required to set up cross-account access for Amazon Keyspaces using interface VPC endpoints in a shared VPC.

For detailed steps how to configure a VPC endpoint for Amazon Keyspaces, see the section called "Step 3: Create a VPC endpoint for Amazon Keyspaces".

In this example we use the following three accounts in a shared VPC:

- `Account A:111111111111` – This account contains infrastructure, including the VPC endpoints, the VPC subnets, and Amazon Keyspaces tables.
- `Account B:222222222222` – This account contains an application in a development environment that needs to connect to the Amazon Keyspaces table in `Account A:111111111111`.
- `Account C:333333333333` – This account contains an application in a production environment that needs to connect to the Amazon Keyspaces table in `Account A:111111111111`.



`Account A:111111111111` is the account that contains the resources (an Amazon Keyspaces table) that `Account B:222222222222` and `Account C:333333333333` need to access, so `Account A:111111111111` is the *trusting* account. `Account B:222222222222` and `Account C:333333333333` are the accounts with the principals that need access to the resources (an Amazon Keyspaces table) in `Account A:111111111111`, so `Account B:222222222222` and `Account C:333333333333` are the *trusted* accounts. The trusting account grants the permissions to the trusted accounts by sharing an IAM role. The following procedure outlines the configuration steps required in `Account A:111111111111`.

Configuration for `Account A:111111111111`

1. Use AWS Resource Access Manager to create a resource share for the subnet and share the private subnet with `Account B:222222222222` and `Account C:333333333333`.

   `Account B:222222222222` and `Account C:333333333333` can now see and create resources in the subnet that has been shared with them.

2. Create an Amazon Keyspaces private VPC endpoint powered by AWS PrivateLink. This creates multiple endpoints across shared subnets and DNS entries for the Amazon Keyspaces service endpoint.

3. Create an Amazon Keyspaces keyspace and table.

4. Create an IAM role in `Account A:111111111111` that has full access to the Amazon Keyspaces table, read access to the Amazon Keyspaces system tables, and is able to describe the Amazon EC2 VPC resources as shown in the following policy example.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CrossAccountAccess",
            "Effect": "Allow",
            "Action": [
                "ec2:DescribeNetworkInterfaces",
                "ec2:DescribeVpcEndpoints",
                "cassandra:*"
            ],
            "Resource": "*"
        }
    ]
}
```

5. Configure a trust policy for the IAM role in `Account A:111111111111` so that `Account B:222222222222` and `Account C:333333333333` can assume the role as trusted accounts. This is shown in the following example.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
```

```
      "Principal": {
        "AWS": [
          "arn:aws:iam::222222222222:role/Cross-Account-Role-B",
          "arn:aws:iam::333333333333:role/Cross-Account-Role-C"
        ]
      },
      "Action": "sts:AssumeRole",
      "Condition": {}
    }
  ]
}
```

For more information about cross-account IAM policies, see Cross-account policies in the IAM User Guide.

Configuration in Account B:222222222222 and Account C:333333333333

1. In Account B:222222222222 and Account C:333333333333, create new roles and attach the following policy that allows the principal to assume the shared role created in Account A:111111111111.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "ec2.amazonaws.com"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

   Allowing the principal to assume the shared role is implemented using the AssumeRole API of the AWS Security Token Service (AWS STS). For more information, see Providing access to an IAM user in another AWS account that you own in the IAM User Guide.

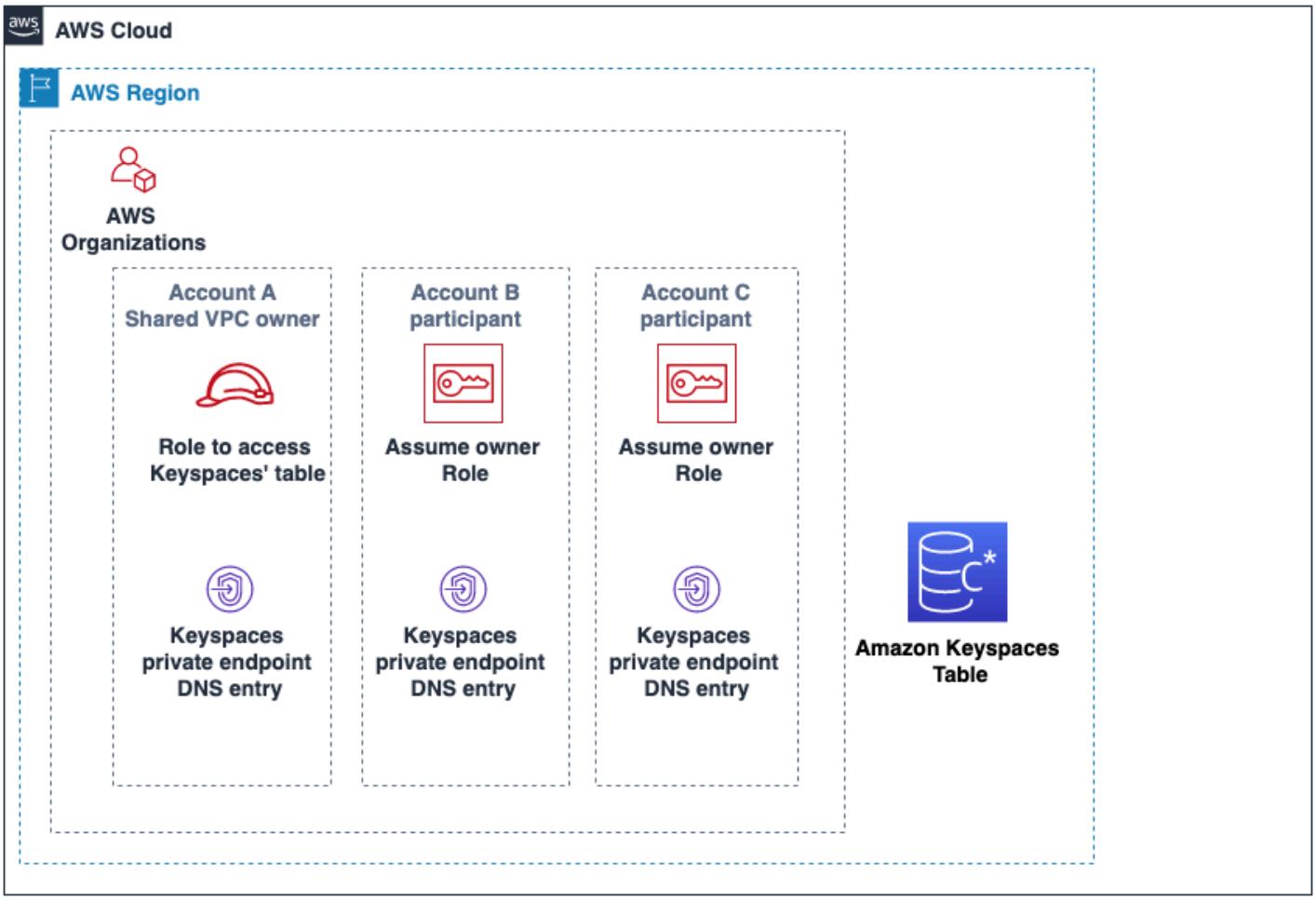
2. In Account B:222222222222 and Account C:333333333333, you can create applications that utilize the SIGV4 authentication plugin, which allows an application to assume the shared role to connect to the Amazon Keyspaces table located in Account A:111111111111

through the VPC endpoint in the shared VPC. For more information about the SIGV4 authentication plugin, see the section called “Create programmatic access credentials”. For more information on how to configure an application to assume a role in another AWS account, see Authentication and access in the *AWS SDKs and Tools Reference Guide*.

Configuring cross-account access to Amazon Keyspaces without a shared VPC

If the Amazon Keyspaces table and private VPC endpoint are owned by different accounts but are not sharing a VPC, applications can still connect cross-account using VPC endpoints. Because the accounts are not sharing the VPC endpoints, `Account A:111111111111`, `Account B:222222222222`, and `Account C:333333333333` require their own VPC endpoints. To the Cassandra client driver, Amazon Keyspaces appears like a single node instead of a multi-node cluster. Upon connection, the client driver reaches the DNS server which returns one of the available endpoints in the account’s VPC.

You can also access Amazon Keyspaces tables across different accounts without a shared VPC endpoint by using the public endpoints or deploying a private VPC endpoint in each account. When not using a shared VPC, each account requires its own VPC endpoint. In this example `Account A:111111111111`, `Account B:222222222222`, and `Account C:333333333333` require their own VPC endpoints to access the table in `Account A:111111111111`. When using VPC endpoints in this configuration, Amazon Keyspaces appears as a single node cluster to the Cassandra client driver instead of a multi-node cluster. Upon connection, the client driver reaches the DNS server which returns one of the available endpoints in the account’s VPC. But the client driver is not able to access the `system.peers` table to discover additional endpoints. Because there are less hosts available, the driver makes less connections. To adjust this, increase the connection pool setting of the driver by a factor of three.



`Account A:111111111111` is the account that contains the resources (an Amazon Keyspaces table) that `Account B:222222222222` and `Account C:333333333333` need to access, so `Account A:111111111111` is the *trusting* account. `Account B:222222222222` and `Account C:333333333333` are the accounts with the principals that need access to the resources (an Amazon Keyspaces table) in `Account A:111111111111`, so `Account B:222222222222` and `Account C:333333333333` are the *trusted* accounts. The trusting account grants the permissions to the trusted accounts by sharing an IAM role. The following procedure outlines the configuration steps required in `Account A:111111111111`.

Configuration for `Account A:111111111111`

1. Create an Amazon Keyspaces keyspace and table in `Account A:111111111111`.
2. Create an IAM role in `Account A:111111111111` that has full access to the Amazon Keyspaces table and read access to the Amazon Keyspaces system tables.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select",
            "cassandra:Modify"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111111111111:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111111111111:/keyspace/system*"
         ]
      }
   ]
}
```

3. Configure a trust policy for the IAM role in `Account A:111111111111` so that principals in `Account B:222222222222` and `Account C:333333333333` can assume the role as trusted accounts. This is shown in the following example.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "AWS": [
          "arn:aws:iam::222222222222:role/Cross-Account-Role-B",
          "arn:aws:iam::333333333333:role/Cross-Account-Role-C"
        ]
      },
      "Action": "sts:AssumeRole",
      "Condition": {}
    }
  ]
}
```

For more information about cross-account IAM policies, see Cross-account policies in the IAM User Guide.

4. Configure the VPC endpoint in Account A:111111111111 and attach permissions to the endpoint that allow the roles from Account B:222222222222 and Account C:333333333333 to assume the role in Account A using the VPC endpoint. These permissions are valid for the VPC endpoint that they are attached to. For more information about VPC endpoint policies, see the section called “Controlling access to interface VPC endpoints for Amazon Keyspaces”.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AllowAccessfromSpecificIAMroles",
      "Effect": "Allow",
      "Action": "cassandra:*",
      "Resource": "*",
      "Principal": "*",
      "Condition": {
        "ArnEquals": {
          "aws:PrincipalArn": [
            "arn:aws:iam::222222222222:role/Cross-Account-Role-B",
            "arn:aws:iam::333333333333:role/Cross-Account-Role-C"
          ]
        }
      }
    }
  ]
}
```

Configuration in Account B:222222222222 and Account C:333333333333

1. In Account B:222222222222 and Account C:333333333333, create new roles and attach the following policy that allows the principal to assume the shared role created in Account A:111111111111.

```
{
    "Version": "2012-10-17",
    "Statement": {
            "Effect": "Allow",
            "Action": "sts:AssumeRole",
            "Resource": "arn:aws:iam::111111111111:role/keyspaces_access"
```

```
        }
}
```

Allowing the principal to assume the shared role is implemented using the `AssumeRole` API of the AWS Security Token Service (AWS STS). For more information, see Providing access to an IAM user in another AWS account that you own in the IAM User Guide.

2. In `Account B:222222222222` and `Account C:333333333333`, you can create applications that utilize the SIGV4 authentication plugin, which allows an application to assume the shared role to connect to the Amazon Keyspaces table located in `Account A:111111111111`. For more information about the SIGV4 authentication plugin, see the section called “Create programmatic access credentials”. For more information on how to configure an application to assume a role in another AWS account, see Authentication and access in the *AWS SDKs and Tools Reference Guide*.

Getting started with Amazon Keyspaces (for Apache Cassandra)

If you're new to Apache Cassandra and Amazon Keyspaces, this tutorial guides you through installing the necessary programs and tools to use Amazon Keyspaces successfully. You'll learn how to create a keyspace and table using Cassandra Query Language (CQL), the AWS Management Console, or the AWS Command Line Interface (AWS CLI). You then use Cassandra Query Language (CQL) to perform create, read, update, and delete (CRUD) operations on data in your Amazon Keyspaces table.

This tutorial covers the following steps.

- **Prerequisites** – Before starting the tutorial, follow the AWS setup instructions to sign up for AWS and create an IAM user with access to Amazon Keyspaces. Then you set up the `cqhsh-expansion` and AWS CloudShell. Alternatively you can use the AWS CLI to create resources in Amazon Keyspaces.
- **Step 1: Create a keyspace and table** – In this section, you'll create a keyspace named "catalog" and a table named "book_awards" within it. You'll specify the table's columns, data types, partition key, and clustering column using the AWS Management Console, CQL, or the AWS CLI.
- **Step 2: Perform CRUD operations** – Here, you'll use the `cqlsh-expansion` in CloudShell to insert, read, update, and delete data in the "book_awards" table. You'll learn how to use various CQL statements like SELECT, INSERT, UPDATE, and DELETE, and practice filtering and modifying data.
- **Step 3: Clean up resources** – To avoid incurring charges for unused resources, this section guides you through deleting the "book_awards" table and "catalog" keyspace using the console, CQL, or the AWS CLI.

For tutorials to connect programmatically to Amazon Keyspaces using different Apache Cassandra client drivers, see the section called “Using a Cassandra client driver”. For code examples using different AWS SDKs, see Code examples for Amazon Keyspaces using AWS SDKs.

Topics

- Tutorial prerequisites and considerations
- Create a keyspace in Amazon Keyspaces
- Check keyspace creation status in Amazon Keyspaces

- Create a table in Amazon Keyspaces
- Check table creation status in Amazon Keyspaces
- Create, read, update, and delete data (CRUD) using CQL in Amazon Keyspaces
- Delete a table in Amazon Keyspaces
- Delete a keyspace in Amazon Keyspaces

Tutorial prerequisites and considerations

Before you can get started with Amazon Keyspaces, follow the AWS setup instructions in Accessing Amazon Keyspaces (for Apache Cassandra). These steps include signing up for AWS and creating an AWS Identity and Access Management (IAM) user with access to Amazon Keyspaces.

To complete all the steps of the tutorial, you need to install `cqlsh`. You can follow the setup instructions at Using `cqlsh` to connect to Amazon Keyspaces.

To access Amazon Keyspaces using `cqlsh` or the AWS CLI, we recommend using AWS CloudShell. CloudShell is a browser-based, pre-authenticated shell that you can launch directly from the AWS Management Console. You can run AWS Command Line Interface (AWS CLI) commands against Amazon Keyspaces using your preferred shell (Bash, PowerShell or Z shell). To use `cqlsh`, you must install the `cqlsh-expansion`. For `cqlsh-expansion` installation instructions, see the section called “Using the `cqlsh-expansion`”. For more information about CloudShell see the section called “Using AWS CloudShell”.

To use the AWS CLI to create, view, and delete resources in Amazon Keyspaces, follow the setup instructions at the section called “Downloading and Configuring the AWS CLI”.

After completing the prerequisite steps, proceed to Create a keyspace in Amazon Keyspaces.

Create a keyspace in Amazon Keyspaces

In this section, you create a keyspace using the console, `cqlsh`, or the AWS CLI.

> **Note**
>
> Before you begin, make sure that you have configured all the tutorial prerequisites.

A *keyspace* groups related tables that are relevant for one or more applications. A keyspace contains one or more tables and defines the replication strategy for all the tables it contains. For more information about keyspaces, see the following topics:

- Data definition language (DDL) statements in the CQL language reference: Keyspaces
- Quotas for Amazon Keyspaces (for Apache Cassandra)

In this tutorial we create a single-Region keyspace, and the replication strategy of the keyspace is `SingleRegionStrategy`. Using `SingleRegionStrategy`, Amazon Keyspaces replicates data across three Availability Zones in one AWS Region. To learn how to create multi-Region keyspaces, see the section called "Create a multi-Region keyspace".

Using the console

To create a keyspace using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose **Create keyspace**.
4. In the **Keyspace name** box, enter **`catalog`** as the name for your keyspace.

   Name constraints:

   - The name can't be empty.
   - Allowed characters: alphanumeric characters and underscore (_).
   - Maximum length is 48 characters.
5. Under **AWS Regions**, confirm that **Single-Region replication** is the replication strategy for the keyspace.
6. To create the keyspace, choose **Create keyspace**.
7. Verify that the keyspace `catalog` was created by doing the following:

   a. In the navigation pane, choose **Keyspaces**.

   b. Locate your keyspace `catalog` in the list of keyspaces.

Using CQL

The following procedure creates a keyspace using CQL.

To create a keyspace using CQL

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

The output of that command should look like this.

```
Connected to Amazon Keyspaces at cassandra.us-east-1.amazonaws.com:9142
[cqlsh 6.1.0 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
Use HELP for help.
cqlsh current consistency level is ONE.
```

2. Create your keyspace using the following CQL command.

```
CREATE KEYSPACE catalog WITH REPLICATION = {'class': 'SingleRegionStrategy'};
```

`SingleRegionStrategy` uses a replication factor of three and replicates data across three AWS Availability Zones in its Region.

> **Note**
>
> Amazon Keyspaces defaults all input to lowercase unless you enclose it in quotation marks.

3. Verify that your keyspace was created.

```
SELECT * from system_schema.keyspaces;
```

The output of this command should look similar to this.

```
cqlsh> SELECT * from system_schema.keyspaces;

 keyspace_name           | durable_writes | replication
```

```
-------------------------+---------------
+-------------------------------------------------------------------------------------
           system_schema |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
      system_schema_mcs |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
                 system |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
 system_multiregion_info |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
                catalog |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}

(5 rows)
```

Using the AWS CLI

The following procedure creates a keyspace using the AWS CLI.

To create a keyspace using the AWS CLI

1. To confirm that your environment is setup, you can run the following command in CloudShell.

   ```
   aws keyspaces help
   ```

2. Create your keyspace using the following AWS CLI statement.

   ```
   aws keyspaces create-keyspace --keyspace-name 'catalog'
   ```

3. Verify that your keyspace was created with the following AWS CLI statement

   ```
   aws keyspaces get-keyspace --keyspace-name 'catalog'
   ```

   The output of this command should look similar to this example.

   ```
   {
       "keyspaceName": "catalog",
       "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/",
       "replicationStrategy": "SINGLE_REGION"
   }
   ```

Check keyspace creation status in Amazon Keyspaces

Amazon Keyspaces performs data definition language (DDL) operations, such as creating and deleting keyspaces, asynchronously.

You can monitor the creation status of new keyspaces in the AWS Management Console, which indicates when a keyspace is pending or active. You can also monitor the creation status of a new keyspace programmatically by using the `system_schema_mcs` keyspace. A keyspace becomes visible in the `system_schema_mcs keyspaces` table when it's ready for use.

The recommended design pattern to check when a new keyspace is ready for use is to poll the Amazon Keyspaces `system_schema_mcs keyspaces` table (system_schema_mcs.*). For a list of DDL statements for keyspaces, see the the section called “Keyspaces” section in the CQL language reference.

The following query shows whether a keyspace has been successfully created.

```
SELECT * FROM system_schema_mcs.keyspaces WHERE keyspace_name = 'mykeyspace';
```

For a keyspace that has been successfully created, the output of the query looks like the following.

```
keyspace_name | durable_writes  | replication
--------------+-----------------+--------------
   mykeyspace | true            |{...} 1 item
```

Create a table in Amazon Keyspaces

In this section, you create a table using the console, `cqlsh`, or the AWS CLI.

A table is where your data is organized and stored. The primary key of your table determines how data is partitioned in your table. The primary key is composed of a required partition key and one or more optional clustering columns. The combined values that compose the primary key must be unique across all the table’s data. For more information about tables, see the following topics:

- Partition key design: the section called “Partition key design”
- Working with tables: the section called “Check table creation status”

- DDL statements in the CQL language reference: Tables
- Table resource management: *Managing serverless resources*
- Monitoring table resource utilization: the section called "Monitoring with CloudWatch"
- Quotas for Amazon Keyspaces (for Apache Cassandra)

When you create a table, you specify the following:

- The name of the table.
- The name and data type of each column in the table.
- The primary key for the table.
  - **Partition key** – Required
  - **Clustering columns** – Optional

Use the following procedure to create a table with the specified columns, data types, partition keys, and clustering columns.

Using the console

The following procedure creates the table `book_awards` with these columns and data types.

```
year           int
award          text
rank           int
category       text
book_title     text
author         text
publisher      text
```

To create a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose `catalog` as the keyspace you want to create this table in.
4. Choose **Create table**.
5. In the **Table name** box, enter **`book_awards`** as a name for your table.

Name constraints:

- The name can't be empty.
- Allowed characters: alphanumeric characters and underscore (_).
- Maximum length is 48 characters.

6. In the **Columns** section, repeat the following steps for each column that you want to add to this table.

   Add the following columns and data types.

```
year           int
award          text
rank           int
category       text
book_title     text
author         text
publisher      text
```

   a. **Name** – Enter a name for the column.

      Name constraints:

      - The name can't be empty.
      - Allowed characters: alphanumeric characters and underscore (_).
      - Maximum length is 48 characters.

   b. **Type** – In the list of data types, choose the data type for this column.

   c. To add another column, choose **Add column**.

7. Choose `award` and `year` as the partition keys under **Partition Key**. A partition key is required for each table. A partition key can be made of one or more columns.

8. Add `category` and `rank` as **Clustering columns**. Clustering columns are optional and determine the sort order within each partition.

   a. To add a clustering column, choose **Add clustering column**.

   b. In the **Column** list, choose **category**. In the **Order** list, choose **ASC** to sort in ascending order on the values in this column. (Choose **DESC** for descending order.)

   c. Then select **Add clustering column** and choose **rank**.

9. In the **Table settings** section, choose **Default settings**.
10. Choose **Create table**.
11. Verify that your table was created.
    a. In the navigation pane, choose **Tables**.
    b. Confirm that your table is in the list of tables.
    c. Choose the name of your table.
    d. Confirm that all your columns and data types are correct.

> **Note**
>
> The columns might not be listed in the same order that you added them to the table.

Using CQL

This procedure creates a table with the following columns and data types using CQL. The `year` and `award` columns are partition keys with `category` and `rank` as clustering columns, together they make up the primary key of the table.

```
year           int
award          text
rank           int
category       text
book_title     text
author         text
publisher      text
```

To create a table using CQL

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *`us-east-1`* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

   The output of that command should look like this.

```
Connected to Amazon Keyspaces at cassandra.us-east-1.amazonaws.com:9142
[cqlsh 6.1.0 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
Use HELP for help.
cqlsh current consistency level is ONE.
```

2. At the keyspace prompt (`cqlsh:keyspace_name>`), create your table by entering the following code into your command window.

```
CREATE TABLE catalog.book_awards (
   year int,
   award text,
   rank int,
   category text,
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank)
   );
```

> **Note**
>
> ASC is the default clustering order. You can also specify DESC for descending order.

Note that the `year` and `award` are partition key columns. Then, `category` and `rank` are the clustering columns ordered by ascending order (ASC). Together, these columns form the primary key of the table.

3. Verify that your table was created.

```
SELECT * from system_schema.tables WHERE keyspace_name='catalog.book_awards' ;
```

The output should look similar to this.

```
 keyspace_name | table_name | bloom_filter_fp_chance | caching | cdc | comment
| compaction | compression | crc_check_chance | dclocal_read_repair_chance
| default_time_to_live | extensions | flags | gc_grace_seconds | id |
max_index_interval | memtable_flush_period_in_ms | min_index_interval |
read_repair_chance | speculative_retry
```

```
---------------+------------+-----------------------+---------+-----+---------
+------------+-------------+-----------------+--------------------------
+----------------------+------------+-------+------------------+----
+--------------------+----------------------------+-------------------
+--------------------+------------------

(0 rows)
```

4. Verify your table's structure.

```
SELECT * FROM system_schema.columns WHERE keyspace_name = 'catalog' AND table_name
 = 'book_awards';
```

The output of this statement should look similar to this example.

```
 keyspace_name | table_name  | column_name | clustering_order | column_name_bytes
    | kind          | position | type
---------------+-------------+-------------+------------------
+------------------------+---------------+----------+------
       catalog | book_awards |        year |             none |
 0x79656172 | partition_key |        0 |  int
       catalog | book_awards |       award |             none |
 0x6177617264 | partition_key |        1 | text
       catalog | book_awards |    category |              asc |
 0x63617465676f7279 |    clustering |        0 | text
       catalog | book_awards |        rank |              asc |
 0x72616e6b |    clustering |        1 |  int
       catalog | book_awards |      author |             none |
 0x617574686f72 |       regular |       -1 | text
       catalog | book_awards |  book_title |             none |
 0x626f6f6b5f7469746c65 |       regular |       -1 | text
       catalog | book_awards |   publisher |             none |
 0x7075626c6973686572 |       regular |       -1 | text

(7 rows)
```

Confirm that all the columns and data types are as you expected. The order of the columns might be different than in the CREATE statement.

Using the AWS CLI

This procedure creates a table with the following columns and data types using the AWS CLI. The `year` and `award` columns make up the partition key with `category` and `rank` as clustering columns.

```
year           int
award          text
rank           int
category       text
book_title     text
author         text
publisher      text
```

To create a table using the AWS CLI

The following command creates a table with the name *book_awards*. The partition key of the table consists of the columns `year` and `award` and the clustering key consists of the columns `category` and `rank`, both clustering columns use the ascending sort order. (For easier readability, the `schema-definition` of the table create command in this section is broken into separate lines.)

1. You can create the table using the following statement.

   ```
   aws keyspaces create-table --keyspace-name 'catalog' \
                         --table-name 'book_awards' \
                         --schema-definition 'allColumns=[{name=year,type=int},
   {name=award,type=text},{name=rank,type=int},
               {name=category,type=text}, {name=author,type=text},
   {name=book_title,type=text},{name=publisher,type=text}],
               partitionKeys=[{name=year},
   {name=award}],clusteringKeys=[{name=category,orderBy=ASC},{name=rank,orderBy=ASC}]'
   ```

   This command results in the following output.

   ```
   {
       "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/
   table/book_awards"
   }
   ```

2. To confirm the metadata and properties of the table, you can use the following command.

```
aws keyspaces get-table --keyspace-name 'catalog' --table-name 'book_awards'
```

This command returns the following output.

```
{
    "keyspaceName": "catalog",
    "tableName": "book_awards",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/catalog/
table/book_awards",
    "creationTimestamp": "2024-07-11T15:12:55.571000+00:00",
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "year",
                "type": "int"
            },
            {
                "name": "award",
                "type": "text"
            },
            {
                "name": "category",
                "type": "text"
            },
            {
                "name": "rank",
                "type": "int"
            },
            {
                "name": "author",
                "type": "text"
            },
            {
                "name": "book_title",
                "type": "text"
            },
            {
                "name": "publisher",
                "type": "text"
            }
        ],
```

```
        "partitionKeys": [
            {
                "name": "year"
            },
            {
                "name": "award"
            }
        ],
        "clusteringKeys": [
            {
                "name": "category",
                "orderBy": "ASC"
            },
            {
                "name": "rank",
                "orderBy": "ASC"
            }
        ],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-07-11T15:12:55.571000+00:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    },
    "replicaSpecifications": []
}
```

To perform CRUD (create, read, update, and delete) operations on the data in your table, proceed to the section called “CRUD operations”.

Check table creation status in Amazon Keyspaces

Amazon Keyspaces performs data definition language (DDL) operations, such as creating and deleting tables, asynchronously. You can monitor the creation status of new tables in the AWS Management Console, which indicates when a table is pending or active. You can also monitor the creation status of a new table programmatically by using the system schema table.

A table shows as active in the system schema when it's ready for use. The recommended design pattern to check when a new table is ready for use is to poll the Amazon Keyspaces system schema tables (`system_schema_mcs.*`). For a list of DDL statements for tables, see the the section called "Tables" section in the CQL language reference.

The following query shows the status of a table.

```
SELECT keyspace_name, table_name, status FROM system_schema_mcs.tables WHERE
 keyspace_name = 'mykeyspace' AND table_name = 'mytable';
```

For a table that is still being created and is pending,the output of the query looks like this.

```
keyspace_name | table_name | status
--------------+------------+--------
   mykeyspace |    mytable | CREATING
```

For a table that has been successfully created and is active, the output of the query looks like the following.

```
keyspace_name | table_name | status
--------------+------------+--------
   mykeyspace |    mytable | ACTIVE
```

Create, read, update, and delete data (CRUD) using CQL in Amazon Keyspaces

In this step of the tutorial, you'll learn how to insert, read, update, and delete data in an Amazon Keyspaces table using CQL data manipulation language (DML) statements. In Amazon Keyspaces,

you can only create DML statements in CQL language. In this tutorial, you'll practice running DML statements using the `cqlsh-expansion` with AWS CloudShell in the AWS Management Console.

- **Inserting data** – This section covers inserting single and multiple records into a table using the `INSERT` statement. You'll learn how to upload data from a CSV file and verify successful inserts using `SELECT` queries.
- **Reading data** – Here, you'll explore different variations of the `SELECT` statement to retrieve data from a table. Topics include selecting all data, selecting specific columns, filtering rows based on conditions using the `WHERE` clause, and understanding simple and compound conditions.
- **Updating data** – In this section, you'll learn how to modify existing data in a table using the `UPDATE` statement. You'll practice updating single and multiple columns while understanding restrictions around updating primary key columns.
- **Deleting data** – The final section covers deleting data from a table using the `DELETE`statement. You'll learn how to delete specific cells, entire rows, and the implications of deleting data versus deleting the entire table or keyspace.

Throughout the tutorial, you'll find examples, tips, and opportunities to practice writing your own CQL queries for various scenarios.

Topics

- Inserting and loading data into an Amazon Keyspaces table
- Read data from a table using the CQL SELECT statement in Amazon Keyspaces
- Update data in an Amazon Keyspaces table using CQL
- Delete data from a table using the CQL DELETE statement

Inserting and loading data into an Amazon Keyspaces table

To create data in your `book_awards` table, use the `INSERT` statement to add a single row.

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *`us-east-1`* with your own Region.

   ```
   cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
   ```

   The output of that command should look like this.

```
Connected to Amazon Keyspaces at cassandra.us-east-1.amazonaws.com:9142
[cqlsh 6.1.0 | Cassandra 3.11.2 | CQL spec 3.4.4 | Native protocol v4]
Use HELP for help.
cqlsh current consistency level is ONE.
```

2. Before you can write data to your Amazon Keyspaces table using cqlsh, you must set the write consistency for the current cqlsh session to `LOCAL_QUORUM`. For more information about supported consistency levels, see the section called “Write consistency levels”. Note that this step is not required if you are using the CQL editor in the AWS Management Console.

```
CONSISTENCY LOCAL_QUORUM;
```

3. To insert a single record, run the following command in the CQL editor.

```
INSERT INTO catalog.book_awards (award, year, category, rank, author, book_title,
 publisher)
VALUES ('Wolf', 2023, 'Fiction',3,'Shirley Rodriguez','Mountain', 'AnyPublisher') ;
```

4. Verify that the data was correctly added to your table by running the following command.

```
SELECT * FROM catalog.book_awards;
```

   The output of the statement should look like this.

```
 year | award | category | rank | author            | book_title | publisher
------+-------+----------+------+-------------------+------------+-------------
 2023 |  Wolf |  Fiction |    3 | Shirley Rodriguez |   Mountain | AnyPublisher

(1 rows)
```

To insert multiple records from a file using cqlsh

1. Download the sample CSV file (`keyspaces_sample_table.csv`) contained in the archive file samplemigration.zip. Unzip the archive and take note of the path to `keyspaces_sample_table.csv`.

award	year	category	rank	author	book_title	publisher
Kwesi Manu Prize	2020	Fiction	1	Akua Mansa	Where did you go?	SomePublisher
Kwesi Manu Prize	2020	Fiction	2	John Stiles	Yesterday	Example Books
Kwesi Manu Prize	2020	Fiction	3	Nikki Wolf	Moving to the Chateau	AnyPublisher
Wolf	2020	Non-Fiction	1	Wang Xiulan	History of Ideas	Example Books
Wolf	2020	Non-Fiction	2	Ana Carolina Silva	Science Today	SomePublisher
Wolf	2020	Non-Fiction	3	Shirley Rodriguez	The Future of Sea Ice	AnyPublisher
Richard Roe	2020	Fiction	1	Alejandro Rosalez	Long Summer	SomePublisher
Richard Roe	2020	Fiction	2	Arnav Desai	The Key	Example Books
Richard Roe	2020	Fiction	3	Mateo Jackson	Inside the Whale	AnyPublisher

2. Open AWS CloudShell in the AWS Management Console and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

3. At the `cqlsh` prompt (`cqlsh>`), specify a keyspace.

```
USE catalog ;
```

4. Set write consistency to `LOCAL_QUORUM`. For more information about supported consistency levels, see the section called “Write consistency levels”.

```
CONSISTENCY LOCAL_QUORUM;
```

5. In the AWS CloudShell choose **Actions** on the top right side of the screen and then choose **Upload file** to upload the csv file downloaded earlier. Take note of the path to the file.
6. At the keyspace prompt (`cqlsh:catalog>`), run the following statement.

```
COPY book_awards (award, year, category, rank, author, book_title, publisher) FROM
 '/home/cloudshell-user/keyspaces_sample_table.csv' WITH header=TRUE ;
```

The output of the statement should look similar to this.

```
cqlsh:catalog> COPY book_awards (award, year, category, rank, author,
 book_title, publisher)                      FROM '/home/cloudshell-user/
keyspaces_sample_table.csv' WITH delimiter=',' AND header=TRUE ;
cqlsh current consistency level is LOCAL_QUORUM.
Reading options from /home/cloudshell-user/.cassandra/cqlshrc:[copy]:
 {'numprocesses': '16', 'maxattempts': '1000'}
```

```
Reading options from /home/cloudshell-user/.cassandra/cqlshrc:[copy-from]:
 {'ingestrate': '1500', 'maxparseerrors': '1000', 'maxinserterrors': '-1',
 'maxbatchsize': '10', 'minbatchsize': '1', 'chunksize': '30'}
Reading options from the command line: {'delimiter': ',', 'header': 'TRUE'}
Using 16 child processes

Starting copy of catalog.book_awards with columns [award, year, category, rank,
 author, book_title, publisher].
OSError: handle is closed      0 rows/s; Avg. rate:       0 rows/s
Processed: 9 rows; Rate:       0 rows/s; Avg. rate:       0 rows/s
9 rows imported from 1 files in 0 day, 0 hour, 0 minute, and 26.706 seconds (0
 skipped).
```

7. Verify that the data was correctly added to your table by running the following query.

```
SELECT * FROM book_awards ;
```

You should see the following output.

```
 year | award            | category    | rank | author             | book_title
        | publisher
------+------------------+-------------+------+--------------------
+----------------------+---------------
 2020 |             Wolf | Non-Fiction |    1 |        Wang Xiulan |      History
 of Ideas | Example Books
 2020 |             Wolf | Non-Fiction |    2 | Ana Carolina Silva |
 Science Today | SomePublisher
 2020 |             Wolf | Non-Fiction |    3 |  Shirley Rodriguez | The Future of
 Sea Ice |  AnyPublisher
 2020 | Kwesi Manu Prize |     Fiction |    1 |         Akua Mansa |     Where did
 you go? | SomePublisher
 2020 | Kwesi Manu Prize |     Fiction |    2 |        John Stiles |
 Yesterday | Example Books
 2020 | Kwesi Manu Prize |     Fiction |    3 |         Nikki Wolf | Moving to the
 Chateau |  AnyPublisher
 2020 |      Richard Roe |     Fiction |    1 |  Alejandro Rosalez |           Long
 Summer | SomePublisher
 2020 |      Richard Roe |     Fiction |    2 |        Arnav Desai |
 The Key | Example Books
 2020 |      Richard Roe |     Fiction |    3 |      Mateo Jackson |      Inside
 the Whale |  AnyPublisher
```

```
(9 rows)
```

To learn more about using `cqlsh COPY` to upload data from csv files to an Amazon Keyspaces table, see the section called “Loading data using cqlsh”.

Read data from a table using the CQL SELECT statement in Amazon Keyspaces

In the Inserting and loading data into an Amazon Keyspaces table section, you used the SELECT statement to verify that you had successfully added data to your table. In this section, you refine your use of SELECT to display specific columns, and only rows that meet specific criteria.

The general form of the SELECT statement is as follows.

```
SELECT column_list FROM table_name [WHERE condition [ALLOW FILTERING]] ;
```

Topics

- Select all the data in your table
- Select a subset of columns
- Select a subset of rows

Select all the data in your table

The simplest form of the SELECT statement returns all the data in your table.

> **Important**
>
> In a production environment, it's typically not a best practice to run this command, because it returns all the data in your table.

To select all your table's data

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

   ```
   cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
   ```

2. Run the following query.

```
SELECT * FROM catalog.book_awards ;
```

Using the wild-card character (*) for the `column_list` selects all columns. The output of the statement looks like the following example.

```
 year | award            | category    | rank | author             | book_title
       | publisher
------+------------------+-------------+------+--------------------
+----------------------+--------------
 2020 |             Wolf | Non-Fiction |    1 |        Wang Xiulan |      History
 of Ideas |  AnyPublisher
 2020 |             Wolf | Non-Fiction |    2 | Ana Carolina Silva |
 Science Today | SomePublisher
 2020 |             Wolf | Non-Fiction |    3 |  Shirley Rodriguez | The Future of
 Sea Ice |  AnyPublisher
 2020 | Kwesi Manu Prize |     Fiction |    1 |         Akua Mansa |     Where did
 you go? | SomePublisher
 2020 | Kwesi Manu Prize |     Fiction |    2 |        John Stiles |
 Yesterday | Example Books
 2020 | Kwesi Manu Prize |     Fiction |    3 |         Nikki Wolf | Moving to the
 Chateau |  AnyPublisher
 2020 |      Richard Roe |     Fiction |    1 |  Alejandro Rosalez |           Long
 Summer | SomePublisher
 2020 |      Richard Roe |     Fiction |    2 |        Arnav Desai |
 The Key | Example Books
 2020 |      Richard Roe |     Fiction |    3 |      Mateo Jackson |      Inside
 the Whale |  AnyPublisher
```

Select a subset of columns

To query for a subset of columns

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

2. To retrieve only the `award`, `category`, and `year` columns, run the following query.

```
SELECT award, category, year FROM catalog.book_awards ;
```

The output contains only the specified columns in the order listed in the SELECT statement.

```
 award            | category    | year
------------------+-------------+------
             Wolf | Non-Fiction | 2020
             Wolf | Non-Fiction | 2020
             Wolf | Non-Fiction | 2020
 Kwesi Manu Prize |     Fiction | 2020
 Kwesi Manu Prize |     Fiction | 2020
 Kwesi Manu Prize |     Fiction | 2020
      Richard Roe |     Fiction | 2020
      Richard Roe |     Fiction | 2020
      Richard Roe |     Fiction | 2020
```

Select a subset of rows

When querying a large dataset, you might only want records that meet certain criteria. To do this, you can append a WHERE clause to the end of our SELECT statement.

To query for a subset of rows

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

2. To retrieve only the records for the awards of a given year, run the following query.

```
SELECT * FROM catalog.book_awards WHERE year=2020 AND award='Wolf' ;
```

The preceding SELECT statement returns the following output.

```
 year | award | category    | rank | author            | book_title           |
 publisher
------+-------+-------------+------+-------------------+----------------------
+---------------
```

```
 2020 |  Wolf | Non-Fiction |    1 |        Wang Xiulan |      History of Ideas |
AnyPublisher
 2020 |  Wolf | Non-Fiction |    2 | Ana Carolina Silva |         Science Today |
SomePublisher
 2020 |  Wolf | Non-Fiction |    3 |  Shirley Rodriguez | The Future of Sea Ice |
AnyPublisher
```

Understanding the WHERE clause

The WHERE clause is used to filter the data and return only the data that meets the specified criteria. The specified criteria can be a simple condition or a compound condition.

How to use conditions in a WHERE clause

- A simple condition – A single column.

  ```
  WHERE column_name=value
  ```

  You can use a simple condition in a WHERE clause if any of the following conditions are met:

  - The column is the only partition key column of the table.
  - You add ALLOW FILTERING after the condition in the WHERE clause.

    Be aware that using ALLOW FILTERING can result in inconsistent performance, especially with large, and multi-partitioned tables.
- A compound condition – Multiple simple conditions connected by AND.

  ```
  WHERE column_name1=value1 AND column_name2=value2 AND column_name3=value3...
  ```

  You can use compound conditions in a WHERE clause if any of the following conditions are met:

  - The columns you can use in the WHERE clause need to include either all or a subset of the columns in the table's partition key. If you want to use only a subset of the columns in the WHERE clause, you must include a contiguous set of partition key columns from left to right, beginning with the partition key's leading column. For example, if the partition key columns are year, month, and award then you can use the following columns in the WHERE clause:
    - year
    - year AND month
    - year AND month AND award

- You add `ALLOW FILTERING` after the compound condition in the `WHERE` clause, as in the following example.

  ```
  SELECT * FROM my_table WHERE col1=5 AND col2='Bob' ALLOW FILTERING ;
  ```

  Be aware that using `ALLOW FILTERING` can result in inconsistent performance, especially with large, and multi-partitioned tables.

Try it

Create your own CQL queries to find the following from your `book_awards` table:

- Find the winners of the 2020 Wolf awards and display the book titles and authors, ordered by rank.
- Show the first prize winners for all awards in 2020 and display the book titles and award names.

Update data in an Amazon Keyspaces table using CQL

To update the data in your `book_awards` table, use the `UPDATE` statement.

The general form of the `UPDATE` statement is as follows.

```
UPDATE table_name SET column_name=new_value WHERE primary_key=value ;
```

Tip

- You can update multiple columns by using a comma-separated list of `column_names` and values, as in the following example.

  ```
  UPDATE my_table SET col1='new_value_1', col2='new_value2' WHERE col3='1' ;
  ```

- If the primary key is composed of multiple columns, all primary key columns and their values must be included in the `WHERE` clause.
- You cannot update any column in the primary key because that would change the primary key for the record.

To update a single cell

Using your book_awards table, change the name of a publisher the for winner of the non-fiction Wolf awards in 2020.

```
UPDATE book_awards SET publisher='new Books' WHERE year = 2020 AND award='Wolf' AND
 category='Non-Fiction' AND rank=1;
```

Verify that the publisher is now new Books.

```
SELECT * FROM book_awards WHERE year = 2020 AND award='Wolf' AND category='Non-Fiction'
 AND rank=1;
```

The statement should return the following output.

```
 year | award | category    | rank | author      | book_title       | publisher
------+-------+-------------+------+-------------+------------------+-----------
 2020 |  Wolf | Non-Fiction |    1 | Wang Xiulan | History of Ideas | new Books
```

Try it

Advanced: The winner of the 2020 fiction "Kwezi Manu Prize" has changed their name. Update this record to change the name to 'Akua Mansa-House'.

Delete data from a table using the CQL DELETE statement

To delete data in your book_awards table, use the DELETE statement.

You can delete data from a row or from a partition. Be careful when deleting data, because deletions are irreversible.

Deleting one or all rows from a table doesn't delete the table. Thus you can repopulate it with data. Deleting a table deletes the table and all data in it. To use the table again, you must re-create it and add data to it. Deleting a keyspace deletes the keyspace and all tables within it. To use the keyspace and tables, you must re-create them, and then populate them with data. You can use Amazon Keyspaces Point-in-time (PITR) recovery to help restore deleted tables, to learn more see the section called “Backup and restore with point-in-time recovery” . To learn how to restore a deleted table with PITR enabled, see the section called “Restore a deleted table”.

Delete cells

Deleting a column from a row removes the data from the specified cell. When you display that column using a SELECT statement, the data is displayed as *null*, though a null value is not stored in that location.

The general syntax to delete one or more specific columns is as follows.

```
DELETE column_name1[, column_name2...] FROM table_name WHERE condition ;
```

In your book_awards table, you can see that the title of the book that won the first price of the 2020 "Richard Roe" price is "Long Summer". Imagine that this title has been recalled, and you need to delete the data from this cell.

To delete a specific cell

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

   ```
   cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
   ```

2. Run the following DELETE query.

   ```
   DELETE book_title FROM catalog.book_awards WHERE year=2020 AND award='Richard Roe'
    AND category='Fiction' AND rank=1;
   ```

3. Verify that the delete request was made as expected.

   ```
   SELECT * FROM catalog.book_awards WHERE year=2020 AND award='Richard Roe' AND
    category='Fiction' AND rank=1;
   ```

   The output of this statement looks like this.

   ```
    year | award       | category | rank | author            | book_title | publisher
   ------+-------------+----------+------+-------------------+------------
   +---------------
    2020 | Richard Roe |  Fiction |    1 | Alejandro Rosalez |       null |
    SomePublisher
   ```

Delete rows

There might be a time when you need to delete an entire row, for example to meet a data deletion request. The general syntax for deleting a row is as follows.

```
DELETE FROM table_name WHERE condition ;
```

To delete a row

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *us-east-1* with your own Region.

   ```
   cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
   ```

2. Run the following DELETE query.

   ```
   DELETE FROM catalog.book_awards WHERE year=2020 AND award='Richard Roe' AND
    category='Fiction' AND rank=1;
   ```

3. Verify that the delete was made as expected.

   ```
   SELECT * FROM catalog.book_awards WHERE year=2020 AND award='Richard Roe' AND
    category='Fiction' AND rank=1;
   ```

   The output of this statement looks like this after the row has been deleted.

   ```
    year | award | category | rank | author | book_title | publisher
   ------+-------+----------+------+--------+------------+-----------

   (0 rows)
   ```

You can delete expired data automatically from your table using Amazon Keyspaces Time to Live, for more information, see the section called “Expire data with Time to Live”.

Delete a table in Amazon Keyspaces

To avoid being charged for tables and data that you don't need, delete all the tables that you're not using. When you delete a table, the table and its data are deleted and you stop accruing charges

for them. However, the keyspace remains. When you delete a keyspace, the keyspace and all its tables are deleted and you stop accruing charges for them.

You can delete a table using the console, CQL, or the AWS CLI. When you delete a table, the table and all its data are deleted.

Using the console

The following procedure deletes a table and all its data using the AWS Management Console.

To delete a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose the box to the left of the name of each table that you want to delete.
4. Choose **Delete**.
5. On the **Delete table** screen, enter **`Delete`** in the box. Then, choose **Delete table**.
6. To verify that the table was deleted, choose **Tables** in the navigation pane, and confirm that the `book_awards` table is no longer listed.

Using CQL

The following procedure deletes a table and all its data using CQL.

To delete a table using CQL

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *`us-east-1`* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

2. Delete your table by entering the following statement.

```
DROP TABLE IF EXISTS catalog.book_awards ;
```

3. Verify that your table was deleted.

```
SELECT * FROM system_schema.tables WHERE keyspace_name = 'catalog' ;
```

The output should look like this. Note that this might take some time, so re-run the statement after a minute if you don't see this result.

```
keyspace_name | table_name | bloom_filter_fp_chance | caching | cdc | comment
 | compaction | compression | crc_check_chance | dclocal_read_repair_chance
 | default_time_to_live | extensions | flags | gc_grace_seconds | id |
 max_index_interval | memtable_flush_period_in_ms | min_index_interval |
 read_repair_chance | speculative_retry
---------------+------------+-----------------------+---------+-----+---------
+------------+-------------+-----------------+--------------------------
+---------------------+------------+-------+-----------------+----
+--------------------+---------------------------+-------------------
+--------------------+------------------

(0 rows)
```

Using the AWS CLI

The following procedure deletes a table and all its data using the AWS CLI.

To delete a table using the AWS CLI

1. Open CloudShell
2. Delete your table with the following statement.

```
aws keyspaces delete-table --keyspace-name 'catalog' --table-name 'book_awards'
```

3. To verify that your table was deleted, you can list all tables in a keyspace.

```
aws keyspaces list-tables --keyspace-name 'catalog'
```

You should see the following output. Note that this asynchronous operation can take some time. Re-run the command again after a short while to confirm that the table has been deleted.

```
{
    "tables": []
}
```

Delete a keyspace in Amazon Keyspaces

To avoid being charged for keyspaces, delete all the keyspaces that you're not using. When you delete a keyspace, the keyspace and all its tables are deleted and you stop accruing charges for them.

You can delete a keyspace using either the console, CQL, or the AWS CLI.

Using the console

The following procedure deletes a keyspace and all its tables and data using the console.

To delete a keyspace using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose the box to the left of the name of each keyspace that you want to delete.
4. Choose **Delete**.
5. On the **Delete keyspace** screen, enter **`Delete`** in the box. Then, choose **Delete keyspace**.
6. To verify that the keyspace `catalog` was deleted, choose **Keyspaces** in the navigation pane and confirm that it is no longer listed. Because you deleted its keyspace, the `book_awards` table under **Tables** should also not be listed.

Using CQL

The following procedure deletes a keyspace and all its tables and data using CQL.

To delete a keyspace using CQL

1. Open AWS CloudShell and connect to Amazon Keyspaces using the following command. Make sure to update *`us-east-1`* with your own Region.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

2. Delete your keyspace by entering the following statement.

```
DROP KEYSPACE IF EXISTS catalog ;
```

3. Verify that your keyspace was deleted.

```
SELECT * from system_schema.keyspaces ;
```

Your keyspace should not be listed. Note that because this is an asynchronous operation, there can be a delay until the keyspace is deleted. After the keyspace has been deleted, the output of the statement should look like this.

```
keyspace_name           | durable_writes | replication
-------------------------+----------------
+-------------------------------------------------------------------------------------
           system_schema |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
      system_schema_mcs |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
                 system |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}
 system_multiregion_info |           True | {'class':
 'org.apache.cassandra.locator.SimpleStrategy', 'replication_factor': '3'}

(4 rows)
```

Using the AWS CLI

The following procedure deletes a keyspace and all its tables and data using the AWS CLI.

To delete a keyspace using the AWS CLI

1. Open AWS CloudShell
2. Delete your keyspace by entering the following statement.

```
aws keyspaces delete-keyspace --keyspace-name 'catalog'
```

3. Verify that your keyspace was deleted.

```
aws keyspaces list-keyspaces
```

The output of this statement should look similar to this, and only list the system keyspaces. Note that because this is an asynchronous operation, there can be a delay until your keyspace is deleted.

```
{
    "keyspaces": [
        {
            "keyspaceName": "system_schema",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
system_schema/",
            "replicationStrategy": "SINGLE_REGION"
        },
        {
            "keyspaceName": "system_schema_mcs",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
system_schema_mcs/",
            "replicationStrategy": "SINGLE_REGION"
        },
        {
            "keyspaceName": "system",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
system/",
            "replicationStrategy": "SINGLE_REGION"
        },
        {
            "keyspaceName": "system_multiregion_info",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
system_multiregion_info/",
            "replicationStrategy": "SINGLE_REGION"
        }
    ]
}
```

Tutorials and solutions for Amazon Keyspaces

This topic includes various tutorials that walk through the detailed steps that are required to connect to Amazon Keyspaces programmatically, or to use Amazon Keyspaces with other AWS services to create solutions. The available tutorials cover different popular cross-service access scenarios and demonstrate how to integrate Amazon Keyspaces with Amazon Virtual Private Cloud, Amazon Elastic Kubernetes Service, Amazon Simple Storage Service, and AWS Glue, or with open source technologies like Apache Spark.

For step-by-step tutorials that show how to connect to Amazon Keyspaces using Apache Cassandra drivers, see the section called "Using a Cassandra client driver".

Topics

- Tutorial: Connect to Amazon Keyspaces using an interface VPC endpoint
- Tutorial: Integrate with Apache Spark to import or export data
- Tutorial: Connect from a containerized application hosted on Amazon Elastic Kubernetes Service
- Tutorial: Export an Amazon Keyspaces table to Amazon S3 using AWS Glue

Tutorial: Connect to Amazon Keyspaces using an interface VPC endpoint

This tutorial walks you through setting up and using an interface VPC endpoint for Amazon Keyspaces.

Interface VPC endpoints enable private communication between your virtual private cloud (VPC) running in Amazon VPC and Amazon Keyspaces. Interface VPC endpoints are powered by AWS PrivateLink, which is an AWS service that enables private communication between VPCs and AWS services. For more information, see the section called "Using interface VPC endpoints".

Topics

- Tutorial prerequisites and considerations
- Step 1: Launch an Amazon EC2 instance
- Step 2: Configure your Amazon EC2 instance
- Step 3: Create a VPC endpoint for Amazon Keyspaces

- Step 4: Configure permissions for the VPC endpoint connection
- Step 5: Configure monitoring with CloudWatch
- Step 6: (Optional) Best practices to configure the connection pool size for your application
- Step 7: (Optional) Clean up

Tutorial prerequisites and considerations

Before you start this tutorial, follow the AWS setup instructions in Accessing Amazon Keyspaces (for Apache Cassandra). These steps include signing up for AWS and creating an AWS Identity and Access Management (IAM) principal with access to Amazon Keyspaces. Take note of the name of the IAM user and the access keys because you'll need them later in this tutorial.

Create a keyspace with the name `myKeyspace`and at least one table to test the connection using the VPC endpoint later in this tutorial. You can find detailed instructions in *Getting started*.

After completing the prerequisite steps, proceed to Step 1: Launch an Amazon EC2 instance.

Step 1: Launch an Amazon EC2 instance

In this step, you launch an Amazon EC2 instance in your default Amazon VPC. You can then create and use a VPC endpoint for Amazon Keyspaces.

To launch an Amazon EC2 instance

1. Open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.
2. Choose **Launch Instance** and do the following:

   From the EC2 console dashboard, in the **Launch instance** box, choose **Launch instance**, and then choose **Launch instance** from the options that appear.

   Under **Name and tags**, for **Name**, enter a descriptive name for your instance.

   Under **Application and OS Images (Amazon Machine Image)**:

   - Choose **Quick Start**, and then choose Ubuntu. This is the operating system (OS) for your instance.
   - Under **Amazon Machine Image (AMI)**, you can use the default image that is marked as **Free tier eligible**. An *Amazon Machine Image (AMI)* is a basic configuration that serves as a template for your instance.

Under **Instance Type**:

- From the **Instance type** list, choose the **t2.micro** instance type, which is selected by default.

Under **Key pair (login)**, for **Key pair name**, choose one of the following options for this tutorial:

- If you don't have an Amazon EC2 key pair, choose **Create a new key pair** and follow the instructions. You will be asked to download a private key file (*.pem* file). You will need this file later when you log in to your Amazon EC2 instance, so take note of the file path.
- If you already have an existing Amazon EC2 key pair, go to **Select a key pair** and choose your key pair from the list. You must already have the private key file (*.pem* file) available in order to log in to your Amazon EC2 instance.

Under **Network Settings**:

- Choose **Edit**.
- Choose **Select an existing security group**.
- In the list of security groups, choose **default**. This is the default security group for your VPC.

Continue to **Summary**.

- Review a summary of your instance configuration in the **Summary** panel. When you're ready, choose **Launch instance**.

3. On the completion screen for the new Amazon EC2 instance, choose the **Connect to instance** tile. The next screen shows the necessary information and the required steps to connect to your new instance. Take note of the following information:

   - The sample command to protect the key file
   - The connection string
   - The **Public IPv4 DNS** name

   After taking note of the information on this page, you can continue to the next step in this tutorial (Step 2: Configure your Amazon EC2 instance).

> **Note**
>
> It takes a few minutes for your Amazon EC2 instance to become available. Before you go on to the next step, ensure that the **Instance State** is `running` and that all of its **Status Checks** have passed.

Step 2: Configure your Amazon EC2 instance

When your Amazon EC2 instance is available, you can log into it and prepare it for first use.

> **Note**
>
> The following steps assume that you're connecting to your Amazon EC2 instance from a computer running Linux. For other ways to connect, see Connect to your Linux instance in the *Amazon EC2 User Guide*.

To configure your Amazon EC2 instance

1. You need to authorize inbound SSH traffic to your Amazon EC2 instance. To do this, create a new EC2 security group, and then assign the security group to your EC2 instance.

   a. In the navigation pane, choose **Security Groups**.

   b. Choose **Create Security Group**. In the **Create Security Group** window, do the following:

   - **Security group name** – Enter a name for your security group. For example: `my-ssh-access`
   - **Description** – Enter a short description for the security group.
   - **VPC** – Choose your default VPC.
   - In the **Inbound rules** section, choose **Add Rule** and do the following:
     - **Type** – Choose **SSH**.
     - **Source** – Choose **My IP**.
     - Choose **Add rule**.

   On the bottom of the page, confirm the configuration settings and choose **Create Security Group**.

c. In the navigation pane, choose **Instances**.

d. Choose the Amazon EC2 instance that you launched in Step 1: Launch an Amazon EC2 instance.

e. Choose **Actions**, choose **Security**, and then choose **Change Security Groups**.

f. In **Change Security Groups**, go to **Associated security groups** and enter the security group that you created earlier in this procedure (for example, `my-ssh-access`). The existing `default` security group should also be selected. Confirm the configuration settings and choose **Save**.

2. Use the following command to protect your private key file from access. If you skip this step, the connection fails.

```
chmod 400 path_to_file/my-keypair.pem
```

3. Use the `ssh` command to log in to your Amazon EC2 instance, as in the following example.

```
ssh -i path_to_file/my-keypair.pem ubuntu@public-dns-name
```

You need to specify your private key file (*.pem* file) and the public DNS name of your instance. (See Step 1: Launch an Amazon EC2 instance).

The login ID is `ubuntu`. No password is required.

For more information about allowing connections to your Amazon EC2 instance and for AWS CLI instructions, see Authorize inbound traffic for your Linux instances in the *Amazon EC2 User Guide*.

4. Download and install the latest version of the AWS Command Line Interface.

a. Install `unzip`.

```
sudo apt install unzip
```

b. Download the `zip` file with the AWS CLI.

```
curl "https://awscli.amazonaws.com/awscli-exe-linux-x86_64.zip" -o
 "awscliv2.zip"
```

c. Unzip the file.

```
unzip awscliv2.zip
```

d. Install the AWS CLI.

```
sudo ./aws/install
```

e. Confirm the version of the AWS CLI installation.

```
aws --version
```

The output should look like this:

```
aws-cli/2.9.19 Python/3.9.11 Linux/5.15.0-1028-aws exe/x86_64.ubuntu.22 prompt/
off
```

5. Configure your AWS credentials, as shown in the following example. Enter your AWS access key ID, secret key, and default Region name when prompted.

```
aws configure

AWS Access Key ID [None]: AKIAIOSFODNN7EXAMPLE
AWS Secret Access Key [None]: wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
Default region name [None]: us-east-1
Default output format [None]:
```

6. Add rules to your VPCs security group that allow inbound HTTP, HTTPS, and SSH access from IPv6 addresses.

7. To confirm that your VPC endpoint has been configured correctly, you have to use a `cqlsh` connection to Amazon Keyspaces. If you use your local environment or the Amazon Keyspaces CQL editor in the AWS Management Console, the connection automatically goes through the public endpoint instead of your VPC endpoint. To use `cqlsh` to test your VPC endpoint connection in this tutorial, complete the setup instructions in Using `cqlsh` to connect to Amazon Keyspaces.

You are now ready to create a dual-stack VPC endpoint for Amazon Keyspaces.

Step 3: Create a VPC endpoint for Amazon Keyspaces

In this step, you create a dual-stack VPC endpoint for Amazon Keyspaces using the AWS CLI.
To create the VPC endpoint using the VPC console, you can follow the Create a VPC endpoint instructions in the *AWS PrivateLink Guide*. When filtering for the **Service name**, enter **`Cassandra`**.

To create a VPC endpoint using the AWS CLI

1. Before you begin, verify that you can communicate with Amazon Keyspaces using its public endpoint.

```
aws keyspaces list-tables --keyspace-name 'myKeyspace'
```

   The output shows a list of Amazon Keyspaces tables that are contained in the specified keyspace. If you don't have any tables, the list is empty.

```
{
    "tables": [
        {
            "keyspaceName": "myKeyspace",
            "tableName": "myTable1",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
catalog/table/myTable1"
        },
        {
            "keyspaceName": "myKeyspace",
            "tableName": "myTable2",
            "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
catalog/table/myTable2"
        }
    ]
}
```

2. Verify that Amazon Keyspaces is an available service for creating VPC endpoints in the current AWS Region. (The command is shown in bold text, followed by example output.)

```
aws ec2 describe-vpc-endpoint-services

{
    "ServiceNames": [
        "com.amazonaws.us-east-1.cassandra",
```

```
        "com.amazonaws.us-east-1.cassandra-fips"
        "api.aws.us-east-1.cassandra-streams"
    ]
}
```

If Amazon Keyspaces is one of the available services in the output of the command, you can proceed with creating a VPC endpoint.

3. To connect to Amazon Keyspaces using IPv6 enabled dual-stack endpoints, confirm that your VPC supports IPv6 and configure subnets with IPv6 support. To add IPv6 support to an existing VPC that currently only supports IPv4, see IPv6 support for your VPC in the *Amazon VPC User Guide;*.

4. Determine your VPC identifier.

```
aws ec2 describe-vpcs

{
    "Vpcs": [
        {
            "OwnerId": "111122223333",
            "InstanceTenancy": "default",
            "Ipv6CidrBlockAssociationSet": [
                {
                    "AssociationId": "vpc-cidr-assoc-0000aaa0a00a00aa0",
                    "Ipv6CidrBlock": "2600:1f18:e19:7d00::/56",
                    "Ipv6CidrBlockState": {
                        "State": "associated"
                    },
                    "NetworkBorderGroup": "us-east-1",
                    "Ipv6Pool": "Amazon",
                    "Ipv6AddressAttribute": "public",
                    "IpSource": "amazon"
                }
            ],
            "CidrBlockAssociationSet": [
                {
                    "AssociationId": "vpc-cidr-assoc-00a0000a",
                    "CidrBlock": "111.11.0.0/16",
                    "CidrBlockState": {
                        "State": "associated"
                    }
                }
```

```
            ],
            "IsDefault": true,
            "BlockPublicAccessStates": {
                "InternetGatewayBlockMode": "off"
            },
            "VpcId": "vpc-a1234bcd",
            "State": "available",
            "CidrBlock": "111.11.0.0/16",
            "DhcpOptionsId": "dopt-a00aaaaa"
        }
    ]
}
```

In the example output, the VPC ID is `vpc-a1234bcd`.

5. Use a filter to gather details about the subnets of the VPC.

```
aws ec2 describe-subnets --filters "Name=vpc-id,Values=vpc-a1234bcd"

{
    "Subnets": [
        {
            "AvailabilityZoneId": "use1-az1",
            "MapCustomerOwnedIpOnLaunch": false,
            "OwnerId": "111122223333",
            "AssignIpv6AddressOnCreation": false,
            "Ipv6CidrBlockAssociationSet": [
                {
                    "AssociationId": "subnet-cidr-assoc-05d75732736740283",
                    "Ipv6CidrBlock": "**********************",
                    "Ipv6CidrBlockState": {
                        "State": "associated"
                    },
                    "Ipv6AddressAttribute": "public",
                    "IpSource": "amazon"
                }
            ],
            "SubnetArn": "arn:aws:ec2:us-east-1:111122223333:subnet/
subnet-70b24b16",
            "EnableDns64": false,
            "Ipv6Native": false,
            "PrivateDnsNameOptionsOnLaunch": {
                "HostnameType": "ip-name",
                "EnableResourceNameDnsARecord": false,
```

```
                "EnableResourceNameDnsAAAARecord": false
            },
            "BlockPublicAccessStates": {
                "InternetGatewayBlockMode": "off"
            },
            "SubnetId": "subnet-70b24b16",
            "State": "available",
            "VpcId": "vpc-a1234bcd",
            "CidrBlock": "**********/20",
            "AvailableIpAddressCount": 4089,
            "AvailabilityZone": "us-east-1a",
            "DefaultForAz": true,
            "MapPublicIpOnLaunch": true
        },
        {
            "AvailabilityZoneId": "use1-az2",
            "MapCustomerOwnedIpOnLaunch": false,
            "OwnerId": "111122223333",
            "AssignIpv6AddressOnCreation": false,
            "Ipv6CidrBlockAssociationSet": [
                {
                    "AssociationId": "subnet-cidr-assoc-0ec6fb253e05b17eb",
                    "Ipv6CidrBlock": "**********************",
                    "Ipv6CidrBlockState": {
                        "State": "associated"
                    },
                    "Ipv6AddressAttribute": "public",
                    "IpSource": "amazon"
                }
            ],
            "SubnetArn": "arn:aws:ec2:us-east-1:111122223333:subnet/subnet-
c63ffbe7",
            "EnableDns64": false,
            "Ipv6Native": false,
            "PrivateDnsNameOptionsOnLaunch": {
                "HostnameType": "ip-name",
                "EnableResourceNameDnsARecord": false,
                "EnableResourceNameDnsAAAARecord": false
            },
            "BlockPublicAccessStates": {
                "InternetGatewayBlockMode": "off"
            },
            "SubnetId": "subnet-c63ffbe7",
            "State": "available",
```

```
            "VpcId": "vpc-a1234bcd",
            "CidrBlock": "***********/20",
            "AvailableIpAddressCount": 4087,
            "AvailabilityZone": "us-east-1b",
            "DefaultForAz": true,
            "MapPublicIpOnLaunch": true
        }
    ]
}
```

In the example output, there are two available subnet IDs: `subnet-70b24b16` and `subnet-c63ffbe7`.

6. Create the VPC endpoint. For the `--vpc-id` parameter, specify the VPC ID from the previous step. For the `--subnet-ids` parameter, specify the subnet IDs from the previous step. Use the `--vpc-endpoint-type` parameter to define the endpoint as an interface. To create a dual-stack endpoint, use `--ip-address-type dualstack`. For more information about the command, see `create-vpc-endpoint` in the *AWS CLI Command Reference*.

```
aws ec2 create-vpc-endpoint \
 --vpc-endpoint-type Interface \
 --vpc-id vpc-a1234bcd \
 --ip-address-type dualstack \
 --service-name com.amazonaws.us-east-1.cassandra \
 --subnet-ids subnet-70b24b16 subnet-c63ffbe7

{
    "VpcEndpoint": {
        "VpcEndpointId": "vpce-000000abc111d2ef3",
        "VpcEndpointType": "Interface",
        "VpcId": "vpc-a1234bcd",
        "ServiceName": "com.amazonaws.us-east-1.cassandra",
        "State": "pending",
        "RouteTableIds": [],
        "SubnetIds": [
            "subnet-70b24b16",
            "subnet-c63ffbe7"
        ],
        "Groups": [
            {
                "GroupId": "sg-0123456789",
                "GroupName": "default"
            }
```

```
        ],
        "IpAddressType": "dualstack",
        "DnsOptions": {
            "DnsRecordIpType": "dualstack"
        },
        "PrivateDnsEnabled": true,
        "RequesterManaged": false,
        "NetworkInterfaceIds": [
            "eni-08cd525f72ea6f1fa",
            "eni-07b1f6c895169d8fb"
        ],
        "DnsEntries": [
            {
                "DnsName": "vpce-0000000000-1234567.cassandra.us-
east-1.vpce.amazonaws.com",
                "HostedZoneId": "Z7HUB22UULQXV"
            },
            {
                "DnsName": "vpce-0000000000-1234567-us-east-1a.cassandra.us-
east-1.vpce.amazonaws.com",
                "HostedZoneId": "Z7HUB22UULQXV"
            },
            {
                "DnsName": "cassandra.us-east-1.amazonaws.com",
                "HostedZoneId": "ZONEIDPENDING"
            },
            {
                "DnsName": "cassandra.us-east-1.api.aws",
                "HostedZoneId": "ZONEIDPENDING"
            }
        ],
        "CreationTimestamp": "2025-09-19T15:19:19.266000+00:00",
        "OwnerId": "111122223333",
        "ServiceRegion": "us-east-1"
    }
}
```


Step 4: Configure permissions for the VPC endpoint connection

The procedures in this step demonstrate how to configure rules and permissions for using the VPC endpoint with Amazon Keyspaces.

To configure an inbound rule for the new endpoint to allow TCP inbound traffic

1. In the Amazon VPC console, on the left-side panel, choose **Endpoints** and choose the endpoint you created in the earlier step.
2. Choose **Manage security groups** and then choose the security group associated with this endpoint.
3. Choose **Inbound rules** and then choose **Edit inbound rules**.
4. Add an inbound rule with **Type** as **CQLSH / CASSANDRA**. This sets the **Port range**, automatically to **9142**.
5. To save the new inbound rule, choose **Save rules**.

To configure IAM user permissions

1. Confirm that the IAM user used to connect to Amazon Keyspaces has the appropriate permissions. In AWS Identity and Access Management (IAM), you can use the AWS managed policy `AmazonKeyspacesReadOnlyAccess` to grant the IAM user read access to Amazon Keyspaces.

   a. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.

   b. On the IAM console dashboard, choose **Users**, and then choose your IAM user from the list.

   c. On the **Summary** page, choose **Add permissions**.

   d. Choose **Attach existing policies directly**.

   e. From the list of policies, choose **AmazonKeyspacesReadOnlyAccess**, and then choose **Next: Review**.

   f. Choose **Add permissions**.

2. Verify that you can access Amazon Keyspaces through the VPC endpoint.

   ```
   aws keyspaces list-tables --keyspace-name 'my_Keyspace'
   ```

   If you want, you can try some other AWS CLI commands for Amazon Keyspaces. For more information, see the AWS CLI Command Reference.

> **Note**
>
> The minimum permissions required for an IAM user or role to access Amazon Keyspaces are read permissions to the system table, as shown in the following policy. For more information about policy-based permissions, see the section called “Identity-based policy examples”.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

3. Grant the IAM user read access to the Amazon EC2 instance with the VPC.

When you use Amazon Keyspaces with VPC endpoints, you need to grant the IAM user or role that accesses Amazon Keyspaces *read-only permissions to your Amazon EC2 instance and the VPC to gather endpoint and network interface data*. Amazon Keyspaces stores this information in the `system.peers` table and uses it to manage connections.

> **Note**
>
> The managed policies `AmazonKeyspacesReadOnlyAccess_v2` and `AmazonKeyspacesFullAccess` include the required permissions to let Amazon Keyspaces access the Amazon EC2 instance to read information about available interface VPC endpoints.

a. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.

b. On the IAM console dashboard, choose **Policies**.

c. Choose **Create policy**, and then choose the **JSON** tab.

d. Copy the following policy and choose **Next: Tags**.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"ListVPCEndpoints",
         "Effect":"Allow",
         "Action":[
            "ec2:DescribeNetworkInterfaces",
            "ec2:DescribeVpcEndpoints"
         ],
         "Resource": "*"
      }
   ]
}
```

e. Choose **Next: Review**, enter the name `keyspacesVPCendpoint` for the policy, and choose **Create policy**.

f. On the IAM console dashboard, choose **Users**, and then choose your IAM user from the list.

g. On the **Summary** page, choose **Add permissions**.

h. Choose **Attach existing policies directly**.

i. From the list of policies, choose **keyspacesVPCendpoint**, and then choose **Next: Review**.

j. Choose **Add permissions**.

4. To verify that the Amazon Keyspaces `system.peers` table is getting updated with VPC information, run the following query from your Amazon EC2 instance using `cqlsh`. If you haven't already installed `cqlsh`on your Amazon EC2 instance in step 2, follow the instructions in the section called “Using the `cqlsh-expansion`”.

```
SELECT * FROM system.peers;
```

The output returns nodes with private IPv6 IP addresses, depending on your VPC and subnet setup in your AWS Region.

```
 peer                                    | data_center | host_id
            | preferred_ip                                | rack      | release_version
 | rpc_address                             | schema_version                        |
 tokens
-----------------------------------------+-------------
+--------------------------------------+-----------------------------------------
+-----------+-----------------+---------------------------------------
+-----------------------------------
+-------------------------------------------
  2600:1111:2222:3333:283b:8e6:d04f      |   us-east-1 | dddddddd-7a22-3582-
a73d-49338a686a53 |  2600:1111:2222:3333:283b:8e6:d04f      | us-east-1 |
    3.11.2 |  2600:1111:2222:3333:283b:8e6:d04f      | 05deae2d-6405-494d-a965-
c0e5836bcb3c |  {'850705917302346158658436518579420528 63'}
 2600:1111:2222:4444:7d26:5a09:1b44      |   us-east-1 | 66666666-035d-37ef-
a247-19a6a867ab09 | 2600:1111:2222:4444:7d26:5a09:1b44      | us-east-1 |
    3.11.2 | 2600:1111:2222:4444:7d26:5a09:1b44      | 05deae2d-6405-494d-a965-
c0e5836bcb3c | {'170141183460469231731687303715884105726'}
```

> **Note**
>
> You have to use a `cqlsh`connection to Amazon Keyspaces to confirm that your VPC endpoint has been configured correctly. If you use your local environment or the Amazon Keyspaces CQL editor in the AWS Management Console, the connection automatically goes through the public endpoint instead of your VPC endpoint. If you see nine IP addresses, these are the entries Amazon Keyspaces automatically writes to the `system.peers` table for public endpoint connections.

Step 5: Configure monitoring with CloudWatch

This step shows you how to use Amazon CloudWatch to monitor the VPC endpoint connection to Amazon Keyspaces.

AWS PrivateLink publishes data points to CloudWatch about your interface endpoints. You can use metrics to verify that your system is performing as expected. The `AWS/PrivateLinkEndpoints`

namespace in CloudWatch includes the metrics for interface endpoints. For more information, see CloudWatch metrics for AWS PrivateLink in the *AWS PrivateLink Guide*.

To create a CloudWatch dashboard with VPC endpoint metrics

1. Open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. In the navigation pane, choose **Dashboards**. Then choose **Create dashboard**. Enter a name for the dashboard and choose **Create**.
3. Under **Add widget**, choose **Number**.
4. Under **Metrics**, choose **AWS/PrivateLinkEndpoints**.
5. Choose **Endpoint Type, Service Name, VPC Endpoint ID, VPC ID**.
6. Select the metrics `ActiveConnections` and `NewConnections`, and choose **Create Widget**.
7. Save the dashboard.

The `ActiveConnections` metric is defined as the number of concurrent active connections that the endpoint received during the last one-minute period. The `NewConnections` metric is defined as the number of new connections that were established through the endpoint during the last one-minute period.

For more information about creating dashboards, see Create dashboard in the *CloudWatch User Guide*.

Step 6: (Optional) Best practices to configure the connection pool size for your application

In this section, we outline how to determine the ideal connection pool size based on the query throughput requirements of your application.

Amazon Keyspaces allows a maximum of 3,000 CQL queries per second per TCP connection. So there's virtually no limit on the number of connections that a driver can establish with Amazon Keyspaces. However, we recommend that you match the connection pool size to the requirements of your application and consider the available endpoints when you're using Amazon Keyspaces with VPC endpoint connections.

You configure the connection pool size in the client driver. For example, based on a local pool size of **2** and a VPC interface endpoint created across **3** Availability Zones, the driver establishes

6 connections for querying (7 in total, which includes a control connection). Using these 6 connections, you can support a maximum of 18,000 CQL queries per second.

If your application needs to support 40,000 CQL queries per second, work backwards from the number of queries that are needed to determine the required connection pool size. To support 40,000 CQL queries per second, you need to configure the local pool size to be at least 5, which supports a minimum of 45,000 CQL queries per second.

You can monitor if you exceed the quota for the maximum number of operations per second, per connection by using the `PerConnectionRequestRateExceeded` CloudWatch metric in the `AWS/Cassandra` namespace. The `PerConnectionRequestRateExceeded` metric shows the number of requests to Amazon Keyspaces that exceed the quota for the per-connection request rate.

The code examples in this step show how to estimate and configure connection pooling when you're using interface VPC endpoints.

Java

You can configure the number of connections per pool in the Java driver. For a complete example of a Java client driver connection, see the section called “Using a Cassandra Java client driver”.

When the client driver is started, first the control connection is established for administrative tasks, such as for schema and topology changes. Then the additional connections are created.

In the following example, the local pool size driver configuration is specified as 2. If the VPC endpoint is created across 3 subnets within the VPC, this results in 7 `NewConnections` in CloudWatch for the interface endpoint, as shown in the following formula.

```
NewConnections = 3 (VPC subnet endpoints created across) * 2 (pool size) + 1
 ( control connection)
```

```
datastax-java-driver {

    basic.contact-points = [ "cassandra.us-east-1.amazonaws.com:9142"]
    advanced.auth-provider{
        class = PlainTextAuthProvider
           username = "ServiceUserName"
           password = "ServicePassword"
    }
    basic.load-balancing-policy {
```

```
        local-datacenter = "us-east-1"
        slow-replica-avoidance = false
    }

    advanced.ssl-engine-factory {
        class = DefaultSslEngineFactory
        truststore-path = "./src/main/resources/cassandra_truststore.jks"
        truststore-password = "my_password"
        hostname-validation = false
      }
    advanced.connection {
        pool.local.size = 2
          }
}
```

If the number of active connections doesn't match your configured pool size (aggregation across subnets) + 1 control connection, something is preventing the connections from being created.

Node.js

You can configure the number of connections per pool in the Node.js driver. For a complete example of a Node.js client driver connection, see the section called "Using a Cassandra Node.js client driver".

The code example below uses the *keyspaces-bundle.pem* file for the digital certicate. See the section called "Before you begin" for more information.

For the following code example, the local pool size driver configuration is specified as 1. If the VPC endpoint is created across 4 subnets within the VPC, this results in 5 `NewConnections` in CloudWatch for the interface endpoint, as shown in the following formula.

```
NewConnections = 4 (VPC subnet endpoints created across) * 1 (pool size) + 1
 ( control connection)
```

```
const cassandra = require('cassandra-driver');
const fs = require('fs');
const types = cassandra.types;
const auth = new cassandra.auth.PlainTextAuthProvider('ServiceUserName',
 'ServicePassword');
const sslOptions1 = {
         ca: [
```

```
                    fs.readFileSync('/home/ec2-user/keyspaces-bundle.pem',
 'utf-8')],
                    host: 'cassandra.us-east-1.amazonaws.com',
                    rejectUnauthorized: true
        };
const client = new cassandra.Client({
                  contactPoints: ['cassandra.us-east-1.amazonaws.com'],
                  localDataCenter: 'us-east-1',
                  pooling: { coreConnectionsPerHost: { [types.distance.local]:
 1 } },
                  consistency: types.consistencies.localQuorum,
                  queryOptions: { isIdempotent: true },
                  authProvider: auth,
                  sslOptions: sslOptions1,
                  protocolOptions: { port: 9142 }
        });
```

Step 7: (Optional) Clean up

If you want to delete the resources that you have created in this tutorial, follow these procedures.

To remove your VPC endpoint for Amazon Keyspaces

1. Log in to your Amazon EC2 instance.
2. Determine the VPC endpoint ID that is used for Amazon Keyspaces. If you omit the `grep` parameters, VPC endpoint information is shown for all services.

```
aws ec2 describe-vpc-endpoint-services | grep ServiceName | grep cassandra

{
    "VpcEndpoint": {
        "PolicyDocument": "{\"Version\":\"2000-00-00",\"Statement\":[{\"Effect\":
\"Allow\",\"Principal\":\"*\",\"Action\":\"*\",\"Resource\":\"*\"}]}",
        "VpcId": "vpc-a1234bcd",
        "State": "available",
        "ServiceName": "com.amazonaws.us-east-1.cassandra",
        "RouteTableIds": [],
        "VpcEndpointId": "vpce-1a23b4c5",
        "CreationTimestamp": "2025-07-26T22:00:14Z"
    }
}
```

In the example output, the VPC endpoint ID is *vpce-1a23b4c5*. Make sure to replace this value with your own.

3. Delete the VPC endpoint.

```
aws ec2 delete-vpc-endpoints --vpc-endpoint-ids vpce-1a23b4c5

{
    "Unsuccessful": []
}
```

The empty array `[]` indicates success (there were no unsuccessful requests).

To terminate your Amazon EC2 instance

1. Open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.
2. In the navigation pane, choose **Instances**.
3. Choose your Amazon EC2 instance.
4. Choose **Actions**, choose **Instance State**, and then choose **Terminate**.
5. In the confirmation window, choose **Yes, Terminate**.

Tutorial: Integrate with Apache Spark to import or export data

Apache Spark is an open-source engine for large-scale data analytics. Apache Spark enables you to perform analytics on data stored in Amazon Keyspaces more efficiently. You can also use Amazon Keyspaces to provide applications with consistent, single-digit-millisecond read access to analytics data from Spark. The open-source Spark Cassandra Connector simplifies reading and writing data between Amazon Keyspaces and Spark.

Amazon Keyspaces support for the Spark Cassandra Connector streamlines running Cassandra workloads in Spark-based analytics pipelines by using a fully managed and serverless database service. With Amazon Keyspaces, you don't need to worry about Spark competing for the same underlying infrastructure resources as your tables. Amazon Keyspaces tables scale up and down automatically based on your application traffic.

The following tutorial walks you through steps and best practices required to read and write data to Amazon Keyspaces using the Spark Cassandra Connector. The tutorial demonstrates how to

migrate data to Amazon Keyspaces by loading data from a file with the Spark Cassandra Connector and writing it to an Amazon Keyspaces table. Then, the tutorial shows how to read the data back from Amazon Keyspaces using the Spark Cassandra Connector. You would do this to run Cassandra workloads in Spark-based analytics pipelines.

Topics

- Prerequisites for establishing connections to Amazon Keyspaces with the Spark Cassandra Connector
- Step 1: Configure Amazon Keyspaces for integration with the Apache Cassandra Spark Connector
- Step 2: Configure the Apache Cassandra Spark Connector
- Step 3: Create the application configuration file
- Step 4: Prepare the source data and the target table in Amazon Keyspaces
- Step 5: Write and read Amazon Keyspaces data using the Apache Cassandra Spark Connector
- Troubleshooting common errors when using the Spark Cassandra Connector with Amazon Keyspaces

Prerequisites for establishing connections to Amazon Keyspaces with the Spark Cassandra Connector

Before you connect to Amazon Keyspaces with the Spark Cassandra Connector, you need to make sure that you've installed the following. The compatibility of Amazon Keyspaces with the Spark Cassandra Connector has been tested with the following recommended versions:

- Java version 8
- Scala 2.12
- Spark 3.4
- Cassandra Connector 2.5 and higher
- Cassandra driver 4.12

1. To install Scala, follow the instructions at https://www.scala-lang.org/download/scala2.html.
2. To install Spark 3.4.1, follow this example.

```
curl -o spark-3.4.1-bin-hadoop3.tgz -k https://dlcdn.apache.org/spark/spark-3.4.1/
spark-3.4.1-bin-hadoop3.tgz
```

```
# now to untar
tar -zxvf spark-3.4.1-bin-hadoop3.tgz

# set this variable.
export SPARK_HOME=$PWD/spark-3.4.1-bin-hadoop3
```

Step 1: Configure Amazon Keyspaces for integration with the Apache Cassandra Spark Connector

In this step, you confirm that the partitioner for your account is compatible with the Apache Spark Connector and setup the required IAM permissions. The following best practices help you to provision sufficient read/write capacity for the table.

1. Confirm that the `Murmur3Partitioner` partitioner is the default partitioner for your account. This partitioner is compatible with the Spark Cassandra Connector. For more information on partitioners and how to change them, see the section called “Working with partitioners”.
2. Setup your IAM permissions for Amazon Keyspaces, using interface VPC endpoints, with Apache Spark.

   - Assign read/write access to the user table and read access to the system tables as shown in the IAM policy example listed below.
   - Populating the system.peers table with your available interface VPC endpoints is required for clients accessing Amazon Keyspaces with Spark over VPC endpoints.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select",
            "cassandra:Modify"
         ],
         "Resource":[
```

```
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      },
      {
         "Sid":"ListVPCEndpoints",
         "Effect":"Allow",
         "Action":[
            "ec2:DescribeNetworkInterfaces",
            "ec2:DescribeVpcEndpoints"
         ],
         "Resource":"*"
      }
   ]
}
```

3. Consider the following best practices to configure sufficient read/write throughput capacity for your Amazon Keyspaces table to support the traffic from the Spark Cassandra Connector.

   - Start using on-demand capacity to help you test the scenario.
   - To optimize the cost of table throughput for production environments, use a rate limiter for traffic from the connector, and configure your table to use provisioned capacity with automatic scaling. For more information, see the section called “Manage throughput capacity with auto scaling”.
   - You can use a fixed rate limiter that comes with the Cassandra driver. There are some rate limiters tailored to Amazon Keyspaces in the AWS samples repo.
   - For more information about capacity management, see the section called “Configure read/write capacity modes”.

Step 2: Configure the Apache Cassandra Spark Connector

Apache Spark is a general-purpose compute platform that you can configure in different ways. To configure Spark and the Spark Cassandra Connector for integration with Amazon Keyspaces, we recommend that you start with the minimum configuration settings described in the following section, and then increase them later as appropriate for your workload.

- **Create Spark partition sizes smaller than 8 MBs.**

In Spark, *partitions* represent an atomic chunk of data that can be run in parallel. When you are writing data to Amazon Keyspaces with the Spark Cassandra Connector, the smaller the Spark partition, the smaller the amount of records that the task is going to write. If a Spark task encounters multiple errors, it fails after the designated number of retries has been exhausted. To avoid replaying large tasks and reprocessing a lot of data, keep the size of the Spark partition small.

- **Use a low concurrent number of writes per executor with a large number of retries.**

  Amazon Keyspaces returns insufficient capacity errors back to Cassandra drivers as operation timeouts. You can't address timeouts caused by insufficient capacity by changing the configured timeout duration because the Spark Cassandra Connector attempts to retry requests transparently using the `MultipleRetryPolicy`. To ensure that retries don't overwhelm the driver's connection pool, use a low concurrent number of writes per executor with a large number of retries. The following code snippet is an example of this.

  ```
  spark.cassandra.query.retry.count = 500
  spark.cassandra.output.concurrent.writes = 3
  ```

- **Break down the total throughput and distribute it across multiple Cassandra sessions.**
  - The Cassandra Spark Connector creates one session for each Spark executor. Think about this session as the unit of scale to determine the required throughput and the number of connections required.
  - When defining the number of cores per executor and the number of cores per task, start low and increase as needed.
  - Set Spark task failures to allow processing in the event of transient errors. After you become familiar with your application's traffic characteristics and requirements, we recommend setting `spark.task.maxFailures` to a bounded value.
  - For example, the following configuration can handle two concurrent tasks per executor, per session:

    ```
    spark.executor.instances = configurable -> number of executors for the session.
    spark.executor.cores = 2 -> Number of cores per executor.
    spark.task.cpus = 1 -> Number of cores per task.
    spark.task.maxFailures = -1
    ```

- **Turn off batching.**

- We recommend that you turn off batching to improve random access patterns. The following code snippet is an example of this.

```
spark.cassandra.output.batch.size.rows = 1 (Default = None)
spark.cassandra.output.batch.grouping.key = none (Default = Partition)
spark.cassandra.output.batch.grouping.buffer.size = 100 (Default = 1000)
```

- **Set `SPARK_LOCAL_DIRS` to a fast, local disk with enough space.**
  - By default, Spark saves map output files and resilient distributed datasets (RDDs) to a `/tmp` folder. Depending on your Spark host's configuration, this can result in *no space left on the device* style errors.
  - To set the `SPARK_LOCAL_DIRS` environment variable to a directory called `/example/spark-dir`, you can use the following command.

```
export SPARK_LOCAL_DIRS=/example/spark-dir
```

Step 3: Create the application configuration file

To use the open-source Spark Cassandra Connector with Amazon Keyspaces, you need to provide an application configuration file that contains the settings required to connect with the DataStax Java driver. You can use either service-specific credentials or the SigV4 plugin to connect.

If you haven't already done so, you need to convert the digital certificate used to create the TLS connection into a trustStore file. You can follow the detailed steps at the section called "Before you begin" from the Java driver connection tutorial. Take note of the trustStore file path and password because you need this information when you create the application config file.

Connect with SigV4 authentication

This section shows you an example `application.conf` file that you can use when connecting with AWS credentials and the SigV4 plugin. If you haven't already done so, you need to generate your IAM access keys (an access key ID and a secret access key) and save them in your AWS config file or as environment variables. For detailed instructions, see the section called "Required credentials for AWS authentication".

In the following example, replace the file path to your trustStore file, and replace the password.

```
datastax-java-driver {
```

```
        basic.contact-points = ["cassandra.us-east-1.amazonaws.com:9142"]
        basic.load-balancing-policy {
            class = DefaultLoadBalancingPolicy
            local-datacenter = us-east-1
            slow-replica-avoidance = false
        }
        basic.request {
              consistency = LOCAL_QUORUM
        }
        advanced {
                auth-provider = {
                   class = software.aws.mcs.auth.SigV4AuthProvider
                   aws-region = us-east-1
                 }
            ssl-engine-factory {
                class = DefaultSslEngineFactory
                truststore-path = "path_to_file/cassandra_truststore.jks"
                truststore-password = "password"
        hostname-validation=false
            }
   }
        advanced.connection.pool.local.size = 3
}
```

Update and save this configuration file as `/home/user1/application.conf`. The following examples use this path.

Connect with service-specific credentials

This section shows you an example `application.conf` file that you can use when connecting with service-specific credentials. If you haven't already done so, you need to generate service-specific credentials for Amazon Keyspaces. For detailed instructions, see the section called “Create service-specific credentials”.

In the following example, replace `username` and `password` with your own credentials. Also, replace the file path to your trustStore file, and replace the password.

```
datastax-java-driver {
        basic.contact-points = ["cassandra.us-east-1.amazonaws.com:9142"]
        basic.load-balancing-policy {
            class = DefaultLoadBalancingPolicy
            local-datacenter = us-east-1
```

```
        }
        basic.request {
              consistency = LOCAL_QUORUM
        }
        advanced {
            auth-provider = {
            class = PlainTextAuthProvider
                    username = "username"
                    password = "password"
                    aws-region = "us-east-1"
            }
            ssl-engine-factory {
                class = DefaultSslEngineFactory
                truststore-path = "path_to_file/cassandra_truststore.jks"
                truststore-password = "password"
                hostname-validation=false
            }
            metadata = {
                schema {
                     token-map.enabled = true
                }
            }
        }
}
```

Update and save this configuration file as `/home/user1/application.conf` to use with the code example.

Connect with a fixed rate

To force a fixed rate per Spark executor, you can define a request throttler. This request throttler limits the rate of requests per second. The Spark Cassandra Connector deploys a Cassandra session per executor. Using the following formula can help you achieve consistent throughput against a table.

```
max-request-per-second * numberOfExecutors = total throughput against a table
```

You can add this example to the application config file that you created earlier.

```
datastax-java-driver {
  advanced.throttler {
    class = RateLimitingRequestThrottler
```

```
    max-requests-per-second = 3000
    max-queue-size = 30000
    drain-interval = 1 millisecond
  }
}
```

Step 4: Prepare the source data and the target table in Amazon Keyspaces

In this step, you create a source file with sample data and an Amazon Keyspaces table.

1. Create the source file. You can choose one of the following options:
   - For this tutorial, you use a comma-separated values (CSV) file with the name `keyspaces_sample_table.csv` as the source file for the data migration. The provided sample file contains a few rows of data for a table with the name `book_awards`.
     - Download the sample CSV file (`keyspaces_sample_table.csv`) that is contained in the following archive file samplemigration.zip. Unzip the archive and take note of the path to `keyspaces_sample_table.csv`.
   - If you want to follow along with your own CSV file to write data to Amazon Keyspaces, make sure that the data is randomized. Data that is read directly from a database or exported to flat files is typically ordered by the partition and primary key. Importing ordered data to Amazon Keyspaces can cause it to be written to smaller segments of Amazon Keyspaces partitions, which results in an uneven traffic distribution. This can lead to slower performance and higher error rates.

     In contrast, randomizing data helps to take advantage of the built-in load balancing capabilities of Amazon Keyspaces by distributing traffic across partitions more evenly. There are various tools that you can use for randomizing data. For an example that uses the open-source tool Shuf, see the section called “Step 2: Prepare the data” in the data migration tutorial. The following is an example that shows how to shuffle data as a `DataFrame`.

     ```
     import org.apache.spark.sql.functions.randval
     shuffledDF = dataframe.orderBy(rand())
     ```

2. Create the target keyspace and table in Amazon Keyspaces.

a. Connect to Amazon Keyspaces using the `cqlsh-expansion`. For `cqlsh-expansion` installation instructions, see the section called “Using the `cqlsh-expansion`”.

   Replace the service endpoint in the following example with your own value.

```
cqlsh-expansion cassandra.us-east-1.amazonaws.com 9142 --ssl
```

b. Create a new keyspace with the name `catalog` as shown in the following example.

```
CREATE KEYSPACE catalog WITH REPLICATION = {'class': 'SingleRegionStrategy'};
```

c. After the new keyspace has a status of available, use the following code to create the target table `book_awards`. To learn more about asynchronous resource creation and how to check if a resource is available, see the section called “Check keyspace creation status”.

```
CREATE TABLE catalog.book_awards (
   year int,
   award text,
   rank int,
   category text,
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank)
   );
```

Step 5: Write and read Amazon Keyspaces data using the Apache Cassandra Spark Connector

In this step, you start by loading the data from the sample file into a `DataFrame` with the Spark Cassandra Connector. Next, you write the data from the `DataFrame` into your Amazon Keyspaces table. You can also use this part independently, for example, to migrate data into an Amazon Keyspaces table. Finally, you read the data from your table into a `DataFrame` using the Spark Cassandra Connector. You can also use this part independently, for example, to read data from an Amazon Keyspaces table to perform data analytics with Apache Spark.

1. Start the Spark Shell as shown in the following example. Note that this example is using SigV4 authentication.

```
./spark-shell --files application.conf --conf
 spark.cassandra.connection.config.profile.path=application.conf
 --packages software.aws.mcs:aws-sigv4-auth-cassandra-java-driver-
plugin:4.0.5,com.datastax.spark:spark-cassandra-connector_2.12:3.1.0 --conf
 spark.sql.extensions=com.datastax.spark.connector.CassandraSparkExtensions
```

2. Import the Spark Cassandra Connector with the following code.

```
import org.apache.spark.sql.cassandra._
```

3. To read data from the CSV file and store it in a `DataFrame`, you can use the following code example.

```
var df =
 spark.read.option("header","true").option("inferSchema","true").csv("keyspaces_sample_tabl
```

You can display the result with the following command.

```
scala> df.show();
```

The output should look similar to this.

```
+----------------+----+-----------+----+------------------+--------------------
+-------------+
|           award|year|   category|rank|            author|          book_title|
 publisher|
+----------------+----+-----------+----+------------------+--------------------
+-------------+
|Kwesi Manu Prize|2020|    Fiction|   1|        Akua Mansa|   Where did you go?|
SomePublisher|
|Kwesi Manu Prize|2020|    Fiction|   2|       John Stiles|           Yesterday|
Example Books|
|Kwesi Manu Prize|2020|    Fiction|   3|        Nikki Wolf|Moving to the Cha...|
 AnyPublisher|
|            Wolf|2020|Non-Fiction|   1|       Wang Xiulan|    History of Ideas|
Example Books|
|            Wolf|2020|Non-Fiction|   2|Ana Carolina Silva|       Science Today|
SomePublisher|
|            Wolf|2020|Non-Fiction|   3| Shirley Rodriguez|The Future of Sea...|
 AnyPublisher|
```

```
|     Richard Roe|2020|    Fiction|   1| Alejandro Rosalez|         Long Summer|
SomePublisher|
|     Richard Roe|2020|    Fiction|   2|       Arnav Desai|             The Key|
Example Books|
|     Richard Roe|2020|    Fiction|   3|     Mateo Jackson|    Inside the Whale|
 AnyPublisher|
+----------------+----+-----------+----+------------------+--------------------
+-------------+
```

You can confirm the schema of the data in the `DataFrame` as shown in the following example.

```
scala> df.printSchema
```

The output should look like this.

```
root
|-- award: string (nullable = true)
|-- year: integer (nullable = true)
|-- category: string (nullable = true)
|-- rank: integer (nullable = true)
|-- author: string (nullable = true)
|-- book_title: string (nullable = true)
|-- publisher: string (nullable = true)
```

4. Use the following command to write the data in the `DataFrame` to the Amazon Keyspaces table.

```
df.write.cassandraFormat("book_awards", "catalog").mode("APPEND").save()
```

5. To confirm that the data was saved, you can read it back to a dataframe, as shown in the following example.

```
var newDf = spark.read.cassandraFormat("book_awards", "catalog").load()
```

Then you can show the data that is now contained in the dataframe.

```
scala> newDf.show()
```

The output of that command should look like this.

```
+--------------------+-----------------+---------------+----------+-------------
+----+----+
|          book_title|           author|          award|  category|
 publisher|rank|year|
+--------------------+-----------------+---------------+----------+-------------
+----+----+
|         Long Summer| Alejandro Rosalez|     Richard Roe|    Fiction|
SomePublisher|   1|2020|
|    History of Ideas|       Wang Xiulan|           Wolf|Non-Fiction|Example
 Books|   1|2020|
|   Where did you go?|        Akua Mansa|Kwesi Manu Prize|    Fiction|
SomePublisher|   1|2020|
|    Inside the Whale|     Mateo Jackson|     Richard Roe|    Fiction|
 AnyPublisher|   3|2020|
|           Yesterday|       John Stiles|Kwesi Manu Prize|    Fiction|Example
 Books|   2|2020|
|Moving to the Cha...|        Nikki Wolf|Kwesi Manu Prize|    Fiction|
 AnyPublisher|   3|2020|
|The Future of Sea...| Shirley Rodriguez|           Wolf|Non-Fiction|
 AnyPublisher|   3|2020|
|       Science Today|Ana Carolina Silva|           Wolf|Non-Fiction|
SomePublisher|   2|2020|
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```

Troubleshooting common errors when using the Spark Cassandra Connector with Amazon Keyspaces

If you're using Amazon Virtual Private Cloud and you connect to Amazon Keyspaces, the most common errors experienced when using the Spark connector are caused by the following configuration issues.

- The IAM user or role used in the VPC lacks the required permissions to access the `system.peers` table in Amazon Keyspaces. For more information, see the section called “Populating `system.peers` table entries with interface VPC endpoint information”.

- The IAM user or role lacks the required read/write permissions to the user table and read access to the system tables in Amazon Keyspaces. For more information, see the section called “Step 1: Configure Amazon Keyspaces”.
- The Java driver configuration doesn't disable hostname verification when creating the SSL/TLS connection. For examples, see the section called “Step 2: Configure the driver”.

For detailed connection troubleshooting steps, see the section called “VPC endpoint connection errors”.

In addition, you can use Amazon CloudWatch metrics to help you troubleshoot issues with your Spark Cassandra Connector configuration in Amazon Keyspaces. To learn more about using Amazon Keyspaces with CloudWatch, see the section called “Monitoring with CloudWatch”.

The following section describes the most useful metrics to observe when you're using the Spark Cassandra Connector.

PerConnectionRequestRateExceeded

Amazon Keyspaces has a quota of 3,000 requests per second, per connection. Each Spark executor establishes a connection with Amazon Keyspaces. Running multiple retries can exhaust your per-connection request rate quota. If you exceed this quota, Amazon Keyspaces emits a `PerConnectionRequestRateExceeded` metric in CloudWatch.

If you see PerConnectionRequestRateExceeded events present along with other system or user errors, it's likely that Spark is running multiple retries beyond the allotted number of requests per connection.

If you see `PerConnectionRequestRateExceeded` events without other errors, then you might need to increase the number of connections in your driver settings to allow for more throughput, or you might need to increase the number of executors in your Spark job.

StoragePartitionThroughputCapacityExceeded

Amazon Keyspaces has a quota of 1,000 WCUs or WRUs per second/3,000 RCUs or RRUs per second, per-partition. If you're seeing `StoragePartitionThroughputCapacityExceeded` CloudWatch events, it could indicate that data is not randomized on load. For examples how to shuffle data, see the section called “Step 4: Prepare the source data and the target table”.

Common errors and warnings

If you're using Amazon Virtual Private Cloud and you connect to Amazon Keyspaces, the Cassandra driver might issue a warning message about the control node itself in the `system.peers` table. For more information, see the section called “Common errors and warnings”. You can safely ignore this warning.

Tutorial: Connect from a containerized application hosted on Amazon Elastic Kubernetes Service

This tutorial walks you through the steps required to set up an Amazon Elastic Kubernetes Service (Amazon EKS) cluster to host a containerized application that connects to Amazon Keyspaces using SigV4 authentication.

Amazon EKS is a managed service that eliminates the need to install, operate, and maintain your own Kubernetes control plane. Kubernetes is an open-source system that automates the management, scaling, and deployment of containerized applications.

The tutorial provides step-by-step guidance to configure, build, and deploy a containerized Java application to Amazon EKS. In the last step you run the application to write data to an Amazon Keyspaces table.

Topics

- Prerequisites for connecting from Amazon EKS to Amazon Keyspaces
- Step 1: Configure the Amazon EKS cluster and setup IAM permissions
- Step 2: Configure the application
- Step 3: Create the application image and upload the Docker file to your Amazon ECR repository
- Step 4: Deploy the application to Amazon EKS and write data to your table
- Step 5: (Optional) Cleanup

Prerequisites for connecting from Amazon EKS to Amazon Keyspaces

Create the following AWS resources before you can begin with the tutorial

1. Before you start this tutorial, follow the AWS setup instructions in Accessing Amazon Keyspaces (for Apache Cassandra). These steps include signing up for AWS and creating an AWS Identity and Access Management (IAM) principal with access to Amazon Keyspaces.
2. Create an Amazon Keyspaces keyspace with the name `aws` and a table with the name `user` that you can write to from the containerized application running in Amazon EKS later in this tutorial. You can do this either with the AWS CLI or using `cqlsh`.

   AWS CLI

   ```
   aws keyspaces create-keyspace --keyspace-name 'aws'
   ```

   To confirm that the keyspace was created, you can use the following command.

   ```
   aws keyspaces list-keyspaces
   ```

   To create the table, you can use the following command.

   ```
   aws keyspaces create-table --keyspace-name 'aws' --table-name 'user' --schema-
   definition 'allColumns=[
               {name=username,type=text}, {name=fname,type=text},
   {name=last_update_date,type=timestamp},{name=lname,type=text}],
               partitionKeys=[{name=username}]'
   ```

   To confirm that your table was created, you can use the following command.

   ```
   aws keyspaces list-tables --keyspace-name 'aws'
   ```

   For more information, see create keyspace and create table in the *AWS CLI Command Reference*.

   cqlsh

   ```
   CREATE KEYSPACE aws WITH replication = {'class': 'SimpleStrategy',
    'replication_factor': '3'}  AND durable_writes = true;
   CREATE TABLE aws.user (
   ```

```
    username text PRIMARY KEY,
    fname text,
    last_update_date timestamp,
    lname text
);
```

To verify that your table was created, you can use the following statement.

```
SELECT * FROM system_schema.tables WHERE keyspace_name = "aws";
```

Your table should be listed in the output of this statement. Note that there can be a delay until the table is created. For more information, see the section called “CREATE TABLE”.

3. Create an Amazon EKS cluster with a **Fargate - Linux** node type. Fargate is a serverless compute engine that lets you deploy Kubernetes Pods without managing Amazon Amazon EC2 instances. To follow this tutorial without having to update the cluster name in all the example commands, create a cluster with the name `my-eks-cluster` following the instructions at Getting started with Amazon EKS – `eksctl` in the *Amazon EKS User Guide*. When your cluster is created, verify that your nodes and the two default Pods are running and healthy. You can do so with the following command.

```
kubectl get pods -A -o wide
```

You should see something similar to this output.

```
NAMESPACE     NAME                          READY   STATUS    RESTARTS   AGE   IP
     NODE                                                NOMINATED NODE   READINESS
 GATES
kube-system   coredns-1234567890-abcde   1/1     Running   0          18m
 192.0.2.0   fargate-ip-192-0-2-0.region-code.compute.internal   <none>
 <none>
kube-system   coredns-1234567890-12345   1/1     Running   0          18m
 192.0.2.1   fargate-ip-192-0-2-1.region-code.compute.internal   <none>
 <none>
```

4. Install Docker. For instructions on how to install Docker on an Amazon EC2 instance, see Install Docker in the Amazon Elastic Container Registry User Guide.

Docker is available for many different operating systems, including most modern Linux distributions, like Ubuntu, and even macOS and Windows. For more information about how to install Docker on your particular operating system, go to the Docker installation guide.

5. Create an Amazon ECR repository. Amazon ECR is an AWS managed container image registry service that you can use with your preferred CLI to push, pull, and manage Docker images. For more information about Amazon ECR repositories, see the Amazon Elastic Container Registry User Guide. You can use the following command to create a repository with the name `my-ecr-repository`.

```
aws ecr create-repository --repository-name my-ecr-repository
```

After completing the prerequisite steps, proceed to the section called “Step 1: Configure the Amazon EKS cluster”.

Step 1: Configure the Amazon EKS cluster and setup IAM permissions

Configure the Amazon EKS cluster and create the IAM resources that are required to allow an Amazon EKS service account to connect to your Amazon Keyspaces table

1. Create an Open ID Connect (OIDC) provider for the Amazon EKS cluster. This is needed to use IAM roles for service accounts. For more information about OIDC providers and how to create them, see Creating an IAM OIDC provider for your cluster in the *Amazon EKS User Guide*.

   a. Create an IAM OIDC identity provider for your cluster with the following command. This example assumes that your cluster name is `my-eks-cluster`. If you have a cluster with a different name, remember to update the name in all future commands.

   ```
   eksctl utils associate-iam-oidc-provider --cluster my-eks-cluster --approve
   ```

   b. Confirm that the OIDC identity provider has been registered with IAM with the following command.

   ```
   aws iam list-open-id-connect-providers --region us-east-1
   ```

   The output should look similar to this. Take note of the OIDC's Amazon Resource Name (ARN), you need it in the next step when you create a trust policy for the service account.

```
{
    "OpenIDConnectProviderList": [
        ..
        {
            "Arn": "arn:aws:iam::111122223333:oidc-provider/oidc.eks.us-
east-1.amazonaws.com/id/EXAMPLED539D4633E53DE1B71EXAMPLE"
        }
    ]
}
```

2. Create a service account for the Amazon EKS cluster. Service accounts provide an identity for processes that run in a *Pod*. A Pod is the smallest and simplest Kubernetes object that you can use to deploy a containerized application. Next, create an IAM role that the service account can assume to obtain permissions to resources. You can access any AWS service from a Pod that has been configured to use a service account that can assume an IAM role with access permissions to that service.

   a. Create a new namespace for the service account. A namespace helps to isolate cluster resources created for this tutorial. You can create a new namespace using the following command.

   ```
   kubectl create namespace my-eks-namespace
   ```

   b. To use a custom namespace, you have to associate it with a Fargate profile. The following code is an example of this.

   ```
   eksctl create fargateprofile \
       --cluster my-eks-cluster \
       --name my-fargate-profile \
       --namespace my-eks-namespace \
       --labels *=*
   ```

   c. Create a service account with the name `my-eks-serviceaccount` in the namespace `my-eks-namespace` for your Amazon EKS cluster by using the following command.

   ```
   cat >my-serviceaccount.yaml <<EOF
   apiVersion: v1
   kind: ServiceAccount
   metadata:
     name: my-eks-serviceaccount
   ```

```
  namespace: my-eks-namespace
EOF
kubectl apply -f my-serviceaccount.yaml
```

d. Run the following command to create a trust policy file that instructs the IAM role to trust your service account. This trust relationship is required before a principal can assume a role. You need to make the following edits to the file:

- For the `Principal`, enter the ARN that IAM returned to the `list-open-id-connect-providers` command. The ARN contains your account number and Region.
- In the `condition` statement, replace the AWS Region and the OIDC id.
- Confirm that the service account name and namespace are correct.

You need to attach the trust policy file in the next step when you create the IAM role.

```
cat >trust-relationship.json <<EOF
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Federated": "arn:aws:iam::111122223333:oidc-provider/
oidc.eks.us-east-1.amazonaws.com/id/EXAMPLED539D4633E53DE1B71EXAMPLE"
            },
            "Action": "sts:AssumeRoleWithWebIdentity",
            "Condition": {
                "StringEquals": {
                    "oidc.eks.us-east-1.amazonaws.com/
id/EXAMPLED539D4633E53DE1B71EXAMPLE:sub": "system:serviceaccount:my-eks-
namespace:my-eks-serviceaccount",
                    "oidc.eks.us-east-1.amazonaws.com/
id/EXAMPLED539D4633E53DE1B71EXAMPLE:aud": "sts.amazonaws.com"
                }
            }
        }
    ]
}
EOF
```

Optional: You can also add multiple entries in the `StringEquals` or `StringLike` conditions to allow multiple service accounts or namespaces to assume the role. To allow your service account to assume an IAM role in a different AWS account, see Cross-account IAM permissions in the *Amazon EKS User Guide*.

3. Create an IAM role with the name `my-iam-role` for the Amazon EKS service account to assume. Attach the trust policy file created in the last step to the role. The trust policy specifies the service account and OIDC provider that the IAM role can trust.

```
aws iam create-role --role-name my-iam-role --assume-role-policy-document file://
trust-relationship.json --description "EKS service account role"
```

4. Assign the IAM role permissions to Amazon Keyspaces by attaching an access policy.

   a. Attach an access policy to define the actions the IAM role can perform on specific Amazon Keyspaces resources. For this tutorial we use the AWS managed policy `AmazonKeyspacesFullAccess`, because our application is going to write data to your Amazon Keyspaces table. As a best practise however, it's recommended to create custom access policies that implement the least privileges principle. For more information, see the section called “How Amazon Keyspaces works with IAM”.

```
aws iam attach-role-policy --role-name my-iam-role --policy-
arn=arn:aws:iam::aws:policy/AmazonKeyspacesFullAccess
```

   Confirm that the policy was successfully attached to the IAM role with the following statement.

```
aws iam list-attached-role-policies --role-name my-iam-role
```

   The output should look like this.

```
{
    "AttachedPolicies": [
        {
            "PolicyName": "AmazonKeyspacesFullAccess",
            "PolicyArn": "arn:aws:iam::aws:policy/AmazonKeyspacesFullAccess"
        }
    ]
}
```

b. Annotate the service account with the Amazon Resource Name (ARN) of the IAM role it can assume. Make sure to update the role ARN with your account ID.

```
kubectl annotate serviceaccount -n my-eks-namespace my-eks-serviceaccount
 eks.amazonaws.com/role-arn=arn:aws:iam::111122223333:role/my-iam-role
```

5. Confirm that the IAM role and the service account are correctly configured.

a. Confirm that the IAM role's trust policy is correctly configured with the following statement.

```
aws iam get-role --role-name my-iam-role --query Role.AssumeRolePolicyDocument
```

The output should look similar to this.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Federated": "arn:aws:iam::111122223333:oidc-provider/
oidc.eks.us-east-1.amazonaws.com/id/EXAMPLED539D4633E53DE1B71EXAMPLE"
            },
            "Action": "sts:AssumeRoleWithWebIdentity",
            "Condition": {
                "StringEquals": {
                    "oidc.eks.us-east-1.amazonaws.com/id/
EXAMPLED539D4633E53DE1B71EXAMPLE:aud": "sts.amazonaws.com",
                    "oidc.eks.us-east-1.amazonaws.com/id/
EXAMPLED539D4633E53DE1B71EXAMPLE:sub": "system:serviceaccount:my-eks-
namespace:my-eks-serviceaccount"
                }
            }
        }
    ]
}
```

b. Confirm that the Amazon EKS service account is annotated with the IAM role.

```
kubectl describe serviceaccount my-eks-serviceaccount -n my-eks-namespace
```

The output should look similar to this.

```
Name: my-eks-serviceaccount
Namespace:my-eks-namespace
Labels: <none>
Annotations: eks.amazonaws.com/role-arn: arn:aws:iam::111122223333:role/my-iam-
role
Image pull secrets: <none>
Mountable secrets: <none>
Tokens: <none>
[...]
```

After you created the Amazon EKS service account, the IAM role, and configured the required relationships and permissions, proceed to the section called “Step 2: Configure the application”.

Step 2: Configure the application

In this step you build your application that connects to Amazon Keyspaces using the SigV4 plugin. You can view and download the example Java application from the Amazon Keyspaces example code repo on Github. Or you can follow along using your own application, making sure to complete all configuration steps.

Configure your application and add the required dependencies.

1. You can download the example Java application by cloning the Github repository using the following command.

   ```
   git clone https://github.com/aws-samples/amazon-keyspaces-examples.git
   ```

2. After downloading the Github repo, unzip the downloaded file and navigate to the `resources` directory to the `application.conf` file.

   a. **Application configuration**

      In this step you configure the SigV4 authentication plugin. You can use the following example in your application. If you haven't already done so, you need to generate your IAM access keys (an access key ID and a secret access key) and save them in your AWS config file or as environment variables. For detailed instructions, see the section called “Required credentials for AWS authentication”. Update the AWS Region and the service

endpoint for Amazon Keyspaces as needed. For more service endpoints, see the section called “Service endpoints”. Replace the truststore location, truststore name, and the truststore password with your own.

```
datastax-java-driver {
  basic.contact-points = ["cassandra.us-east-1.amazonaws.com:9142"]
  basic.load-balancing-policy.local-datacenter = "us-east-1"
  advanced.auth-provider {
    class = software.aws.mcs.auth.SigV4AuthProvider
    aws-region = "us-east-1"
  }
  advanced.ssl-engine-factory {
    class = DefaultSslEngineFactory
    truststore-path = "truststore_locationtruststore_name.jks"
    truststore-password = "truststore_password;"
  }
}
```

b. **Add the STS module dependency.**

This adds the ability to use a `WebIdentityTokenCredentialsProvider` that returns the AWS credentials that the application needs to provide so that the service account can assume the IAM role. You can do this based on the following example.

```
        <dependency>
            <groupId>com.amazonaws</groupId>
            <artifactId>aws-java-sdk-sts</artifactId>
            <version>1.11.717</version>
        </dependency>
```

c. **Add the SigV4 dependency.**

This package implements the SigV4 authentication plugin that is needed to authenticate to Amazon Keyspaces

```
        <dependency>
            <groupId>software.aws.mcs</groupId>
            <artifactId>aws-sigv4-auth-cassandra-java-driver-plugin</
artifactId>
            <version>4.0.3</version>
        </dependency>
```

3. **Add a logging dependency.**

   Without logs, troubleshooting connection issues is impossible. In this tutorial, we use `slf4j` as the logging framework, and use `logback.xml` to store the log output. We set the logging level to debug to establish the connection. You can use the following example to add the dependency.

```
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
            <version>2.0.5</version>
        </dependency>
```

   You can use the following code snippet to configure the logging.

```
<configuration>
    <appender name="STDOUT" class="ch.qos.logback.core.ConsoleAppender">

        <encoder>
            <pattern>%d{HH:mm:ss.SSS} [%thread] %-5level %logger{36} - %msg%n</
pattern>
        </encoder>
    </appender>

    <root level="debug">
        <appender-ref ref="STDOUT" />
    </rootv
</configuration>
```

   Note

   The debug level is needed to investigate connection failures. After you have successfully connected to Amazon Keyspaces from your application, you can change the logging level to `info` or `warning` as needed.

Step 3: Create the application image and upload the Docker file to your Amazon ECR repository

In this step, you compile the example application, build a Docker image, and push the image to your Amazon ECR repository.

Build your application, build a Docker image, and submit it to Amazon Elastic Container Registry

1. Set environment variables for the build that define your AWS Region. Replace the Regions in the examples with your own.

```
export CASSANDRA_HOST=cassandra.us-east-1.amazonaws.com:9142
export CASSANDRA_DC=us-east-1
```

2. Compile your application with Apache Maven version 3.6.3 or higher using the following command.

```
mvn clean install
```

   This creates a JAR file with all dependencies included in the `target` directory.

3. Retrieve your ECR repository URI that's needed for the next step with the following command. Make sure to update the Region to the one you've been using.

```
aws ecr describe-repositories --region us-east-1
```

   The output should look like in the following example.

```
"repositories": [
 {
 "repositoryArn": "arn:aws:ecr:us-east-1:111122223333:repository/my-ecr-
repository",
 "registryId": "111122223333",
 "repositoryName": "my-ecr-repository",
 "repositoryUri": "111122223333.dkr.ecr.us-east-1.amazonaws.com/my-ecr-repository",
 "createdAt": "2023-11-02T03:46:34+00:00",
 "imageTagMutability": "MUTABLE",
 "imageScanningConfiguration": {
 "scanOnPush": false
```

```
},
"encryptionConfiguration": {
"encryptionType": "AES256"
}
},
```

4. From the application's root directory build the Docker image using the repository URI from the last step. Modify the Docker file as needed. In the build command, make sure to replace your account ID and set the AWS Region to the Region where the Amazon ECR repository `my-ecr-repository` is located.

```
docker build -t 111122223333.dkr.ecr.us-east-1.amazonaws.com/my-ecr-repository:latest .
```

5. Retrieve an authentication token to push the Docker image to Amazon ECR. You can do so with the following command.

```
aws ecr get-login-password --region us-east-1 | docker login --username AWS --password-stdin 111122223333.dkr.ecr.us-east-1.amazonaws.com
```

6. First, check for existing images in your Amazon ECR repository. You can use the following command.

```
aws ecr describe-images --repository-name my-ecr-repository --region us-east-1
```

   Then, push the Docker image to the repo. You can use the following command.

```
docker push 111122223333.dkr.ecr.us-east-1.amazonaws.com/my-ecr-repository:latest
```

Step 4: Deploy the application to Amazon EKS and write data to your table

In this step of the tutorial, you configure the Amazon EKS deployment for your application, and confirm that the application is running and can connect to Amazon Keyspaces.

To deploy an application to Amazon EKS, you need to configure all relevant settings in a file called `deployment.yaml`. This file is then used by Amazon EKS to deploy the application. The metadata in the file should contain the following information:

- **Application name** the name of the application. For this tutorial, we use `my-keyspaces-app`.
- **Kubernetes namespace** the namespace of the Amazon EKS cluster. For this tutorial, we use `my-eks-namespace`.
- **Amazon EKS service account name** the name of the Amazon EKS service account. For this tutorial, we use `my-eks-serviceaccount`.
- **image name** the name of the application image. For this tutorial, we use `my-keyspaces-app`.
- **Image URI** the Docker image URI from Amazon ECR.
- **AWS account ID** your AWS account ID.
- **IAM role ARN** the ARN of the IAM role created for the service account to assume. For this tutorial, we use `my-iam-role`.
- **AWS Region of the Amazon EKS cluster** the AWS Region you created your Amazon EKS cluster in.

In this step, you deploy and run the application that connects to Amazon Keyspaces and writes data to the table.

1. Configure the `deployment.yaml` file. You need to replace the following values:

   - `name`
   - `namespace`
   - `serviceAccountName`
   - `image`
   - `AWS_ROLE_ARN value`
   - The AWS Region in `CASSANDRA_HOST`
   - `AWS_REGION`

   You can use the following file as an example.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: my-keyspaces-app
  namespace: my-eks-namespace
spec:
  replicas: 1
```

```
  selector:
    matchLabels:
      app: my-keyspaces-app
  template:
    metadata:
      labels:
        app: my-keyspaces-app
    spec:
      serviceAccountName: my-eks-serviceaccount
      containers:
      - name: my-keyspaces-app
        image: 111122223333.dkr.ecr.us-east-1.amazonaws.com/my-ecr-
repository:latest
        ports:
        - containerPort: 8080
        env:
        - name: CASSANDRA_HOST
          value: "cassandra.us-east-1.amazonaws.com:9142"
        - name: CASSANDRA_DC
          value: "us-east-1"
        - name: AWS_WEB_IDENTITY_TOKEN_FILE
          value: /var/run/secrets/eks.amazonaws.com/serviceaccount/token
        - name: AWS_ROLE_ARN
          value: "arn:aws:iam::111122223333:role/my-iam-role"
        - name: AWS_REGION
          value: "us-east-1"
```

2. Deploy `deployment.yaml`.

```
kubectl apply -f deployment.yaml
```

The output should look like this.

```
deployment.apps/my-keyspaces-app created
```

3. Check the status of the Pod in your namespace of the Amazon EKS cluster.

```
kubectl get pods -n my-eks-namespace
```

The output should look similar to this example.

```
NAME                     READY STATUS RESTARTS AGE
my-keyspaces-app-123abcde4f-g5hij 1/1 Running 0 75s
```

For more details, you can use the following command.

```
kubectl describe pod my-keyspaces-app-123abcde4f-g5hij -n my-eks-namespace
```

```
Name:                 my-keyspaces-app-123abcde4f-g5hij
Namespace:            my-eks-namespace
Priority:             2000001000
Priority Class Name:  system-node-critical
Service Account:      my-eks-serviceaccount
Node:                 fargate-ip-192-168-102-209.ec2.internal/192.168.102.209
Start Time:           Thu, 23 Nov 2023 12:15:43 +0000
Labels:               app=my-keyspaces-app
                      eks.amazonaws.com/fargate-profile=my-fargate-profile
                      pod-template-hash=6c56fccc56
Annotations:          CapacityProvisioned: 0.25vCPU 0.5GB
                      Logging: LoggingDisabled: LOGGING_CONFIGMAP_NOT_FOUND
Status:               Running
IP:                   192.168.102.209
IPs:
  IP:           192.168.102.209
Controlled By:  ReplicaSet/my-keyspaces-app-6c56fccc56
Containers:
  my-keyspaces-app:
    Container ID:
 containerd://41ff7811d33ae4bc398755800abcdc132335d51d74f218ba81da0700a6f8c67b
    Image:          111122223333.dkr.ecr.us-east-1.amazonaws.com/
my_eks_repository:latest
    Image ID:       111122223333.dkr.ecr.us-east-1.amazonaws.com/
my_eks_repository@sha256:fd3c6430fc5251661efce99741c72c1b4b03061474940200d0524b84a951439c
    Port:           8080/TCP
    Host Port:      0/TCP
    State:          Running
      Started:      Thu, 23 Nov 2023 12:15:19 +0000
      Finished:     Thu, 23 Nov 2023 12:16:17 +0000
    Ready:          True
    Restart Count:  1
    Environment:
      CASSANDRA_HOST:               cassandra.us-east-1.amazonaws.com:9142
```

```
      CASSANDRA_DC:                 us-east-1
      AWS_WEB_IDENTITY_TOKEN_FILE:  /var/run/secrets/eks.amazonaws.com/
serviceaccount/token
      AWS_ROLE_ARN:                 arn:aws:iam::111122223333:role/my-iam-role
      AWS_REGION:                   us-east-1
      AWS_STS_REGIONAL_ENDPOINTS:   regional
    Mounts:
      /var/run/secrets/eks.amazonaws.com/serviceaccount from aws-iam-token (ro)
      /var/run/secrets/kubernetes.io/serviceaccount from kube-api-access-fssbf (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  aws-iam-token:
    Type:                     Projected (a volume that contains injected data from
 multiple sources)
    TokenExpirationSeconds:  86400
  kube-api-access-fssbf:
    Type:                     Projected (a volume that contains injected data from
 multiple sources)
    TokenExpirationSeconds:  3607
    ConfigMapName:           kube-root-ca.crt
    ConfigMapOptional:       <nil>
    DownwardAPI:             true
QoS Class:                   BestEffort
Node-Selectors:              <none>
Tolerations:                 node.kubernetes.io/not-ready:NoExecute op=Exists for
 300s
                             node.kubernetes.io/unreachable:NoExecute op=Exists for
 300s
Events:
  Type     Reason           Age                From               Message
  ----     ------           ----               ----               -------
  Warning  LoggingDisabled  2m13s              fargate-scheduler  Disabled logging
 because aws-logging configmap was not found. configmap "aws-logging" not found
  Normal   Scheduled        89s                fargate-scheduler  Successfully
 assigned my-eks-namespace/my-keyspaces-app-6c56fccc56-mgs2m to fargate-
ip-192-168-102-209.ec2.internal
  Normal   Pulled           75s                kubelet
 Successfully pulled image "111122223333.dkr.ecr.us-east-1.amazonaws.com/
my_eks_repository:latest" in 13.027s (13.027s including waiting)
```

```
  Normal   Pulling          54s (x2 over 88s)  kubelet            Pulling image
 "111122223333.dkr.ecr.us-east-1.amazonaws.com/my_eks_repository:latest"
  Normal   Created          54s (x2 over 75s)  kubelet            Created container
 my-keyspaces-app
  Normal   Pulled           54s                kubelet
 Successfully pulled image "111122223333.dkr.ecr.us-east-1.amazonaws.com/
my_eks_repository:latest" in 222ms (222ms including waiting)
  Normal   Started          53s (x2 over 75s)  kubelet            Started container
 my-keyspaces-app
```

4. Check the Pod's logs to confirm that your application is running and can connect to your Amazon Keyspaces table. You can do so with the following command. Make sure to replace the name of your deployment.

```
kubectl logs -f my-keyspaces-app-123abcde4f-g5hij -n my-eks-namespace
```

You should be able to see application log entries confirming the connection to Amazon Keyspaces like in the example below.

```
2:47:20.553 [s0-admin-0] DEBUG c.d.o.d.i.c.metadata.MetadataManager
 - [s0] Adding initial contact points [Node(endPoint=cassandra.us-
east-1.amazonaws.com/1.222.333.44:9142, hostId=null, hashCode=e750d92)]
22:47:20.562 [s0-admin-1] DEBUG c.d.o.d.i.c.c.ControlConnection - [s0] Initializing
 with event types [SCHEMA_CHANGE, STATUS_CHANGE, TOPOLOGY_CHANGE]
22:47:20.564 [s0-admin-1] DEBUG c.d.o.d.i.core.context.EventBus - [s0] Registering
 com.datastax.oss.driver.internal.core.metadata.LoadBalancingPolicyWrapper$$Lambda
$812/0x0000000801105e88@769afb95 for class
 com.datastax.oss.driver.internal.core.metadata.NodeStateEvent
22:47:20.566 [s0-admin-1] DEBUG c.d.o.d.i.c.c.ControlConnection -
 [s0] Trying to establish a connection to Node(endPoint=cassandra.us-
east-1.amazonaws.com/1.222.333.44:9142, hostId=null, hashCode=e750d92)
```

5. Run the following CQL query on your Amazon Keyspaces table to confirm that one row of data has been written to your table:

```
SELECT * from aws.user;
```

You should see the following output:

```
fname    | lname | username | last_update_date
----------+-------+----------+---------------------------
```

```
random    | k     | test     | 2023-12-07 13:58:31.57+0000
```

Step 5: (Optional) Cleanup

Follow these steps to remove all the resources created in this tutorial.

Remove the resources created in this tutorial

1. Delete your deployment. You can use the following command to do so.

```
kubectl delete deployment my-keyspaces-app -n my-eks-namespace
```

2. Delete the Amazon EKS cluster and all Pods contained in it. This also deletes related resources like the service account and OIDC identity provider. You can use the following command to do so.

```
eksctl delete cluster --name my-eks-cluster --region us-east-1
```

3. Delete the IAM role used for the Amazon EKS service account with access permissions to Amazon Keyspaces. First, you have to remove the managed policy that is attached to the role.

```
aws iam detach-role-policy --role-name my-iam-role --policy-arn
 arn:aws:iam::aws:policy/AmazonKeyspacesFullAccess
```

   Then you can delete the role using the following command.

```
aws iam delete-role --role-name my-iam-role
```

   For more information, see Deleting an IAM role (AWS CLI) in the *IAM User Guide*.

4. Delete the Amazon ECR repository including all the images stored in it. You can do so using the following command.

```
aws ecr delete-repository \
      --repository-name my-ecr-repository \
      --force \
      --region us-east-1
```

Note that the `force` flag is required to delete a repository that contains images. To delete your image first, you can do so using the following command.

```
aws ecr batch-delete-image \
      --repository-name my-ecr-repository \
      --image-ids imageTag=latest \
      --region us-east-1
```

For more information, see Delete an image in the Amazon Elastic Container Registry User Guide.

5. Delete the Amazon Keyspaces keyspace and table. Deleting the keyspace automatically deletes all tables in that keyspace. You can use one the following options to do so.

   AWS CLI

   ```
   aws keyspaces delete-keyspace --keyspace-name 'aws'
   ```

   To confirm that the keyspace was deleted, you can use the following command.

   ```
   aws keyspaces list-keyspaces
   ```

   To delete the table first, you can use the following command.

   ```
   aws keyspaces delete-table --keyspace-name 'aws' --table-name 'user'
   ```

   To confirm that your table was deleted, you can use the following command.

   ```
   aws keyspaces list-tables --keyspace-name 'aws'
   ```

   For more information, see delete keyspace and delete table in the *AWS CLI Command Reference*.

   cqlsh

   ```
   DROP KEYSPACE IF EXISTS "aws";
   ```

   To verify that your keyspaces was deleted, you can use the following statement.

```
SELECT * FROM system_schema.keyspaces ;
```

Your keyspace should not be listed in the output of this statement. Note that there can be a delay until the keyspaces is deleted. For more information, see the section called “DROP KEYSPACE”.

To delete the table first, you can use the following command.

```
DROP TABLE "aws.user"
```

To confirm that your table was deleted, you can use the following command.

```
SELECT * FROM system_schema.tables WHERE keyspace_name = "aws";
```

Your table should not be listed in the output of this statement. Note that there can be a delay until the table is deleted. For more information, see the section called “DROP TABLE”.

Tutorial: Export an Amazon Keyspaces table to Amazon S3 using AWS Glue

This tutorial shows you how to export an Amazon Keyspaces table to an Amazon S3 bucket using AWS Glue. The tutorial uses the `keyspaces-bulk-cli` CLI tool available in the Amazon Keyspaces GitHub repo. Using this tool, you can export Amazon Keyspaces data to Amazon S3 without having to set up a Spark cluster.

Topics

- Prerequisites for exporting data from Amazon Keyspaces to Amazon S3
- Step 1: Bootstrap the infrastructure and AWS Glue jobs
- Step 2: Run the export job
- Step 3: (Optional) Create a trigger to schedule the export job
- Step 4: (Optional) Cleanup

Prerequisites for exporting data from Amazon Keyspaces to Amazon S3

Confirm the following prerequisites and create the Amazon Keyspaces resources before you begin with the tutorial

1. Before you start this tutorial, follow the AWS setup instructions in Accessing Amazon Keyspaces (for Apache Cassandra). These steps include signing up for AWS and creating an AWS Identity and Access Management (IAM) principal with access to Amazon Keyspaces.
2. The CLI tool in this tutorial uses your credentials and default AWS Region stored in a known location. For more information, see the section called "Manage access keys".

   The following example shows how to store the required values as environment variables for the default user.

   ```
   $ export AWS_ACCESS_KEY_ID=AKIAIOSFODNN7EXAMPLE
   $ export AWS_SECRET_ACCESS_KEY=wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
   $ export AWS_DEFAULT_REGION=us-east-1
   ```

3. To run the `keyspaces-bulk-cli` CLI in this tutorial, you need the following software and tools installed on your machine:

   - Python 3.8 or later
   - Java (JDK 11 or later)
   - Apache Maven
   - Git
   - curl
   - AWS CLI

   Java, Git, and Maven are required by the bootstrap step to download and build the retry policy helper. This tutorial was tested with AWS CLI 2, Python 3.11, Java 17.0.13, and Apache Maven 3.8.7.
4. You need an Amazon Keyspaces table with sample data to export later in this tutorial. You can use your own Amazon Keyspaces table or create a sample table following the steps in the *Getting started* tutorial.

   a. To install the `cqlsh-expansion`, follow the steps at the section called "Using the `cqlsh-expansion`".

b. Confirm that the `Murmur3Partitioner` partitioner is the default partitioner for your account. This partitioner is compatible with the Apache Spark Cassandra Connector and with AWS Glue. For more information on partitioners, see the section called "Working with partitioners".

   To change the partitioner of your account, you can use the following statement.

```
SELECT partitioner FROM system.local;

UPDATE system.local set
 partitioner='org.apache.cassandra.dht.Murmur3Partitioner' where key='local';
```

c. To create an Amazon Keyspaces keyspace, follow the steps at the section called "Create a keyspace".

d. To create the Amazon Keyspaces table, follow the steps at the section called "Create a table".

e. To load sample data into the table to export to Amazon S3, follow the steps at the section called "Create".

After completing the prerequisite steps, proceed to the section called "Step 1: Bootstrap infrastructure and AWS Glue jobs".

Step 1: Bootstrap the infrastructure and AWS Glue jobs

In this step, you use the `keyspaces-bulk-cli` CLI to create and configure all the AWS resources required for the automated data export of an Amazon Keyspaces table to an Amazon S3 bucket using AWS Glue. The `bootstrap` command performs all setup tasks in a single step.

The `bootstrap` command automates the following tasks.

1. Creates an **Amazon S3 bucket** and an **IAM service role** using CloudFormation.
2. Downloads the Apache Spark Cassandra Connector, the SigV4 Authentication plugin, and the Apache Spark Extensions.
3. Downloads and builds the Keyspaces Retry Policy helper using Maven.
4. Uploads all JAR files and the `keyspaces-application.conf` configuration file to the Amazon S3 bucket.

5. Deploys three AWS Glue jobs: export (export a table to Amazon S3), import (import data from Amazon S3 into a table), and count (count rows in a table).
6. Saves the stack configuration to a local `.keyspaces-bulk-cli.json` file for use by subsequent commands.

To bootstrap the infrastructure and AWS Glue jobs

1. Clone the files from the aws-glue repository on GitHub to your local machine.

```
$ git clone https://github.com/aws-samples/amazon-keyspaces-examples.git
$ cd amazon-keyspaces-examples/scala/datastax-v4/aws-glue
```

2. Run the `bootstrap` command. The following example uses the default stack name `aksglue` and specifies the keyspace and table as defaults for the deployed jobs. You can override these values when running individual commands such as `export`, `import`, or `count`.

```
$ ./keyspaces-bulk-cli bootstrap --stack aksglue --keyspace catalog --
table book_awards
```

The following table describes the optional parameters you can pass to customize the bootstrap.

Option	Default	Description
`--stack`	`aksglue`	CloudFormation stack name prefix
`--bucket`	Auto-generated from stack and account	Amazon S3 bucket for artifacts
`--role-name`	Auto-generated from stack	IAM service role name
`--keyspace`	`mykeyspace`	Default keyspace for deployed jobs
`--table`	`mytable`	Default table for deployed jobs

Option	Default	Description
`--s3-uri`	`s3://{bucket}/export`	Default Amazon S3 path for exported data
`--format`	`parquet`	Default data format
`--region`	From AWS config	AWS Region
`--profile`	From AWS config	AWS named profile

To confirm that the Amazon S3 bucket created by bootstrap exists, you can use the following AWS CLI command. Replace *YOURACCOUNTID* with your AWS account ID.

```
$ aws s3 ls s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID
```

The output of the command looks similar to the following:

```
                           PRE conf/
                           PRE jars/
                           PRE scripts/
```

To confirm that the AWS Glue export job was deployed, you can use the following command.

```
$ aws glue list-jobs
```

The output lists the deployed jobs:

```
{
    "JobNames": [
        "AmazonKeyspacesExportToS3-aksglue",
        "AmazonKeyspacesImportFromS3-aksglue",
        "AmazonKeyspacesCount-aksglue"
    ]
}
```

If the CloudFormation stack process fails, you can review the detailed error information about the failed stack in the CloudFormation console. To retry, delete the failed stack using `aws cloudformation delete-stack --stack-name aksglue`, fix the underlying issue, and run the bootstrap command again. The bootstrap command is idempotent and skips resources that already exist.

After the bootstrap completes and all resources are created, proceed to the section called “Step 2: Run the export job”.

Step 2: Run the export job

In this step, you run the AWS Glue export job created in the previous step. After you start the export, you can monitor the job progress with the `status` and `logs` commands.

To run and monitor the export job

1. Run the export command. Specify the keyspace, table, and the Amazon S3 bucket to export to. Use the bucket that was created by the bootstrap command in the previous step. Replace *YOURACCOUNTID* with your AWS account ID.

   ```
   $ ./keyspaces-bulk-cli export --keyspace catalog --table book_awards \
       --s3-uri s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID
   ```

   - You can override additional parameters when running the export. The following command increases the number of AWS Glue workers. Start with the default of 2 workers and increase as needed based on table size and export duration. Monitor the job with the `status` command and scale up if the export takes longer than expected.

     ```
     $ ./keyspaces-bulk-cli export --keyspace catalog --table book_awards \
         --s3-uri s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID --workers 8
     ```

2. Monitor the status of the export job. You can check the current run status and view logs.

   ```
   $ ./keyspaces-bulk-cli status export
   ```

   The output shows the job run details. Wait until the `State` field shows SUCCEEDED:

   ```
           Job Run: jr_6f8de24d7131da54...
   ################################################################
   # Field          # Value                                       #
   ```

```
################################################################
# Job Name       # AmazonKeyspacesExportToS3-aksglue           #
# State          # SUCCEEDED                                   #
# Started        # 2025-01-30 14:54:22                         #
# Completed      # 2025-01-30 14:56:45                         #
# Execution Time # 143s                                        #
# Workers        # 2                                           #
# Worker Type    # G.2X                                        #
################################################################
```

To view the logs for the running or completed job, use the following command.

```
$ ./keyspaces-bulk-cli logs export
```

To view only error logs, use the following command.

```
$ ./keyspaces-bulk-cli logs export --log-type error
```

3. Confirm that the export completed by listing the Amazon S3 bucket contents. Based on the size of the table, the export can take some time. When the export job finishes, you can see the following folders in the bucket. Replace *YOURACCOUNTID* with your AWS account ID.

```
$ aws s3 ls s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID
```

The output shows the following structure in your bucket:

```
                           PRE conf/
                           PRE export/
                           PRE jars/
                           PRE scripts/
                           PRE spark-logs/
```

Your exported data files are in the following folder structure (date and time values reflect your own export run):

```
\------- export
            \----- catalog
                \----- book_awards
                   \----- snapshot
                       \----- year=2025
```

```
                                \----- month=01
                                   \----- day=30
                                       \----- hour=14
                                           \----- minute=54
                                               \--- part-00000-*.snappy.parquet
```

To schedule the AWS Glue job you just ran manually, proceed to the section called “Step 3: (Optional) Schedule the export job”.

Step 3: (Optional) Create a trigger to schedule the export job

To run the export job on a regular basis, you can create a scheduled trigger using the AWS CLI. For more information, see AWS Glue triggers in the AWS Glue Developer Guide.

To schedule the AWS Glue export job

1. To find the job name and parameters from a previous run, use the `--json` flag to output the run details including the arguments used.

   ```
   $ ./keyspaces-bulk-cli runs export --json
   ```

   The output includes the job name, worker configuration, and all arguments from each run:

   ```
   [
     {
       "JobName": "AmazonKeyspacesExportToS3-aksglue",
       "RunId": "jr_2d827b0637a36b25f32f03b83e107cf8...",
       "State": "SUCCEEDED",
       "Started": "2025-01-30T14:54:22.480000-04:00",
       "Duration": 127,
       "Workers": 2,
       "WorkerType": "G.2X",
       "Arguments": {
         "--KEYSPACE_NAME": "catalog",
         "--DRIVER_CONF": "keyspaces-application.conf",
         "--TABLE_NAME": "book_awards",
         "--S3_URI": "s3://amazon-keyspaces-bulk-cli-aksglue-111122223333",
         "--FORMAT": "parquet"
       }
     }
   ```

```
]
```

Use the `JobName`, `Workers`, `WorkerType`, and `Arguments` values from the output in the next step to create the trigger.

2. The following AWS CLI command creates a trigger with the name `KeyspacesExportWeeklyTrigger` that runs the AWS Glue export job once per week on Monday at 12:00 UTC. Use the values from the JSON output of the previous step for the job name, worker configuration, and arguments.

```
aws glue create-trigger \
  --name KeyspacesExportWeeklyTrigger \
  --type SCHEDULED \
  --schedule "cron(0 12 ? * MON *)" \
  --start-on-creation \
  --actions '[{
     "JobName": "AmazonKeyspacesExportToS3-aksglue",
     "NumberOfWorkers": 2,
     "WorkerType": "G.2X",
     "Arguments": {
       "--KEYSPACE_NAME": "catalog",
       "--DRIVER_CONF": "keyspaces-application.conf",
       "--TABLE_NAME": "book_awards",
       "--S3_URI": "s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID",
       "--FORMAT": "parquet"
     }
  }]'
```

- To override specific parameters for the scheduled job, change the values in the `Arguments` block. The following example schedules an export of a different table with more workers.

```
aws glue create-trigger \
  --name KeyspacesExportWeeklyTrigger \
  --type SCHEDULED \
  --schedule "cron(0 12 ? * MON *)" \
  --start-on-creation \
  --actions '[{
     "JobName": "AmazonKeyspacesExportToS3-aksglue",
     "NumberOfWorkers": 8,
     "WorkerType": "G.2X",
     "Arguments": {
```

```
        "--KEYSPACE_NAME": "my_keyspace",
        "--DRIVER_CONF": "keyspaces-application.conf",
        "--TABLE_NAME": "my_table",
        "--S3_URI": "s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID",
        "--FORMAT": "parquet"
      }
  }]'
```

3. To confirm that the trigger was created, use the following command.

```
$ aws glue list-triggers
```

The output of the command looks similar to the following:

```
{
    "TriggerNames": [
        "KeyspacesExportWeeklyTrigger"
    ]
}
```

To clean up the AWS resources created in this tutorial, proceed to the section called “Step 4: (Optional) Cleanup”.

Step 4: (Optional) Cleanup

Follow these steps to remove all the AWS resources created in this tutorial. The AWS Glue job stacks must be deleted before the parent infrastructure stack because they reference its exported values.

To remove the resources created in this tutorial

1. Delete the Amazon S3 bucket contents created by bootstrap. Replace *YOURACCOUNTID* with your AWS account ID.

```
$ aws s3 rm s3://amazon-keyspaces-bulk-cli-aksglue-YOURACCOUNTID --recursive
```

2. Delete the AWS Glue job stacks created by the bootstrap command. These child stacks must be deleted before the parent stack. You can use the following commands.

```
$ aws cloudformation delete-stack --stack-name aksglue-export
```

```
$ aws cloudformation delete-stack --stack-name aksglue-import
$ aws cloudformation delete-stack --stack-name aksglue-count
```

Wait for the child stacks to finish deleting before proceeding. You can check the status with the following command.

```
$ aws cloudformation wait stack-delete-complete --stack-name aksglue-export
$ aws cloudformation wait stack-delete-complete --stack-name aksglue-import
$ aws cloudformation wait stack-delete-complete --stack-name aksglue-count
```

3. Delete the parent CloudFormation stack. This removes the Amazon S3 bucket resource and the IAM role created in this tutorial.

```
$ aws cloudformation delete-stack --stack-name aksglue
```

4. If you created a trigger in the previous step, delete it using the following command.

```
$ aws glue delete-trigger --name KeyspacesExportWeeklyTrigger
```

5. Delete the Amazon Keyspaces keyspace and table. Deleting the keyspace automatically deletes all tables in that keyspace. You can use one of the following options.

   AWS CLI

   ```
   $ aws keyspaces delete-keyspace --keyspace-name 'catalog'
   ```

   To confirm that the keyspace was deleted, you can use the following command.

   ```
   $ aws keyspaces list-keyspaces
   ```

   To delete the table first, you can use the following command.

   ```
   $ aws keyspaces delete-table --keyspace-name 'catalog' --table-name
    'book_awards'
   ```

   To confirm that your table was deleted, you can use the following command.

   ```
   $ aws keyspaces list-tables --keyspace-name 'catalog'
   ```

For more information, see delete keyspace and delete table in the *AWS CLI Command Reference*.

cqlsh

```
DROP KEYSPACE IF EXISTS "catalog";
```

To verify that your keyspace was deleted, you can use the following statement.

```
SELECT * FROM system_schema.keyspaces ;
```

Your keyspace should not be listed in the output of this statement. Note that there can be a delay until the keyspace is deleted. For more information, see the section called “DROP KEYSPACE”.

To delete the table first, you can use the following command.

```
DROP TABLE "catalog"."book_awards";
```

To confirm that your table was deleted, you can use the following command.

```
SELECT * FROM system_schema.tables WHERE keyspace_name = "catalog";
```

Your table should not be listed in the output of this statement. Note that there can be a delay until the table is deleted. For more information, see the section called “DROP TABLE”.

Managing serverless resources in Amazon Keyspaces (for Apache Cassandra)

Amazon Keyspaces (for Apache Cassandra) is serverless. Instead of deploying, managing, and maintaining storage and compute resources for your workload through nodes in a cluster, Amazon Keyspaces allocates storage and read/write throughput resources directly to tables.

Amazon Keyspaces provisions storage automatically based on the data stored in your tables. It scales storage up and down as you write, update, and delete data, and you pay only for the storage you use. Data is replicated across multiple Availability Zones for high availability. Amazon Keyspaces monitors the size of your tables continuously to determine your storage charges. For more information about how Amazon Keyspaces calculates the billable size of the data, see the section called "Estimate row size".

This chapter covers key aspects of resource management in Amazon Keyspaces.

- **Estimate row size** – To estimate the encoded size of rows in Amazon Keyspaces, consider factors like partition key metadata, clustering column metadata, column identifiers, data types, and row metadata. This encoded row size is used for billing, quota management, and provisioned throughput capacity planning.
- **Estimate capacity consumption** – This section covers examples of how to estimate read and write capacity consumption for common scenarios like range queries, limit queries, table scans, lightweight transactions, static columns, and multi-Region tables. You can use Amazon CloudWatch to monitor actual capacity utilization. For more information about monitoring with CloudWatch, see the section called "Monitoring with CloudWatch".
- **Configure read/write capacity modes** – You can choose between two capacity modes for processing reads and writes on your tables:
  - **On-demand mode (default)** – Pay per request for read and write throughput. Amazon Keyspaces can instantly scale capacity up to any previously reached traffic level.
  - **Provisioned mode** – Specify the required number of read and write capacity units in advance. This mode helps maintain predictable throughput performance.
- **Manage throughput capacity with automatic scaling** – For provisioned tables, you can enable automatic scaling to adjust throughput capacity automatically based on actual application traffic. Amazon Keyspaces uses target tracking to increase or decrease provisioned capacity, keeping utilization at your specified target.

- **Use burst capacity effectively** – Amazon Keyspaces provides burst capacity by reserving a portion of unused throughput for handling spikes in traffic. This flexibility allows occasional bursts of activity beyond your provisioned throughput.

To troubleshoot capacity errors, see the section called “Serverless capacity errors”.

Topics

- Estimate row size in Amazon Keyspaces
- Estimate capacity consumption of read and write throughput in Amazon Keyspaces
- Configure read/write capacity modes in Amazon Keyspaces
- Manage throughput capacity automatically with Amazon Keyspaces auto scaling
- Use burst capacity effectively in Amazon Keyspaces

Estimate row size in Amazon Keyspaces

Amazon Keyspaces provides fully managed storage that offers single-digit millisecond read and write performance and stores data durably across multiple AWS Availability Zones. Amazon Keyspaces attaches metadata to all rows and primary key columns to support efficient data access and high availability.

This topic provides details about how to estimate the encoded size of rows in Amazon Keyspaces. The encoded row size is used when calculating your bill and quota use. You can also use the encoded row size when estimating provisioned throughput capacity requirements for tables.

To calculate the encoded size of rows in Amazon Keyspaces, you can use the following guidelines.

Topics

- Estimate the encoded size of columns
- Estimate the encoded size of data values based on data type
- Consider the impact of Amazon Keyspaces features on row size
- Choose the right formula to calculate the encoded size of a row
- Row size calculation example

Estimate the encoded size of columns

This section shows how to estimate the encoded size of columns in Amazon Keyspaces.

- **Regular columns** – For regular columns, which are columns that aren't primary keys, clustering columns, or `STATIC` columns, use the raw size of the cell data based on the data type and add the required metadata. The data types and some key differences in how Amazon Keyspaces stores data type values and metadata are listed in the next section.
- **Partition key columns** – Partition keys can contain up to 2048 bytes of data. Each key column in the partition key requires up to 3 bytes of metadata. When calculating the size of your row, you should assume each partition key column uses the full 3 bytes of metadata.
- **Clustering columns** – Clustering columns can store up to 850 bytes of data. In addition to the size of the data value, each clustering column requires up to 20% of the data value size for metadata. When calculating the size of your row, you should add 1 byte of metadata for each 5 bytes of clustering column data value.

  > **Note**
  >
  > To support efficient querying and built-in indexing, Amazon Keyspaces stores the data value of each partition key and clustering key column twice.

- **Column names** – The space required for each column name is stored using a column identifier and added to each data value stored in the column. The storage value of the column identifier depends on the overall number of columns in your table:
  - 1–62 columns: 1 byte
  - 63–124 columns: 2 bytes
  - 125–186 columns: 3 bytes

  For each additional 62 columns add 1 byte. Note that in Amazon Keyspaces, up to 225 regular columns can be modified with a single `INSERT` or `UPDATE` statement. For more information, see the section called “Amazon Keyspaces service quotas”.

Estimate the encoded size of data values based on data type

This section shows how to estimate the encoded size of different data types in Amazon Keyspaces.

- **String types** – Cassandra `ASCII`, `TEXT`, and `VARCHAR` string data types are all stored in Amazon Keyspaces using Unicode with UTF-8 binary encoding. The size of a string in Amazon Keyspaces equals the number of UTF-8 encoded bytes.
- **Numeric types** – Cassandra `INT`, `BIGINT`, `SMALLINT`, `TINYINT`, and `VARINT` data types are stored in Amazon Keyspaces as data values with variable length, with up to 38 significant digits. Leading and trailing zeroes are trimmed. The size of any of these data types is approximately 1 byte per two significant digits + 1 byte.
- **Blob type** – A `BLOB` in Amazon Keyspaces is stored with the value's raw byte length.
- **Boolean type** – The size of a `Boolean` value or a `Null` value is 1 byte.
- **Collection types** – A column that stores collection data types like `LIST` or `MAP` requires 3 bytes of metadata, regardless of its contents. The size of a `LIST` or `MAP` is (column id) + sum (size of nested elements) + (3 bytes). The size of an empty `LIST` or `MAP` is (column id) + (3 bytes). Each individual `LIST` or `MAP` element also requires 1 byte of metadata.
- **User-defined types** – A user-defined type (UDT) requires 3 bytes for metadata, regardless of its contents. For each UDT element, Amazon Keyspaces requires an additional 1 byte of metadata.

  To calculate the encoded size of a UDT, start with the `field name` and the `field value` for the fields of a UDT:

  - **field name** – Each field name of the top-level UDT is stored using an identifier. The storage value of the identifier depends on the overall number of fields in your top-level UDT, and can vary between 1 and 3 bytes:
    - 1–62 fields: 1 byte
    - 63–124 fields: 2 bytes
    - 125– max fields: 3 bytes
  - **field value** – The bytes required to store the field values of the top-level UDT depend on the data type stored:
    - **Scalar data type** – The bytes required for storage are the same as for the same data type stored in a regular column.
    - **Frozen UDT** – For each frozen nested UDT, the nested UDT has the same size as it would have in the CQL binary protocol. For a nested UDT, 4 bytes are stored for each field (including empty fields) and the value of the stored field is the CQL binary protocol serialization format of the field value.
    - **Frozen collections**:

  - **LIST** and **SET** – For a nested frozen `LIST` or `SET`, 4 bytes are stored for each element of the collection plus the CQL binary protocol serialization format of the collection's value.
  - **MAP** – For a nested frozen `MAP`, each key-value pair has the following storage requirements:
    - For each key allocate 4 bytes, then add the CQL binary protocol serialization format of the key.
    - For each value allocate 4 bytes, then add the CQL binary protocol serialization format of the value.
- **FROZEN keyword** – For frozen collections nested within frozen collections, Amazon Keyspaces doesn't require any additional bytes for meta data.
- **STATIC keyword** – `STATIC` column data doesn't count towards the maximum row size of 1 MB. To calculate the data size of static columns, see the section called "Calculate static column size per logical partition".

Consider the impact of Amazon Keyspaces features on row size

This section shows how Client-side timestamps and Time to Live (TTL) features in Amazon Keyspaces impact the encoded size of a row.

When client-side timestamps are turned on or TTL is utilized (using the `USING TTL` clause), additional metadata is stored for every column of every row in your table. Additionally, metadata may also be stored for each element in case of certain collection data types. The following table shows the metadata overhead for each data type.

Column/Data Type	Client-side timestamps enabled	TTL without client-side timestamps	Client-side timestamps enabled with TTL
Scalar types	18 bytes/column	16 bytes/column	27 bytes/column
Frozen collection / Frozen UDT / Tuple	18 bytes/column	16 bytes/column	27 bytes/column
Non-frozen List	30 bytes/element + 19 bytes/column	15 bytes/element	39 bytes/element + 19 bytes/column

Column/Data Type	Client-side timestamps enabled	TTL without client-side timestamps	Client-side timestamps enabled with TTL
Non-frozen Set	14 bytes/element + 26 bytes/column	12 bytes/element + 7 bytes/column	23 bytes/element + 26 bytes/column
Non-frozen Map / Non-frozen UDT	17 bytes/element + 26 bytes/column	15 bytes/element + 7 bytes/column	26 bytes/element + 26 bytes/column
Counter (single-Region)	51 bytes/column	N/A (no TTL support)	N/A (no TTL support)
Counter (multi-Region)	25 + (N_regions × 26) bytes/column	N/A (no TTL support)	N/A (no TTL support)

These metadata bytes count towards your 1-MB row size quota. In the counter formula, N_regions represents the number of AWS Regions in which the counter column has received at least one write operation. Counter overhead values are approximate and may vary slightly. For more information about client-side timestamps, see the section called “Client-side timestamps”. For more information about TTL, see the section called “Expire data with Time to Live”.

Choose the right formula to calculate the encoded size of a row

This section shows the different formulas that you can use to estimate either the storage or the capacity throughput requirements for a row of data in Amazon Keyspaces.

The total encoded size of a row of data can be estimated based on one of the following formulas, based on your goal:

- **Throughput capacity** – To estimate the encoded size of a row to assess the required read/write request units (RRUs/WRUs) or read/write capacity units (RCUs/WCUs):

```
total encoded size of row = partition key columns + clustering columns + regular
 columns
```

- **Storage size** – To estimate the encoded size of a row to predict the `BillableTableSizeInBytes`, add the required metadata for the storage of the row:

```
total encoded size of row = partition key columns + clustering columns + regular
 columns + row metadata (100 bytes)
```

> **Important**
>
> All column metadata, for example column ids, partition key metadata, clustering column metadata, as well as client-side timestamps, TTL, and row metadata count towards the maximum row size of 1 MB.

Row size calculation example

Consider the following example of a table where all columns are of type integer. The table has two partition key columns, two clustering columns, and one regular column. Because this table has five columns, the space required for the column name identifier is 1 byte.

```
CREATE TABLE mykeyspace.mytable(pk_col1 int, pk_col2 int, ck_col1 int, ck_col2 int,
 reg_col1 int, primary key((pk_col1, pk_col2),ck_col1, ck_col2));
```

In this example, we calculate the size of data when we write a row to the table as shown in the following statement:

```
INSERT INTO mykeyspace.mytable (pk_col1, pk_col2, ck_col1, ck_col2, reg_col1)
 values(1,2,3,4,5);
```

To estimate the total bytes required by this write operation, you can use the following steps.

1. Calculate the size of a partition key column by adding the bytes for the data type stored in the column and the metadata bytes. Repeat this for all partition key columns.

   a. Calculate the size of the first column of the partition key (pk_col1):

   ```
   (2 bytes for the integer data type) x 2 + 1 byte for the column id + 3 bytes
    for partition key metadata = 8 bytes
   ```

   b. Calculate the size of the second column of the partition key (pk_col2):

```
(2 bytes for the integer data type) x 2 + 1 byte for the column id + 3 bytes
 for partition key metadata = 8 bytes
```

c. Add both columns to get the total estimated size of the partition key columns:

```
8 bytes + 8 bytes = 16 bytes for the partition key columns
```

2. Calculate the size of the clustering column by adding the bytes for the data type stored in the column and the metadata bytes. Repeat this for all clustering columns.

   a. Calculate the size of the first column of the clustering column (ck_col1):

```
(2 bytes for the integer data type) x 2 + 20% of the data value (2 bytes) for
 clustering column metadata + 1 byte for the column id  = 6 bytes
```

   b. Calculate the size of the second column of the clustering column (ck_col2):

```
(2 bytes for the integer data type) x 2 + 20% of the data value (2 bytes) for
 clustering column metadata + 1 byte for the column id = 6 bytes
```

   c. Add both columns to get the total estimated size of the clustering columns:

```
6 bytes + 6 bytes = 12 bytes for the clustering columns
```

3. Add the size of the regular columns. In this example we only have one column that stores a single digit integer, which requires 2 bytes with 1 byte for the column id.
4. Finally, to get the total encoded row size, add up the bytes for all columns. To estimate the billable size for storage, add the additional 100 bytes for row metadata:

```
16 bytes for the partition key columns + 12 bytes for clustering columns + 3 bytes
 for the regular column + 100 bytes for row metadata = 131 bytes.
```

To learn how to monitor serverless resources with Amazon CloudWatch, see the section called “Monitoring with CloudWatch”.

Estimate capacity consumption of read and write throughput in Amazon Keyspaces

When you read or write data in Amazon Keyspaces, the amount of read/write request units (RRUs/WRUs) or read/write capacity units (RCUs/WCUs) your query consumes depends on the total amount of data Amazon Keyspaces has to process to run the query. In some cases, the data returned to the client can be a subset of the data that Amazon Keyspaces had to read to process the query. For conditional writes, Amazon Keyspaces consumes write capacity even if the conditional check fails.

To estimate the total amount of data being processed for a request, you have to consider the encoded size of a row and the total number of rows. This topic covers some examples of common scenarios and access patterns to show how Amazon Keyspaces processes queries and how that affects capacity consumption. You can follow the examples to estimate the capacity requirements of your tables and use Amazon CloudWatch to observe the read and write capacity consumption for these use cases.

For information on how to calculate the encoded size of rows in Amazon Keyspaces, see the section called “Estimate row size”.

Topics

- Estimate the capacity consumption of range queries in Amazon Keyspaces
- Estimate the read capacity consumption of limit queries
- Estimate the read capacity consumption of table scans
- Estimate capacity consumption of lightweight transactions in Amazon Keyspaces
- Estimate capacity consumption for static columns in Amazon Keyspaces
- Estimate and provision capacity for a multi-Region table in Amazon Keyspaces
- Estimate read and write capacity consumption with Amazon CloudWatch in Amazon Keyspaces

Estimate the capacity consumption of range queries in Amazon Keyspaces

To look at the read capacity consumption of a range query, we use the following example table which is using on-demand capacity mode.

```
pk1 | pk2 | pk3 | ck1 | ck2 | ck3 | value
-----+-----+-----+-----+-----+-----+-------
a | b | 1 | a | b | 50 | <any value that results in a row size larger than 4KB>
a | b | 1 | a | b | 60 | value_1
a | b | 1 | a | b | 70 | <any value that results in a row size larger than 4KB>
```

Now run the following query on this table.

```
SELECT * FROM amazon_keyspaces.example_table_1 WHERE pk1='a' AND pk2='b' AND pk3=1 AND
 ck1='a' AND ck2='b' AND ck3 > 50 AND ck3 < 70;
```

You receive the following result set from the query and the read operation performed by Amazon Keyspaces consumes 2 RRUs in `LOCAL_QUORUM` consistency mode.

```
pk1 | pk2 | pk3 | ck1 | ck2 | ck3 | value
-----+-----+-----+-----+-----+-----+-------
a | b | 1 | a | b | 60 | value_1
```

Amazon Keyspaces consumes 2 RRUs to evaluate the rows with the values `ck3=60` and `ck3=70` to process the query. However, Amazon Keyspaces only returns the row where the `WHERE` condition specified in the query is true, which is the row with value `ck3=60`. To evaluate the range specified in the query, Amazon Keyspaces reads the row matching the upper bound of the range, in this case `ck3 = 70`, but doesn't return that row in the result. The read capacity consumption is based on the data read when processing the query, not on the data returned.

Estimate the read capacity consumption of limit queries

When processing a query that uses the `LIMIT` clause, Amazon Keyspaces reads rows up to the maximum page size when trying to match the condition specified in the query. If Amazon Keyspaces can't find sufficient matching data that meets the `LIMIT` value on the first page, one or more paginated calls could be needed. To continue reads on the next page, you can use a pagination token. The default page size is 1MB. To consume less read capacity when using `LIMIT` clauses, you can reduce the page size. For more information about pagination, see the section called “Paginate results”.

For an example, let's look at the following query.

```
SELECT * FROM my_table WHERE partition_key=1234 LIMIT 1;
```

If you don't set the page size, Amazon Keyspaces reads 1MB of data even though it returns only 1 row to you. To only have Amazon Keyspaces read one row, you can set the page size to 1 for this query. In this case, Amazon Keyspaces would only read one row provided you don't have expired rows based on Time-to-live settings or client-side timestamps.

The `PAGE SIZE` parameter determines how many rows Amazon Keyspaces scans from disk for each request, not how many rows Amazon Keyspaces returns to the client. Amazon Keyspaces applies the filters you provide, for example inequality on non-key columns or a `LIMIT` after it scans the data on disk. If you don't explicitly set the `PAGE SIZE`, Amazon Keyspaces reads up to 1MB of data before applying filters. For example, if you're using `LIMIT 1` without specifying the `PAGE SIZE`, Amazon Keyspaces could read thousands of rows from disk before applying the limit clause and returning only a single row.

To avoid over-reading, reduce the `PAGE SIZE` which reduces the number of rows Amazon Keyspaces scans for each fetch. For example, if you define `LIMIT 5` in your query, set the `PAGE SIZE` to a value between 5 - 10 so that Amazon Keyspaces only scans 5 - 10 rows on each paginated call. You can modify this number to reduce the number of fetches. For limits that are larger than the page size, Amazon Keyspaces maintains the total result count with pagination state. In the case of a `LIMIT` of 10,000 rows, Amazon Keyspaces can fetch these results in two pages of 5,000 rows each. The 1MB limit is the upper bound for any page size set.

Estimate the read capacity consumption of table scans

Queries that result in full table scans, for example queries using the `ALLOW FILTERING` option, are another example of queries that process more reads than what they return as results. And the read capacity consumption is based on the data read, not the data returned.

For the table scan example we use the following example table in on-demand capacity mode.

```
pk | ck | value
---+----+---------
pk | 10 | <any value that results in a row size larger than 4KB>
pk | 20 | value_1
pk | 30 | <any value that results in a row size larger than 4KB>
```

Amazon Keyspaces creates a table in on-demand capacity mode with four partitions by default. In this example table, all the data is stored in one partition and the remaining three partitions are empty.

Now run the following query on the table.

```
SELECT * from amazon_keyspaces.example_table_2;
```

This query results in a table scan operation where Amazon Keyspaces scans all four partitions of the table and consumes 6 RRUs in `LOCAL_QUORUM` consistency mode. First, Amazon Keyspaces consumes 3 RRUs for reading the three rows with `pk='pk'`. Then, Amazon Keyspaces consumes the additional 3 RRUs for scanning the three empty partitions of the table. Because this query results in a table scan, Amazon Keyspaces scans all the partitions in the table, including partitions without data.

Estimate capacity consumption of lightweight transactions in Amazon Keyspaces

Lightweight transactions (LWT) allow you to perform conditional write operations against your table data. Conditional update operations are useful when inserting, updating and deleting records based on conditions that evaluate the current state.

In Amazon Keyspaces, all write operations require LOCAL_QUORUM consistency and there is no additional charge for using LWTs. The difference for LWTs is that when a LWT condition check results in `FALSE`, Amazon Keyspaces consumes write capacity units (WCUs) or write request units (WRUs). The number of WCUs/WRUs consumed depends on the size of the row.

For example, if the row size is 2 KB, the failed conditional write consumes two WCUs/WRUs. If the row doesn't currently exist in the table, the operation consumes one WCUs/WRUs.

To determine the number of requests that resulted in condition check failures, you can monitor the `ConditionalCheckFailed` metric in CloudWatch.

Estimate LWT costs for tables with Time to Live (TTL)

LWTs can require additional read capacity units (RCUs) or read request units (RRUs) for tables configured with TTL that don't use client-side timestamps. When using `IF EXISTS` or `IF NOT EXISTS` keywords condition check results in `FALSE`, the following capacity units are consumed:

- RCUs/RRUs – If the row exists, the RCUs/RRUs consumed are based on the size of the existing row.
- RCUs/RRUs – If the row doesn't exist, a single RCU/RRU is consumed.

If the evaluated condition results in a successful write operation, WCUs/WRUs are consumed based on the size of the new row.

Estimate capacity consumption for static columns in Amazon Keyspaces

In an Amazon Keyspaces table with clustering columns, you can use the `STATIC` keyword to create a static column. The value stored in a static column is shared between all rows in a logical partition. When you update the value of this column, Amazon Keyspaces applies the change automatically to all rows in the partition.

This section describes how to calculate the encoded size of data when you're writing to static columns. This process is handled separately from the process that writes data to the nonstatic columns of a row. In addition to size quotas for static data, read and write operations on static columns also affect metering and throughput capacity for tables independently. For functional differences with Apache Cassandra when using static columns and paginated range read results, see the section called “Pagination”.

Topics

- Calculate the static column size per logical partition in Amazon Keyspaces
- Estimate capacity throughput requirements for read/write operations on static data in Amazon Keyspaces

Calculate the static column size per logical partition in Amazon Keyspaces

This section provides details about how to estimate the encoded size of static columns in Amazon Keyspaces. The encoded size is used when you're calculating your bill and quota use. You should also use the encoded size when you calculate provisioned throughput capacity requirements for tables. To calculate the encoded size of static columns in Amazon Keyspaces, you can use the following guidelines.

- Partition keys can contain up to 2048 bytes of data. Each key column in the partition key requires up to 3 bytes of metadata. These metadata bytes count towards your static data size quota of 1 MB per partition. When calculating the size of your static data, you should assume that each partition key column uses the full 3 bytes of metadata.
- Use the raw size of the static column data values based on the data type. For more information about data types, see the section called “Data types”.
- Add 104 bytes to the size of the static data for metadata.

- Clustering columns and regular, nonprimary key columns do not count towards the size of static data. To learn how to estimate the size of nonstatic data within rows, see the section called "Estimate row size".

The total encoded size of a static column is based on the following formula:

```
partition key columns + static columns + metadata = total encoded size of static data
```

Consider the following example of a table where all columns are of type integer. The table has two partition key columns, two clustering columns, one regular column, and one static column.

```
CREATE TABLE mykeyspace.mytable(pk_col1 int, pk_col2 int, ck_col1 int, ck_col2
 int, reg_col1 int, static_col1 int static, primary key((pk_col1, pk_col2),ck_col1,
 ck_col2));
```

In this example, we calculate the size of static data of the following statement:

```
INSERT INTO mykeyspace.mytable (pk_col1, pk_col2, static_col1) values(1,2,6);
```

To estimate the total bytes required by this write operation, you can use the following steps.

1. Calculate the size of a partition key column by adding the bytes for the data type stored in the column and the metadata bytes. Repeat this for all partition key columns.

   a. Calculate the size of the first column of the partition key (pk_col1):

   ```
   4 bytes for the integer data type + 3 bytes for partition key metadata = 7
    bytes
   ```

   b. Calculate the size of the second column of the partition key (pk_col2):

   ```
   4 bytes for the integer data type + 3 bytes for partition key metadata = 7
    bytes
   ```

   c. Add both columns to get the total estimated size of the partition key columns:

   ```
   7 bytes + 7 bytes = 14 bytes for the partition key columns
   ```

2. Add the size of the static columns. In this example, we only have one static column that stores an integer (which requires 4 bytes).

3. Finally, to get the total encoded size of the static column data, add up the bytes for the primary key columns and static columns, and add the additional 104 bytes for metadata:

```
14 bytes for the partition key columns + 4 bytes for the static column + 104 bytes
 for metadata = 122 bytes.
```

You can also update static and nonstatic data with the same statement. To estimate the total size of the write operation, you must first calculate the size of the nonstatic data update. Then calculate the size of the row update as shown in the example at the section called “Estimate row size”, and add the results.

In this case, you can write a total of 2 MB—1 MB is the maximum row size quota, and 1 MB is the quota for the maximum static data size per logical partition.

To calculate the total size of an update of static and nonstatic data in the same statement, you can use the following formula:

```
(partition key columns + static columns + metadata = total encoded size of static data)
 + (partition key columns + clustering columns + regular columns + row metadata = total
 encoded size of row)
= total encoded size of data written
```

Consider the following example of a table where all columns are of type integer. The table has two partition key columns, two clustering columns, one regular column, and one static column.

```
CREATE TABLE mykeyspace.mytable(pk_col1 int, pk_col2 int, ck_col1 int, ck_col2
 int, reg_col1 int, static_col1 int static, primary key((pk_col1, pk_col2),ck_col1,
 ck_col2));
```

In this example, we calculate the size of data when we write a row to the table, as shown in the following statement:

```
INSERT INTO mykeyspace.mytable (pk_col1, pk_col2, ck_col1, ck_col2, reg_col1,
 static_col1) values(2,3,4,5,6,7);
```

To estimate the total bytes required by this write operation, you can use the following steps.

1. Calculate the total encoded size of static data as shown earlier. In this example, it's 122 bytes.

2. Add the size of the total encoded size of the row based on the update of nonstatic data, following the steps at the section called "Estimate row size". In this example, the total size of the row update is 134 bytes.

```
122 bytes for static data + 134 bytes for nonstatic data = 256 bytes.
```

Estimate capacity throughput requirements for read/write operations on static data in Amazon Keyspaces

Static data is associated with logical partitions in Cassandra, not individual rows. Logical partitions in Amazon Keyspaces can be virtually unbound in size by spanning across multiple physical storage partitions. As a result, Amazon Keyspaces meters write operations on static and nonstatic data separately. Furthermore, writes that include both static and nonstatic data require additional underlying operations to provide data consistency.

If you perform a mixed write operation of both static and nonstatic data, this results in two separate write operations—one for nonstatic and one for static data. This applies to both on-demand and provisioned read/write capacity modes.

The following example provides details about how to estimate the required read capacity units (RCUs) and write capacity units (WCUs) when you're calculating provisioned throughput capacity requirements for tables in Amazon Keyspaces that have static columns. You can estimate how much capacity your table needs to process writes that include both static and nonstatic data by using the following formula:

```
2 x WCUs required for nonstatic data + 2 x WCUs required for static data
```

For example, if your application writes 27 KBs of data per second and each write includes 25.5 KBs of nonstatic data and 1.5 KBs of static data, then your table requires 56 WCUs (2 x 26 WCUs + 2 x 2 WCUs).

Amazon Keyspaces meters the reads of static and nonstatic data the same as reads of multiple rows. As a result, the price of reading static and nonstatic data in the same operation is based on the aggregate size of the data processed to perform the read.

To learn how to monitor serverless resources with Amazon CloudWatch, see the section called "Monitoring with CloudWatch".

Estimate and provision capacity for a multi-Region table in Amazon Keyspaces

You can configure the throughput capacity of a multi-Region table in one of two ways:

- On-demand capacity mode, measured in write request units (WRUs)
- Provisioned capacity mode with auto scaling, measured in write capacity units (WCUs)

You can use provisioned capacity mode with auto scaling or on-demand capacity mode to help ensure that a multi-Region table has sufficient capacity to perform replicated writes to all AWS Regions.

> **Note**
>
> Changing the capacity mode of the table in one of the Regions changes the capacity mode for all replicas.

By default, Amazon Keyspaces uses on-demand mode for multi-Region tables. With on-demand mode, you don't need to specify how much read and write throughput that you expect your application to perform. Amazon Keyspaces instantly accommodates your workloads as they ramp up or down to any previously reached traffic level. If a workload's traffic level hits a new peak, Amazon Keyspaces adapts rapidly to accommodate the workload.

If you choose provisioned capacity mode for a table, you have to configure the number of read capacity units (RCUs) and write capacity units (WCUs) per second that your application requires.

To plan a multi-Region table's throughput capacity needs, you should first estimate the number of WCUs per second needed for each Region. Then you add the writes from all Regions that your table is replicated in, and use the sum to provision capacity for each Region. This is required because every write that is performed in one Region must also be repeated in each replica Region.

If the table doesn't have enough capacity to handle the writes from all Regions, capacity exceptions will occur. In addition, inter-Regional replication wait times will rise.

For example, if you have a multi-Region table where you expect 5 writes per second in US East (N. Virginia), 10 writes per second in US East (Ohio), and 5 writes per second in Europe (Ireland), you should expect the table to consume 20 WCUs in each Region: US East (N. Virginia), US East (Ohio),

and Europe (Ireland). That means that in this example, you need to provision 20 WCUs for each of the table's replicas. You can monitor your table's capacity consumption using Amazon CloudWatch. For more information, see the section called “Monitoring with CloudWatch”.

Each write is billed as 1 WCU, so you would see a total of 60 WCUs billed in this example. For more information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

For more information about provisioned capacity with Amazon Keyspaces auto scaling, see the section called “Manage throughput capacity with auto scaling”.

> **Note**
>
> If a table is running in provisioned capacity mode with auto scaling, the provisioned write capacity is allowed to float within those auto scaling settings for each Region.

Estimate read and write capacity consumption with Amazon CloudWatch in Amazon Keyspaces

To estimate and monitor read and write capacity consumption, you can use a CloudWatch dashboard. For more information about available metrics for Amazon Keyspaces, see the section called “Metrics and dimensions”.

To monitor read and write capacity units consumed by a specific statement with CloudWatch, you can follow these steps.

1. Create a new table with sample data
2. Configure a Amazon Keyspaces CloudWatch dashboard for the table. To get started, you can use a dashboard template available on Github.
3. Run the CQL statement, for example using the `ALLOW FILTERING` option, and check the read capacity units consumed for the full table scan in the dashboard.

Configure read/write capacity modes in Amazon Keyspaces

Amazon Keyspaces has two read/write capacity modes for processing reads and writes on your tables:

- On-demand (default)

- Provisioned

The read/write capacity mode that you choose controls how you are charged for read and write throughput and how table throughput capacity is managed.

Topics

- Configure on-demand capacity mode
- Configure provisioned capacity mode
- View the capacity mode of a table in Amazon Keyspaces
- Change the capacity mode of a table in Amazon Keyspaces
- Configure pre-warming for tables in Amazon Keyspaces

Configure on-demand capacity mode

Amazon Keyspaces (for Apache Cassandra) *on-demand* capacity mode is a flexible billing option capable of serving thousands of requests per second without capacity planning. This option offers pay-per-request pricing for read and write requests so that you pay only for what you use.

When you choose on-demand mode, Amazon Keyspaces can scale the throughput capacity for your table up to any previously reached traffic level instantly, and then back down when application traffic decreases. If a workload's traffic level hits a new peak, the service adapts rapidly to increase throughput capacity for your table. You can enable on-demand capacity mode for both new and existing tables.

On-demand mode is a good option if any of the following is true:

- You create new tables with unknown workloads.
- You have unpredictable application traffic.
- You prefer the ease of paying for only what you use.

To get started with on-demand mode, you can create a new table or update an existing table to use on-demand capacity mode using the console or with a few lines of Cassandra Query Language (CQL) code. For more information, see the section called "Tables".

Topics

- Read request units and write request units

- Peak traffic and scaling properties
- Initial throughput for on-demand capacity mode

Read request units and write request units

With on-demand capacity mode tables, you don't need to specify how much read and write throughput you expect your application to use in advance. Amazon Keyspaces charges you for the reads and writes that you perform on your tables in terms of read request units (RRUs) and write request units (WRUs).

- One *RRU* represents one `LOCAL_QUORUM` read request, or two `LOCAL_ONE` read requests, for a row up to 4 KB in size. If you need to read a row that is larger than 4 KB, the read operation uses additional RRUs. The total number of RRUs required depends on the row size, and whether you want to use `LOCAL_QUORUM` or `LOCAL_ONE` read consistency. For example, reading an 8 KB row requires 2 RRUs using `LOCAL_QUORUM` read consistency, and 1 RRU if you choose `LOCAL_ONE` read consistency.
- One *WRU* represents one write for a row up to 1 KB in size. All writes are using `LOCAL_QUORUM` consistency, and there is no additional charge for using lightweight transactions (LWTs). If you need to write a row that is larger than 1 KB, the write operation uses additional WRUs. The total number of WRUs required depends on the row size. For example, if your row size is 2 KB, you require 2 WRUs to perform one write request.

For information about supported consistency levels, see the section called “Supported Cassandra consistency levels”.

Peak traffic and scaling properties

Amazon Keyspaces tables that use on-demand capacity mode automatically adapt to your application’s traffic volume. On-demand capacity mode instantly accommodates up to double the previous peak traffic on a table. For example, your application's traffic pattern might vary between 5,000 and 10,000 `LOCAL_QUORUM` reads per second, where 10,000 reads per second is the previous traffic peak.

With this pattern, on-demand capacity mode instantly accommodates sustained traffic of up to 20,000 reads per second. If your application sustains traffic of 20,000 reads per second, that peak becomes your new previous peak, enabling subsequent traffic to reach up to 40,000 reads per second.

If you need more than double your previous peak on a table, Amazon Keyspaces automatically allocates more capacity as your traffic volume increases. This helps ensure that your table has enough throughput capacity to process the additional requests. However, you might observe insufficient throughput capacity errors if you exceed double your previous peak within 30 minutes.

For example, suppose that your application's traffic pattern varies between 5,000 and 10,000 strongly consistent reads per second, where 20,000 reads per second is the previously reached traffic peak. In this case, the service recommends that you space your traffic growth over at least 30 minutes before driving up to 40,000 reads per second.

To learn how to estimate read and write capacity consumption of a table, see the section called "Estimate capacity consumption".

To learn more about default quotas for your account and how to increase them, see *Quotas*.

Initial throughput for on-demand capacity mode

If you create a new table with on-demand capacity mode enabled or switch an existing table to on-demand capacity mode for the first time, the table has the following previous peak settings, even though it hasn't served traffic previously using on-demand capacity mode:

- **Newly created table with on-demand capacity mode:** The previous peak is 2,000 WRUs and 6,000 RRUs. You can drive up to double the previous peak immediately. Doing this enables newly created on-demand tables to serve up to 4,000 WRUs and 12,000 RRUs.
- **Existing table switched to on-demand capacity mode:** The previous peak is half the previous WCUs and RCUs provisioned for the table or the settings for a newly created table with on-demand capacity mode, whichever is higher.

Configure provisioned capacity mode

If you choose *provisioned throughput* capacity mode, you specify the number of reads and writes per second that are required for your application. This helps you manage your Amazon Keyspaces usage to stay at or below a defined request rate to maintain predictability. To learn more about automatic scaling for provisioned throughput see the section called "Manage throughput capacity with auto scaling".

Provisioned throughput capacity mode is a good option if any of the following is true:

- You have predictable application traffic.

- You run applications whose traffic is consistent or ramps up gradually.
- You can forecast capacity requirements.

Read capacity units and write capacity units

For provisioned throughput capacity mode tables, you specify throughput capacity in terms of read capacity units (RCUs) and write capacity units (WCUs):

- One *RCU* represents one `LOCAL_QUORUM` read per second, or two `LOCAL_ONE` reads per second, for a row up to 4 KB in size. If you need to read a row that is larger than 4 KB, the read operation uses additional RCUs.

  The total number of RCUs required depends on the row size, and whether you want `LOCAL_QUORUM` or `LOCAL_ONE` reads. For example, if your row size is 8 KB, you require 2 RCUs to sustain one `LOCAL_QUORUM` read per second, and 1 RCU if you choose `LOCAL_ONE` reads.
- One *WCU* represents one write per second for a row up to 1 KB in size. All writes are using `LOCAL_QUORUM` consistency, and there is no additional charge for using lightweight transactions (LWTs). If you need to write a row that is larger than 1 KB, the write operation uses additional WCUs.

  The total number of WCUs required depends on the row size. For example, if your row size is 2 KB, you require 2 WCUs to sustain one write request per second. For more information about how to estimate read and write capacity consumption of a table, see the section called “Estimate capacity consumption”.

If your application reads or writes larger rows (up to the Amazon Keyspaces maximum row size of 1 MB), it consumes more capacity units. To learn more about how to estimate the row size, see the section called “Estimate row size”. For example, suppose that you create a provisioned table with 6 RCUs and 6 WCUs. With these settings, your application could do the following:

- Perform `LOCAL_QUORUM` reads of up to 24 KB per second (4 KB × 6 RCUs).
- Perform `LOCAL_ONE` reads of up to 48 KB per second (twice as much read throughput).
- Write up to 6 KB per second (1 KB × 6 WCUs).

Provisioned throughput is the maximum amount of throughput capacity an application can consume from a table. If your application exceeds your provisioned throughput capacity, you might observe insufficient capacity errors.

For example, a read request that doesn't have enough throughput capacity fails with a `Read_Timeout` exception and is posted to the `ReadThrottleEvents` metric. A write request that doesn't have enough throughput capacity fails with a `Write_Timeout` exception and is posted to the `WriteThrottleEvents` metric.

You can use Amazon CloudWatch to monitor your provisioned and actual throughput metrics and insufficient capacity events. For more information about these metrics, see the section called "Metrics and dimensions".

> **Note**
>
> Repeated errors due to insufficient capacity can lead to client-side driver specific exceptions, for example the DataStax Java driver fails with a `NoHostAvailableException`.

To change the throughput capacity settings for tables, you can use the AWS Management Console or the `ALTER TABLE` statement using CQL, for more information see the section called "ALTER TABLE".

To learn more about default quotas for your account and how to increase them, see *Quotas*.

View the capacity mode of a table in Amazon Keyspaces

You can query the system table in the Amazon Keyspaces system keyspace to review capacity mode information about a table. You can also see whether a table is using on-demand or provisioned throughput capacity mode. If the table is configured with provisioned throughput capacity mode, you can see the throughput capacity provisioned for the table.

You can also use the AWS CLI to view the capacity mode of a table.

To change the provisioned throughput of a table, see the section called "Change capacity mode".

Cassandra Query Language (CQL)

Example

```
SELECT * from system_schema_mcs.tables where keyspace_name = 'mykeyspace' and
 table_name = 'mytable';
```

A table configured with on-demand capacity mode returns the following.

```
{
   "capacity_mode":{
      "last_update_to_pay_per_request_timestamp":"1579551547603",
      "throughput_mode":"PAY_PER_REQUEST"
   }
}
```

A table configured with provisioned throughput capacity mode returns the following.

```
{
   "capacity_mode":{
      "last_update_to_pay_per_request_timestamp":"1579048006000",
      "read_capacity_units":"5000",
      "throughput_mode":"PROVISIONED",
      "write_capacity_units":"6000"
   }
}
```

The `last_update_to_pay_per_request_timestamp` value is measured in milliseconds.

CLI

View a table's throughput capacity mode using the AWS CLI

```
aws keyspaces get-table --keyspace-name myKeyspace --table-name myTable
```

The output of the command can look similar to this for a table in provisioned capacity mode.

```
"capacitySpecification": {
        "throughputMode": "PROVISIONED",
        "readCapacityUnits": 4000,
        "writeCapacityUnits": 2000
    }
```

The output for a table in on-demand mode looks like this.

```
"capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-10-03T10:48:19.092000+00:00"
    }
```

Change the capacity mode of a table in Amazon Keyspaces

When you switch a table from provisioned capacity mode to on-demand capacity mode, Amazon Keyspaces makes several changes to the structure of your table and partitions. This process can take several minutes. During the switching period, your table delivers throughput that is consistent with the previously provisioned WCU and RCU amounts.

When you switch from on-demand capacity mode back to provisioned capacity mode, your table delivers throughput that is consistent with the previous peak reached when the table was set to on-demand capacity mode.

The following waiting periods apply when you switch capacity modes:

- You can switch a newly created table in on-demand mode to provisioned capacity mode at any time. However, you can only switch it back to on-demand mode 24 hours after the table's creation timestamp.
- You can switch an existing table in on-demand mode to provisioned capacity mode at any time. However, you can switch capacity modes from provisioned to on-demand only once in a 24-hour period.

Cassandra Query Language (CQL)

Change a table's throughput capacity mode using CQL

1. To change a table's capacity mode to `PROVIOSIONED` you have to configure the read capacity and write capacity units based on your workloads expected peak values. the following statement is an example of this. You can also run this statement to adjust the read capacity or the write capacity units of the table.

```
ALTER TABLE catalog.book_awards WITH CUSTOM_PROPERTIES={'capacity_mode':
{'throughput_mode': 'PROVISIONED', 'read_capacity_units': 6000,
 'write_capacity_units': 3000}};
```

To configure provisioned capacity mode with auto-scaling, see the section called “Configure automatic scaling on an existing table”.

2. To change the capacity mode of a table to on-demand mode, set the throughput mode to PAY_PER_REQUEST. The following statement is an example of this.

```
ALTER TABLE catalog.book_awards WITH CUSTOM_PROPERTIES={'capacity_mode':
{'throughput_mode': 'PAY_PER_REQUEST'}};
```

3. You can use the following statement to confirm the table's capacity mode.

```
SELECT * from system_schema_mcs.tables where keyspace_name = 'catalog' and
 table_name = 'book_awards';
```

A table configured with on-demand capacity mode returns the following.

```
{
   "capacity_mode":{
      "last_update_to_pay_per_request_timestamp":"1727952499092",
      "throughput_mode":"PAY_PER_REQUEST"
   }
}
```

The `last_update_to_pay_per_request_timestamp` value is measured in milliseconds.

CLI

Change a table's throughput capacity mode using the AWS CLI

1. To change the table's capacity mode to PROVIOSIONED you have to configure the read capacity and write capacity units based on the expected peak values of your workload. The following command is an example of this. You can also run this command to adjust the read capacity or the write capacity units of the table.

```
aws keyspaces update-table --keyspace-name catalog --table-name book_awards
                                    \--capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=6000,writeCapacityUnits=3000
```

To configure provisioned capacity mode with auto-scaling, see the section called “Configure automatic scaling on an existing table”.

2. To change the capacity mode of a table to on-demand mode, you set the throughput mode to PAY_PER_REQUEST. The following statement is an example of this.

```
aws keyspaces update-table --keyspace-name catalog --table-name book_awards
                                    \--capacity-specification
 throughputMode=PAY_PER_REQUEST
```

3. You can use the following command to review the capacity mode that's configured for a table.

```
aws keyspaces get-table --keyspace-name catalog --table-name book_awards
```

The output for a table in on-demand mode looks like this.

```
"capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-10-03T10:48:19.092000+00:00"
    }
```

Configure pre-warming for tables in Amazon Keyspaces

Amazon Keyspaces automatically scales storage partitions based on on-demand or provisioned throughput, but for new tables or sudden throughput peaks, it can take longer to allocate the required storage partitions. To insure that a new or existing table has enough capacity to support anticipated peak throughput, you can manually set specific *warm throughput* values to *pre-warm* your table.

Warm throughput refers to the number of read and write operations your Amazon Keyspaces table can instantaneously support. These values are available by default for all new and existing tables. If you are using on-demand mode, or if you update your provisioned throughput, Amazon Keyspaces ensures that your application is able to issue requests up to those values instantly.

Amazon Keyspaces automatically adjusts warm throughput values as your usage increases. To adjust throughput capacity for upcoming peak events, for example when you're migrating data from another database, which may require loading terabytes of data in a short period of time, you

can manually increase your tables warm throughput values. This is useful for planned peak events where request rates might increase by 10x, 100x, or more. First, assess whether the current warm throughput is sufficient to handle the expected traffic. Then, if you need to pre-warm the table for the planned peak workload, you can increase the warm throughput value manually without changing your throughput settings or capacity mode.

You can pre-warm tables for read operations, write operations, or both. You can increase this value for new and existing single-Region tables and multi-Region tables and the warm throughput settings you set apply automatically to all replicas of the multi-Region tables. There is no limit to the number of Amazon Keyspaces tables you can pre-warm at any time. The time to complete pre-warming depends on the values you set and the size of the table. You can submit simultaneous pre-warm requests and these requests don't interfere with any table operations. You can pre-warm your table up to the table quota limit for your account in that Region. Use the Service Quotas console to check your current quotas and increase them if needed.

The warm throughput values that Amazon Keyspaces adjusts based on your on-demand usage or provisioned capacity are available by default for all tables without additional charges. However, if you manually increase the default warm throughput values to pre-warm tables for peak traffic events, additional charges apply. For more information, see Amazon Keyspaces pricing.

Here are some different scenarios and best practices you might consider when pre-warming Amazon Keyspaces tables.

Warm throughput and uneven access patterns

A table might have a warm throughput of 30,000 read units per second and 10,000 write units per second, but you could still experience capacity exceeded events on reads or writes before hitting those values. This is likely due to a hot partition. While Amazon Keyspaces can keep scaling to support virtually unlimited throughput, each individual partition is limited to 1,000 write units per second and 3,000 read units per second. If your application drives too much traffic to a small portion of the table’s partitions, capacity exceeded events can occur even before you reach the table's warm throughput values. We recommend following Amazon Keyspaces best practices to ensure seamless scalability and avoid hot partitions.

Warm throughput for a provisioned table

Consider a provisioned table that has a warm throughput of 30,000 read units per second and 10,000 write units per second but currently has a provisioned throughput of 4,000 RCUs and 8,000 WCUs. You can instantly scale the table's provisioned throughput up to 30,000 RCUs or

10,000 WCUs by updating your provisioned throughput settings. As you increase the provisioned throughput beyond these values, the warm throughput adjusts automatically to the new higher values, because you have established a new peak throughput. For example, if you set the provisioned throughput to 50,000 RCU, the warm throughput increases to 50,000 read units per second.

```
"ProvisionedThroughput":
    {
        "ReadCapacityUnits": 4000,
        "WriteCapacityUnits": 8000
    }
"WarmThroughput":
    {
        "ReadUnitsPerSecond": 30000,
        "WriteUnitsPerSecond": 10000
    }
```

Warm throughput for an on-demand table

A new on-demand table starts with a warm throughput of 12,000 read units per second and 4,000 write units per second. Your table can instantly accommodate sustained traffic up to these levels. When your requests exceed 12,000 read units per second or 4,000 write units per second, the warm throughput adjusts automatically to the higher values.

```
"WarmThroughput":
    {
        "ReadUnitsPerSecond": 12000,
        "WriteUnitsPerSecond": 4000
    }
```

Best practices for pre-warming Amazon Keyspaces tables

Follow these best practices when implementing pre-warming for your Amazon Keyspaces tables:

Accurately estimate the required capacity

Because pre-warming incurs a one-time cost, carefully calculate the throughput needed based on expected workload to avoid over-provisioning.

Consider the table's schema

Tables with larger rows may require more partitions for the same throughput. Factor in your average row size when estimating pre-warming requirements.

Monitor table performance

After pre-warming, use CloudWatch metrics to verify that your table is handling the load as expected. For more information, see the section called “Monitor pre-warming with CloudWatch”.

Manage quotas

If your application requires higher throughput than the default quotas allow (40,000 RCUs/WCUs or 2,000 partitions), request quota increases well in advance of your high-traffic event. To request a quota increase, use the Service Quotas console.

Optimize costs

For temporary high-traffic events, consider using pre-warming instead of switching to provisioned mode with high capacity, as it may be more cost-effective for short duration events. For more information about pricing, see Amazon Keyspaces pricing.

> **Note**
>
> Monitor your application's performance metrics during the test phase to validate that your pre-warming configuration adequately supports your workload requirements.

Topics

- Create a new Amazon Keyspaces table with higher warm throughput
- Increase your existing Amazon Keyspaces table's warm throughput
- View warm throughput of an Amazon Keyspaces table
- Monitor the performance of a pre-warmed table using Amazon CloudWatch

Create a new Amazon Keyspaces table with higher warm throughput

You can adjust the warm throughput values when you create your Amazon Keyspaces table by using the console, CQL, or the AWS CLI.

Console

How to create a new table with warm-throughput settings

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
4. In the **Columns** section, create the schema for your table.
5. In the **Primary key** section, define the primary key of the table and select optional clustering columns.
6. In the **Table settings** section, choose **Customize settings**.
7. Continue to **Read/write capacity settings**.
8. For **Capacity mode**, you can choose either **On-demand** or **Provisioned**.
9. In the **Pre-warming for tables** section, you can increase the values for **Read units per second** and **Write units per second** as needed to prepare your table to handle planned peak events.

   The warm throughput values that Amazon Keyspaces adjusts based on your on-demand usage or provisioned capacity are available by default for all tables without additional charges. Note that if you manually increase the default warm throughput values to pre-warm the table for peak traffic events, additional charges apply.
10. Configure other optional table features as needed. Then choose **Create table**.

Cassandra Query Language (CQL)

- Create a table with warm throughput using one of the following methods:
  - For provisioned mode, create a table and specify the expected peak capacity for reads and writes using the following CQL syntax:

```
CREATE TABLE catalog.book_awards (
   year int,
   award text,
   rank int,
   category text,
```

```
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank))
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
       'throughput_mode': 'PROVISIONED',
       'read_capacity_units': 20000,
       'write_capacity_units': 10000
     },
    'warm_throughput': {
        'read_units_per_second': 40000,
        'write_units_per_second': 20000
     }
};
```

- For on-demand mode, create a table and specify the expected peak capacity for reads and writes using the following CQL syntax:

```
CREATE TABLE catalog.book_awards (
   year int,
   award text,
   rank int,
   category text,
   book_title text,
   author text,
   publisher text,
   PRIMARY KEY ((year, award), category, rank))
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
       'throughput_mode': 'PAY_PER_REQUEST'
     },
    'warm_throughput': {
        'read_units_per_second': 40000,
        'write_units_per_second': 20000
     }
};
```

To confirm the capacity settings of the table, see the section called “View your table's warm throughput”.

CLI

1. Create a table with warm throughput using one of the following methods using the AWS CLI

   - Create a new table in provisioned mode and specify the expected peak capacity values for reads and writes for the new table. The following statement is an example of this.

```
aws keyspaces create-table \
--keyspace-name 'catalog' \
--table-name 'book_awards' \
--schema-definition 'allColumns=[{name=year,type=int},
{name=award,type=text},{name=rank,type=int},{name=category,type=text},
{name=book_title,type=text},{name=author,type=text},
{name=publisher,type=text}],partitionKeys=[{name=year},
{name=award}],clusteringKeys=[{name=category,orderBy=ASC},
{name=rank,orderBy=ASC}]' \
--capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=20000,writeCapacityUnits=10000
 \
--warm-throughput-specification
 readUnitsPerSecond=40000,writeUnitsPerSecond=20000
```

   - Create a new table in on-demand mode and specify the expected peak capacity values for reads and writes for the new table. The following statement is an example of this.

```
aws keyspaces create-table \
--keyspace-name 'catalog' \
--table-name 'book_awards' \
--schema-definition 'allColumns=[{name=year,type=int},
{name=award,type=text},{name=rank,type=int},{name=category,type=text},
{name=book_title,type=text},{name=author,type=text},
{name=publisher,type=text}],partitionKeys=[{name=year},
{name=award}],clusteringKeys=[{name=category,orderBy=ASC},
{name=rank,orderBy=ASC}]' \
--warmThroughputSpecification
 readUnitsPerSecond=40000,writeUnitsPerSecond=20000
```

2. The output of the command returns the ARN of the table as shown in the following example.

```
{
```

```
    "resourceArn": "arn:aws::cassandra:us-east-1:111122223333:/keyspace/catalog/
table/book_awards>"
}
```

To confirm the capacity settings of the table, see the section called “View your table's warm throughput”.

Java

Create a new table using the SDK for Java.

- Create a new table in provisioned mode and specify the expected peak capacity values for reads and writes for the new table. The following code example is an example of this.

```
import software.amazon.awssdk.services.keyspaces.KeyspacesClient;
import software.amazon.awssdk.services.keyspaces.model.*;

public class PreWarmingExample {
    public static void main(String[] args) {
        KeyspacesClient keyspacesClient = KeyspacesClient.builder().build();

        // Define schema
        List<ColumnDefinition> columns = Arrays.asList(
            ColumnDefinition.builder().name("year").type("int").build(),
            ColumnDefinition.builder().name("award").type("text").build(),
            ColumnDefinition.builder().name("rank").type("int").build(),
            ColumnDefinition.builder().name("category").type("text").build(),
            ColumnDefinition.builder().name("book_title").type("text").build(),
            ColumnDefinition.builder().name("author").type("text").build(),
            ColumnDefinition.builder().name("publisher").type("text").build()
        );

        List<PartitionKey> partitionKeys = Arrays.asList(
            PartitionKey.builder().name("year").build(),
            PartitionKey.builder().name("award").build()
        );

        List<ClusteringKey> clusteringKeys = Arrays.asList(
            ClusteringKey.builder().name("category").orderBy("ASC").build(),
            ClusteringKey.builder().name("rank").orderBy("ASC").build()
        );
```

```
        SchemaDefinition schema = SchemaDefinition.builder()
            .allColumns(columns)
            .partitionKeys(partitionKeys)
            .clusteringKeys(clusteringKeys)
            .build();

        // Define capacity specification
        CapacitySpecification capacitySpec = CapacitySpecification.builder()
            .throughputMode(ThroughputMode.PROVISIONED)
            .readCapacityUnits(20000)
            .writeCapacityUnits(10000)
            .build();

        // Define warm throughput specification
        WarmThroughputSpecification warmThroughput =
 WarmThroughputSpecification.builder()
            .readUnitsPerSecond(40000L)
            .writeUnitsPerSecond(20000L)
            .build();

        // Create table with PreWarming
        CreateTableRequest request = CreateTableRequest.builder()
            .keyspaceName("catalog")
            .tableName("book_awards")
            .schemaDefinition(schema)
            .capacitySpecification(capacitySpec)
            .warmThroughputSpecification(warmThroughput)
            .build();

        CreateTableResponse response = keyspacesClient.createTable(request);
        System.out.println("Table created with ARN: " + response.resourceArn());
    }
}
```

Increase your existing Amazon Keyspaces table's warm throughput

You can increase your Amazon Keyspaces table's current warm throughput values using the console, CQL, or the AWS CLI.

Console

How to increase pre-warm settings of a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose the table that you want to update.
3. On the **Capacity** tab of the table, continue to **Pre-warming for tables**.
4. In the **Pre-warming for tables** section, choose **Edit**.
5. On the **Edit pre-warming for tables** page, you can updated the values for **Read units per second** and for **Write units per second**.
6. Choose **Save changes**. Your table is getting updated with the specified pre-warming settings.

Cassandra Query Language (CQL)

Increase the warm throughput settings of a table using CQL

- Use the `ALTER TABLE`statement to increase warm-throughput of a table. The following statement is an example of this.

```
ALTER TABLE catalog.book_awards
WITH CUSTOM_PROPERTIES = {
    'warm_throughput': {
        'read_units_per_second': 60000,
        'write_units_per_second': 30000
    }
};
```

To confirm the updated capacity settings of the table, see the section called “View your table's warm throughput”.

CLI

Increase the pre-warming settings of a table using the AWS CLI

- To increase the warm-throughput of table, you can use the `update-table` command. The following statement is an example of this.

```
aws keyspaces update-table \
--keyspace-name 'catalog' \
--table-name 'book_awards' \
--warmThroughputSpecification readUnitsPerSecond=60000,writeUnitsPerSecond=30000
```

To confirm the updated capacity settings of the table, see the section called “View your table's warm throughput”.

Java

Update the pre-warming settings of a table using the SDK for Java.

- Update the warm-throughput settings for a table. The following code example is an example of this.

```
import software.amazon.awssdk.services.keyspaces.KeyspacesClient;
import software.amazon.awssdk.services.keyspaces.model.*;

public class UpdatePreWarmingExample {
    public static void main(String[] args) {
        KeyspacesClient keyspacesClient = KeyspacesClient.builder().build();

        // Define new warm throughput specification
        WarmThroughputSpecification warmThroughput =
 WarmThroughputSpecification.builder()
            .readUnitsPerSecond(60000L)
            .writeUnitsPerSecond(30000L)
            .build();

        // Update table with new PreWarming settings
        UpdateTableRequest request = UpdateTableRequest.builder()
            .keyspaceName("catalog")
            .tableName("book_awards")
            .warmThroughputSpecification(warmThroughput)
            .build();

        UpdateTableResponse response = keyspacesClient.updateTable(request);
        System.out.println("Table update requested: " + response.resourceArn());
    }
}
```

View warm throughput of an Amazon Keyspaces table

You can view your Amazon Keyspaces table's current warm throughput values using the console, CQL, or the AWS CLI.

Console

How to view your table's pre-warming settings using the console.

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose the table that you want to review.
3. On the **Capacity** tab of the table, continue to **Pre-warming for tables**.

Cassandra Query Language (CQL)

View the warm-throughput settings of a table using CQL

- To view the warm-throughput settings of a table, you can use the following CQL statement.

```
SELECT custom_properties
FROM system_schema_mcs.tables
WHERE keyspace_name='catalog' and table_name='book_awards';

// Output:
...
custom_properties
--------------------------------------------------------------------------------
{
    'warm_throughput':
    {
        'read_units_per_second': '40000',
        'write_units_per_second': '20000',
        'status': 'AVAILABLE'
    }
}
...
```

CLI

View the warm-throughput settings of a table using the AWS CLI

- You can view the warm-throughput settings of a table using the `get-table` command as shown in the following example.

```
aws keyspaces get-table \
--keyspace-name 'catalog' \
--table-name 'book_awards'
```

The following is showing the example output of the `get-table` command for a single-Region table in provisioned mode.

```
{
    "keyspaceName": "catalog",
    "tableName": "book_awards",
    ... Existing Fields ...,
    "capacitySpecificationSummary": {
        "throughputMode": "PROVISIONED",
        "readCapacityUnits": 20000,
        "writeCapacityUnits": 10000
    },
    "warmThroughputSpecificationSummary": {
        "readUnitsPerSecond": 40000,
        "writeUnitsPerSecond": 20000,
        "status": "AVAILABLE"
    }
}
```

The following is showing the example output for a single-Region table in on-demand mode.

```
{
    "keyspaceName": "catalog",
    "tableName": "book_awards_ondemand",
    ... Existing Fields ...,
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST"
    },
    "warmThroughputSpecificationSummary": {
```

```
        "readUnitsPerSecond": 40000,
        "writeUnitsPerSecond": 20000,
        "status": "AVAILABLE"
    }
}
```

Java

Read the pre-warming settings of a table using the SDK for Java.

- Read the warm-throughput values of a table using `get-table`. The following code example is an example of this.

```
import software.amazon.awssdk.services.keyspaces.KeyspacesClient;
import software.amazon.awssdk.services.keyspaces.model.*;

public class GetTableWithPreWarmingExample {
    public static void main(String[] args) {
        KeyspacesClient keyspacesClient = KeyspacesClient.builder().build();

        // Get table details including PreWarming specification
        GetTableRequest request = GetTableRequest.builder()
            .keyspaceName("catalog")
            .tableName("book_awards")
            .build();

        GetTableResponse response = keyspacesClient.getTable(request);

        // Access PreWarming details
        if (response.warmThroughputSpecification() != null) {
            WarmThroughputSpecificationSummary warmThroughputSummary =
 response.warmThroughputSpecification();
            System.out.println("PreWarming Status: " +
 warmThroughputSummary.status());
            System.out.println("Read Units: " +
 warmThroughputSummary.readUnitsPerSecond());
            System.out.println("Write Units: " +
 warmThroughputSummary.writeUnitsPerSecond());

            // Check if PreWarming is active
            if (warmThroughputSummary.status().equals("AVAILABLE")) {
```

```
                System.out.println("Table is fully pre-warmed and ready for high
 throughput");
            } else if (warmThroughputSummary.status().equals("UPDATING")) {
                System.out.println("Table PreWarming is currently being
 updated");
            }
        } else {
            System.out.println("Table does not have PreWarming enabled");
        }
    }
}
```

Monitor the performance of a pre-warmed table using Amazon CloudWatch

Amazon Keyspaces pre-warming doesn't introduce new CloudWatch metrics, but you can monitor the performance of pre-warmed tables using existing Amazon Keyspaces metrics:

SuccessfulRequestLatency

Monitor this metric to verify that the pre-warmed table is handling requests with expected latency.

WriteThrottleEvents and ReadThrottleEvents

These metrics should remain low for a properly pre-warmed table. If you see insufficient capacity errors despite pre-warming, you might need to adjust your warm-throughput values.

ConsumedReadCapacityUnits and ConsumedWriteCapacityUnits

These metrics show the actual consumption of capacity, which can help validate if your pre-warming configuration is appropriate.

ProvisionedReadCapacityUnits and ProvisionedWriteCapacityUnits

For provisioned tables, these metrics show the currently allocated capacity.

These metrics can be viewed in the CloudWatch console or queried using the CloudWatch API. For more information, see the section called “Monitoring with CloudWatch”.

Manage throughput capacity automatically with Amazon Keyspaces auto scaling

Many database workloads are cyclical in nature or are difficult to predict in advance. For example, consider a social networking app where most of the users are active during daytime hours. The database must be able to handle the daytime activity, but there's no need for the same levels of throughput at night.

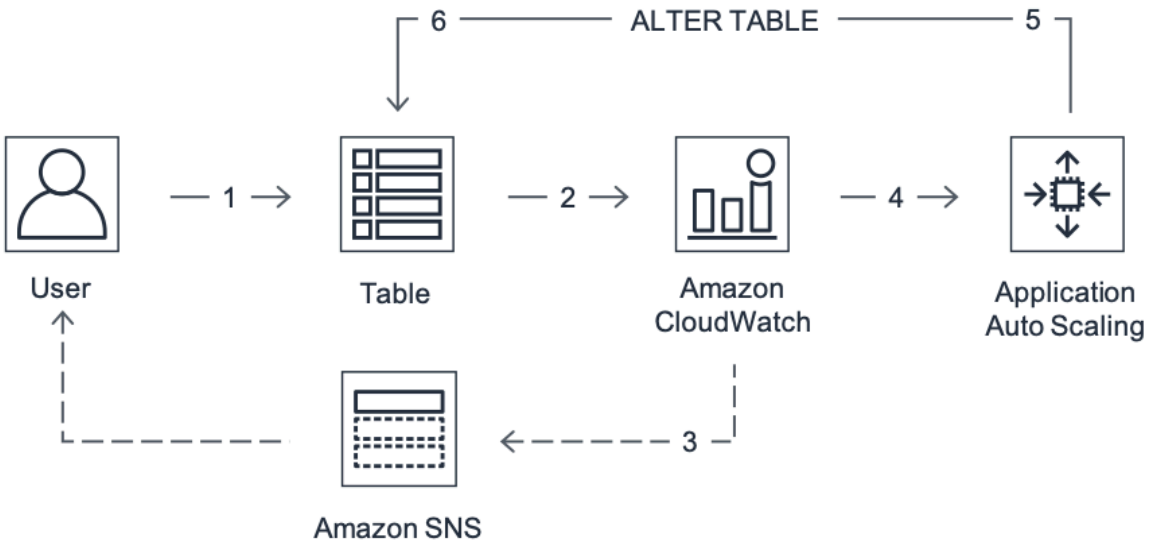
Another example might be a new mobile gaming app that is experiencing rapid adoption. If the game becomes very popular, it could exceed the available database resources, which would result in slow performance and unhappy customers. These kinds of workloads often require manual intervention to scale database resources up or down in response to varying usage levels.

Amazon Keyspaces (for Apache Cassandra) helps you provision throughput capacity efficiently for variable workloads by adjusting throughput capacity automatically in response to actual application traffic. Amazon Keyspaces uses the Application Auto Scaling service to increase and decrease a table's read and write capacity on your behalf. For more information about Application Auto Scaling, see the Application Auto Scaling User Guide.

> **Note**
>
> To get started with Amazon Keyspaces automatic scaling quickly, see the section called "Configure and update auto scaling policies".

How Amazon Keyspaces automatic scaling works

The following diagram provides a high-level overview of how Amazon Keyspaces automatic scaling manages throughput capacity for a table.



To enable automatic scaling for a table, you create a *scaling policy*. The scaling policy specifies whether you want to scale read capacity or write capacity (or both), and the minimum and maximum provisioned capacity unit settings for the table.

The scaling policy also defines a *target utilization*. Target utilization is the ratio of consumed capacity units to provisioned capacity units at a point in time, expressed as a percentage. Automatic scaling uses a *target tracking* algorithm to adjust the provisioned throughput of the table upward or downward in response to actual workloads. It does this so that the actual capacity utilization remains at or near your target utilization.

You can set the automatic scaling target utilization values between 20 and 90 percent for your read and write capacity. The default target utilization rate is 70 percent. You can set the target utilization to be a lower percentage if your traffic changes quickly and you want capacity to begin scaling up sooner. You can also set the target utilization rate to a higher rate if your application traffic changes more slowly and you want to reduce the cost of throughput.

For more information about scaling policies, see Target tracking scaling policies for Application Auto Scaling in the *Application Auto Scaling User Guide*.

When you create a scaling policy, Amazon Keyspaces creates two pairs of Amazon CloudWatch alarms on your behalf. Each pair represents your upper and lower boundaries for provisioned and consumed throughput settings. These CloudWatch alarms are triggered when the table's actual utilization deviates from your target utilization for a sustained period of time. To learn more about Amazon CloudWatch, see the Amazon CloudWatch User Guide.

When one of the CloudWatch alarms is triggered, Amazon Simple Notification Service (Amazon SNS) sends you a notification (if you have enabled it). The CloudWatch alarm then invokes Application Auto Scaling to evaluate your scaling policy. This in turn issues an Alter Table request to Amazon Keyspaces to adjust the table's provisioned capacity upward or downward as appropriate. To learn more about Amazon SNS notifications, see Setting up Amazon SNS notifications.

Amazon Keyspaces processes the Alter Table request by increasing (or decreasing) the table's provisioned throughput capacity so that it approaches your target utilization.

> **Note**
>
> Amazon Keyspaces auto scaling modifies provisioned throughput settings only when the actual workload stays elevated (or depressed) for a sustained period of several minutes. The target tracking algorithm seeks to keep the target utilization at or near your chosen value over the long term. Sudden, short-duration spikes of activity are accommodated by the table's built-in burst capacity.

How auto scaling works for multi-Region tables

To ensure that there's always enough read and write capacity for all table replicas in all AWS Regions of a multi-Region table in provisioned capacity mode, we recommend that you configure Amazon Keyspaces auto scaling.

When you use a multi-Region table in provisioned mode with auto scaling, you can't disable auto scaling for a single table replica. But you can adjust the table's read auto scaling settings for different Regions. For example, you can specify different read capacity and read auto scaling settings for each Region that the table is replicated in.

The read auto scaling settings that you configure for a table replica in a specified Region overwrite the general auto scaling settings of the table. The write capacity, however, has to remain synchronized across all table replicas to ensure that there's enough capacity to replicate writes in all Regions.

Amazon Keyspaces auto scaling independently updates the provisioned capacity of the table in each AWS Region based on the usage in that Region. As a result, the provisioned capacity in each Region for a multi-Region table might be different when auto scaling is active.

You can configure the auto scaling settings of a multi-Region table and its replicas using the Amazon Keyspaces console, API, AWS CLI, or CQL. For more information on how to create and update auto scaling settings for multi-Region tables, see the section called "Update provisioned capacity and auto scaling settings for a multi-Region table".

> **Note**
>
> If you use auto scaling for multi-Region tables, you must always use Amazon Keyspaces API operations to configure auto scaling settings. If you use Application Auto Scaling API operations directly to configure auto scaling settings, you don't have the ability to specify the AWS Regions of the multi-Region table. This can result in unsupported configurations.

Usage notes

Before you begin using Amazon Keyspaces automatic scaling, you should be aware of the following:

- Amazon Keyspaces automatic scaling is not available in the Middle East (UAE) Region.
- Amazon Keyspaces automatic scaling can increase read capacity or write capacity as often as necessary, in accordance with your scaling policy. All Amazon Keyspaces quotas remain in effect, as described in *Quotas*.
- Amazon Keyspaces automatic scaling doesn't prevent you from manually modifying provisioned throughput settings. These manual adjustments don't affect any existing CloudWatch alarms that are attached to the scaling policy.
- If you use the console to create a table with provisioned throughput capacity, Amazon Keyspaces automatic scaling is enabled by default. You can modify your automatic scaling settings at any time. For more information, see the section called "Turn off Amazon Keyspaces auto scaling for a table".
- If you're using CloudFormation to create scaling policies, you should manage the scaling policies from CloudFormation so that the stack is in sync with the stack template. If you change scaling policies from Amazon Keyspaces, they will get overwritten with the original values from the CloudFormation stack template when the stack is reset.
- If you use CloudTrail to monitor Amazon Keyspaces automatic scaling, you might see alerts for calls made by Application Auto Scaling as part of its configuration validation process. You can filter out these alerts by using the `invokedBy` field, which contains `application-autoscaling.amazonaws.com` for these validation checks.

Configure and update Amazon Keyspaces automatic scaling policies

You can use the console, CQL, or the AWS Command Line Interface (AWS CLI) to configure Amazon Keyspaces automatic scaling for new and existing tables. You can also modify automatic scaling settings or disable automatic scaling.

For more advanced features like setting scale-in and scale-out cooldown times, we recommend that you use CQL or the AWS CLI to manage Amazon Keyspaces scaling policies.

Topics

- Configure permissions for Amazon Keyspaces automatic scaling
- Create a new table with automatic scaling
- Configure automatic scaling on an existing table
- View your table's Amazon Keyspaces auto scaling configuration
- Turn off Amazon Keyspaces auto scaling for a table
- View auto scaling activity for a Amazon Keyspaces table in Amazon CloudWatch

Configure permissions for Amazon Keyspaces automatic scaling

To get started, confirm that the principal has the appropriate permissions to create and manage automatic scaling settings. In AWS Identity and Access Management (IAM), the AWS managed policy `AmazonKeyspacesFullAccess` is required to manage Amazon Keyspaces scaling policies.

> **Important**
>
> `application-autoscaling:*` permissions are required to disable automatic scaling on a table. You must turn off auto scaling for a table before you can delete it.

To set up an IAM user or role for Amazon Keyspaces console access and Amazon Keyspaces automatic scaling, add the following policy.

To attach the `AmazonKeyspacesFullAccess` policy

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.

2. On the IAM console dashboard, choose **Users**, and then choose your IAM user or role from the list.
3. On the **Summary** page, choose **Add permissions**.
4. Choose **Attach existing policies directly**.
5. From the list of policies, choose **AmazonKeyspacesFullAccess**, and then choose **Next: Review**.
6. Choose **Add permissions**.

Create a new table with automatic scaling

When you create a new Amazon Keyspaces table, you can automatically enable auto scaling for the table's write or read capacity. This allows Amazon Keyspaces to contact Application Auto Scaling on your behalf to register the table as a scalable target and adjust the provisioned write or read capacity.

For more information on how to create a multi-Region table and configure different auto scaling settings for table replicas, see the section called “Create a multi-Region table in provisioned mode”.

> **Note**
>
> Amazon Keyspaces automatic scaling requires the presence of a service-linked role (`AWSServiceRoleForApplicationAutoScaling_CassandraTable`) that performs automatic scaling actions on your behalf. This role is created automatically for you. For more information, see the section called “Using service-linked roles”.

Console

Create a new table with automatic scaling enabled using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
4. In the **Columns** section, create the schema for your table.
5. In the **Primary key** section, define the primary key of the table and select optional clustering columns.

6. In the **Table settings** section, choose **Customize settings**.
7. Continue to **Read/write capacity settings**.
8. For **Capacity mode**, choose **Provisioned**.
9. In the **Read capacity** section, confirm that **Scale automatically** is selected.

   In this step, you select the minimum and maximum read capacity units for the table, as well as the target utilization.

   - **Minimum capacity units** – Enter the value for the minimum level of throughput that the table should always be ready to support. The value must be between 1 and the maximum throughput per second quota for your account (40,000 by default).
   - **Maximum capacity units** – Enter the maximum amount of throughput you want to provision for the table. The value must be between 1 and the maximum throughput per second quota for your account (40,000 by default).
   - **Target utilization** – Enter a target utilization rate between 20% and 90%. When traffic exceeds the defined target utilization rate, capacity is automatically scaled up. When traffic falls below the defined target, it is automatically scaled down again.

   > **Note**
   >
   > To learn more about default quotas for your account and how to increase them, see *Quotas*.

10. In the **Write capacity** section, choose the same settings as defined in the previous step for read capacity, or configure capacity values manually.
11. Choose **Create table**. Your table is created with the specified automatic scaling parameters.

Cassandra Query Language (CQL)

Create a new table with Amazon Keyspaces automatic scaling using CQL

To configure auto scaling settings for a table programmatically, you use the `AUTOSCALING_SETTINGS` statement that contains the parameters for Amazon Keyspaces auto scaling. The parameters define the conditions that direct Amazon Keyspaces to adjust your table's provisioned throughput, and what additional optional actions to take. In this example, you define the auto scaling settings for *mytable*.

The policy contains the following elements:

- `AUTOSCALING_SETTINGS` – Specifies if Amazon Keyspaces is allowed to adjust throughput capacity on your behalf. The following values are required:
  - `provisioned_write_capacity_autoscaling_update`:
    - `minimum_units`
    - `maximum_units`
  - `provisioned_read_capacity_autoscaling_update`:
    - `minimum_units`
    - `maximum_units`
  - `scaling_policy` – Amazon Keyspaces supports the target tracking policy. To define the target tracking policy, you configure the following parameters.
    - `target_value` – Amazon Keyspaces auto scaling ensures that the ratio of consumed capacity to provisioned capacity stays at or near this value. You define `target_value` as a percentage.
    - `disableScaleIn`: (Optional) A `boolean` that specifies if `scale-in` is disabled or enabled for the table. This parameter is disabled by default. To turn on `scale-in`, set the `boolean` value to `FALSE`. This means that capacity is automatically scaled down for a table on your behalf.
    - `scale_out_cooldown` – A scale-out activity increases the provisioned throughput of your table. To add a cooldown period for scale-out activities, specify a value, in seconds, for `scale_out_cooldown`. If you don't specify a value, the default value is 0. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.
    - `scale_in_cooldown` – A scale-in activity decreases the provisioned throughput of your table. To add a cooldown period for scale-in activities, specify a value, in seconds, for `scale_in_cooldown`. If you don't specify a value, the default value is 0. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.

> **Note**
>
> To further understand how `target_value` works, suppose that you have a table with a provisioned throughput setting of 200 write capacity units. You decide to create a scaling policy for this table, with a `target_value` of 70 percent.
> Now suppose that you begin driving write traffic to the table so that the actual write throughput is 150 capacity units. The consumed-to-provisioned ratio is now (150 / 200), or 75 percent. This ratio exceeds your target, so auto scaling increases the provisioned write capacity to 215 so that the ratio is (150 / 215), or 69.77 percent—as close to your `target_value` as possible, but not exceeding it.

For *mytable*, you set `TargetValue` for both read and write capacity to 50 percent. Amazon Keyspaces auto scaling adjusts the table's provisioned throughput within the range of 5–10 capacity units so that the consumed-to-provisioned ratio remains at or near 50 percent. For read capacity, you set the values for `ScaleOutCooldown` and `ScaleInCooldown` to 60 seconds.

You can use the following statement to create a new Amazon Keyspaces table with auto scaling enabled.

```
CREATE TABLE mykeyspace.mytable(pk int, ck int, PRIMARY KEY (pk, ck))
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
        'throughput_mode': 'PROVISIONED',
        'read_capacity_units': 1,
        'write_capacity_units': 1
    }
} AND AUTOSCALING_SETTINGS = {
    'provisioned_write_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50
            }
        }
    },
    'provisioned_read_capacity_autoscaling_update': {
        'maximum_units': 10,
```

```
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50,
                'scale_in_cooldown': 60,
                'scale_out_cooldown': 60
            }
        }
    }
};
```

CLI

Create a new table with Amazon Keyspaces automatic scaling using the AWS CLI

To configure auto scaling settings for a table programmatically, you use the `autoScalingSpecification` action that defines the parameters for Amazon Keyspaces auto scaling. The parameters define the conditions that direct Amazon Keyspaces to adjust your table's provisioned throughput, and what additional optional actions to take. In this example, you define the auto scaling settings for *mytable*.

The policy contains the following elements:

- `autoScalingSpecification` – Specifies if Amazon Keyspaces is allowed to adjust capacity throughput on your behalf. You can enable auto scaling for read and for write capacity separately. Then you must specify the following parameters for `autoScalingSpecification`:
  - `writeCapacityAutoScaling` – The maximum and minimum write capacity units.
  - `readCapacityAutoScaling` – The maximum and minimum read capacity units.
  - `scalingPolicy` – Amazon Keyspaces supports the target tracking policy. To define the target tracking policy, you configure the following parameters.
    - `targetValue` – Amazon Keyspaces auto scaling ensures that the ratio of consumed capacity to provisioned capacity stays at or near this value. You define `targetValue` as a percentage.
    - `disableScaleIn`: (Optional) A `boolean` that specifies if `scale-in` is disabled or enabled for the table. This parameter is disabled by default. To turn on `scale-in`, set the `boolean` value to `FALSE`. This means that capacity is automatically scaled down for a table on your behalf.

- `scaleOutCooldown` – A scale-out activity increases the provisioned throughput of your table. To add a cooldown period for scale-out activities, specify a value, in seconds, for `ScaleOutCooldown`. The default value is 0. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.
- `scaleInCooldown` – A scale-in activity decreases the provisioned throughput of your table. To add a cooldown period for scale-in activities, specify a value, in seconds, for `ScaleInCooldown`. The default value is 0. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.

> **Note**
>
> To further understand how `TargetValue` works, suppose that you have a table with a provisioned throughput setting of 200 write capacity units. You decide to create a scaling policy for this table, with a `TargetValue` of 70 percent.
> Now suppose that you begin driving write traffic to the table so that the actual write throughput is 150 capacity units. The consumed-to-provisioned ratio is now (150 / 200), or 75 percent. This ratio exceeds your target, so auto scaling increases the provisioned write capacity to 215 so that the ratio is (150 / 215), or 69.77 percent—as close to your `TargetValue` as possible, but not exceeding it.

For *mytable*, you set `TargetValue` for both read and write capacity to 50 percent. Amazon Keyspaces auto scaling adjusts the table's provisioned throughput within the range of 5–10 capacity units so that the consumed-to-provisioned ratio remains at or near 50 percent. For read capacity, you set the values for `ScaleOutCooldown` and `ScaleInCooldown` to 60 seconds.

When creating tables with complex auto scaling settings, it's helpful to load the auto scaling settings from a JSON file. For the following example, you can download the example JSON file from auto-scaling.zip and extract `auto-scaling.json`, taking note of the path to the file. In this example, the JSON file is located in the current directory. For different file path options, see How to load parameters from a file.

```
aws keyspaces create-table --keyspace-name mykeyspace --table-name mytable
```

```
            \ --schema-definition 'allColumns=[{name=pk,type=int},
{name=ck,type=int}],partitionKeys=[{name=pk},{name=ck}]'
            \ --capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=1,writeCapacityUnits=1
            \ --auto-scaling-specification file://auto-scaling.json
```

Configure automatic scaling on an existing table

You can update an existing Amazon Keyspaces table to turn on auto scaling for the table's write or read capacity. If you're updating a table that is currently in on-demand capacity mode, than you first have to change the table's capacity mode to provisioned capacity mode.

For more information on how to update auto scaling settings for a multi-Region table, see the section called “Update provisioned capacity and auto scaling settings for a multi-Region table”.

Amazon Keyspaces automatic scaling requires the presence of a service-linked role (`AWSServiceRoleForApplicationAutoScaling_CassandraTable`) that performs automatic scaling actions on your behalf. This role is created automatically for you. For more information, see the section called “Using service-linked roles”.

Console

Configure Amazon Keyspaces automatic scaling for an existing table

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose the table that you want to work with, and go to the **Capacity** tab.
3. In the **Capacity settings** section, choose **Edit**.
4. Under **Capacity mode**, make sure that the table is using **Provisioned** capacity mode.
5. Select **Scale automatically** and see step 6 in the section called “Create a new table with automatic scaling” to edit read and write capacity.
6. When the automatic scaling settings are defined, choose **Save**.

Cassandra Query Language (CQL)

Configure an existing table with Amazon Keyspaces automatic scaling using CQL

You can use the `ALTER TABLE` statement for an existing Amazon Keyspaces table to configure auto scaling for the table's write or read capacity. If you're updating a table that is currently in on-demand capacity mode, you have to set `capacity_mode` to provisioned. If your table is already in provisioned capacity mode, this field can be omitted.

In the following example, the statement updates the table *mytable*, which is in on-demand capacity mode. The statement changes the capacity mode of the table to provisioned mode with auto scaling enabled.

The write capacity is configured within the range of 5–10 capacity units with a target value of 50%. The read capacity is also configured within the range of 5–10 capacity units with a target value of 50%. For read capacity, you set the values for `scale_out_cooldown` and `scale_in_cooldown` to 60 seconds.

```
ALTER TABLE mykeyspace.mytable
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
        'throughput_mode': 'PROVISIONED',
        'read_capacity_units': 1,
        'write_capacity_units': 1
    }
} AND AUTOSCALING_SETTINGS = {
    'provisioned_write_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50
            }
        }
    },
    'provisioned_read_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50,
                'scale_in_cooldown': 60,
                'scale_out_cooldown': 60
            }
        }
    }
```

```
};
```

CLI

Configure an existing table with Amazon Keyspaces automatic scaling using the AWS CLI

For an existing Amazon Keyspaces table, you can turn on auto scaling for the table's write or read capacity using the `UpdateTable` operation.

You can use the following command to turn on Amazon Keyspaces auto scaling for an existing table. The auto scaling settings for the table are loaded from a JSON file. For the following example, you can download the example JSON file from auto-scaling.zip and extract `auto-scaling.json`, taking note of the path to the file. In this example, the JSON file is located in the current directory. For different file path options, see How to load parameters from a file.

For more information about the auto scaling settings used in the following example, see the section called "Create a new table with automatic scaling".

```
aws keyspaces update-table --keyspace-name mykeyspace --table-name mytable
            \ --capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=1,writeCapacityUnits=1
            \ --auto-scaling-specification file://auto-scaling.json
```

View your table's Amazon Keyspaces auto scaling configuration

You can use the console, CQL, or the AWS CLI to view and update the Amazon Keyspaces automatic scaling settings of a table.

Console

View automatic scaling settings using the console

1. Choose the table you want to view and go to the **Capacity** tab.
2. In the **Capacity settings** section, choose **Edit**. You can now modify the settings in the **Read capacity** or **Write capacity** sections. For more information about these settings, see the section called "Create a new table with automatic scaling".

Cassandra Query Language (CQL)

View your table's Amazon Keyspaces automatic scaling policy using CQL

To view details of the auto scaling configuration of a table, use the following command.

```
SELECT * FROM system_schema_mcs.autoscaling WHERE keyspace_name = 'mykeyspace' AND
 table_name = 'mytable';
```

The output for this command looks like this.

```
 keyspace_name | table_name | provisioned_read_capacity_autoscaling_update

                                                                                |
 provisioned_write_capacity_autoscaling_update
---------------+------------
+-------------------------------------------------------------------------------------------------
+-------------------------------------------------------------------------------------------------
 mykeyspace    | mytable    | {'minimum_units': 5, 'maximum_units':
 10, 'scaling_policy': {'target_tracking_scaling_policy_configuration':
 {'scale_out_cooldown': 60, 'disable_scale_in': false, 'target_value':
 50, 'scale_in_cooldown': 60}}} | {'minimum_units': 5, 'maximum_units':
 10, 'scaling_policy': {'target_tracking_scaling_policy_configuration':
 {'scale_out_cooldown': 0, 'disable_scale_in': false, 'target_value': 50,
 'scale_in_cooldown': 0}}}
```

CLI

View your table's Amazon Keyspaces automatic scaling policy using the AWS CLI

To view the auto scaling configuration of a table, you can use the `get-table-auto-scaling-settings` operation. The following CLI command is an example of this.

```
aws keyspaces get-table-auto-scaling-settings --keyspace-name mykeyspace --table-
name mytable
```

The output for this command looks like this.

```
{
    "keyspaceName": "mykeyspace",
    "tableName": "mytable",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/mytable",
```

```
    "autoScalingSpecification": {
        "writeCapacityAutoScaling": {
            "autoScalingDisabled": false,
            "minimumUnits": 5,
            "maximumUnits": 10,
            "scalingPolicy": {
                "targetTrackingScalingPolicyConfiguration": {
                    "disableScaleIn": false,
                    "scaleInCooldown": 0,
                    "scaleOutCooldown": 0,
                    "targetValue": 50.0
                }
            }
        },
        "readCapacityAutoScaling": {
            "autoScalingDisabled": false,
            "minimumUnits": 5,
            "maximumUnits": 10,
            "scalingPolicy": {
                "targetTrackingScalingPolicyConfiguration": {
                    "disableScaleIn": false,
                    "scaleInCooldown": 60,
                    "scaleOutCooldown": 60,
                    "targetValue": 50.0
                }
            }
        }
    }
}
```

Turn off Amazon Keyspaces auto scaling for a table

You can turn off Amazon Keyspaces auto scaling for your table at any time. If you no longer need to scale your table's read or write capacity, you should consider turning off auto scaling so that Amazon Keyspaces doesn't continue modifying your table's read or write capacity settings. You can update the table using the console, CQL, or the AWS CLI.

Turning off auto scaling also deletes the CloudWatch alarms that were created on your behalf.

To delete the service-linked role used by Application Auto Scaling to access your Amazon Keyspaces table, follow the steps in the section called "Deleting a service-linked role for Amazon Keyspaces".

> **Note**
>
> To delete the service-linked role that Application Auto Scaling uses, you must disable automatic scaling on all tables in the account across all AWS Regions.

Console

Turn off Amazon Keyspaces automatic scaling for your table using the console

Using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose the table you want to update and go to the **Capacity** tab.
3. In the **Capacity settings** section, choose **Edit**.
4. To disable Amazon Keyspaces automatic scaling, clear the **Scale automatically** check box. Disabling automatic scaling deregisters the table as a scalable target with Application Auto Scaling.

Cassandra Query Language (CQL)

Turn off Amazon Keyspaces automatic scaling for your table using CQL

The following statement turns off auto scaling for write capacity of the table *mytable*.

```
ALTER TABLE mykeyspace.mytable
WITH AUTOSCALING_SETTINGS = {
    'provisioned_write_capacity_autoscaling_update': {
        'autoscaling_disabled': true
    }
};
```

CLI

Turn off Amazon Keyspaces automatic scaling for your table using the AWS CLI

The following command turns off auto scaling for the table's read capacity. It also deletes the CloudWatch alarms that were created on your behalf.

```
aws keyspaces update-table --keyspace-name mykeyspace --table-name mytable
            \ --auto-scaling-specification
 readCapacityAutoScaling={autoScalingDisabled=true}
```

View auto scaling activity for a Amazon Keyspaces table in Amazon CloudWatch

You can monitor how Amazon Keyspaces automatic scaling uses resources by using Amazon CloudWatch, which generates metrics about your usage and performance. Follow the steps in the Application Auto Scaling User Guide to create a CloudWatch dashboard.

Use burst capacity effectively in Amazon Keyspaces

Amazon Keyspaces provides some flexibility in your per-partition throughput provisioning by providing *burst capacity*. Whenever you're not fully using a partition's throughput, Amazon Keyspaces reserves a portion of that unused capacity for later *bursts* of throughput to handle usage spikes.

Amazon Keyspaces currently retains up to 5 minutes (300 seconds) of unused read and write capacity. During an occasional burst of read or write activity, these extra capacity units can be consumed quickly—even faster than the per-second provisioned throughput capacity that you've defined for your table.

Amazon Keyspaces can also consume burst capacity for background maintenance and other tasks without prior notice.

Note that these burst capacity details might change in the future.

Working with Amazon Keyspaces (for Apache Cassandra) features

This chapter provides details about working with Amazon Keyspaces and various database features, for example backup and restore, Time to Live, and multi-Region replication.

- **Time to Live** – Amazon Keyspaces expires data from tables automatically based on the Time to Live value you set. Learn how to configure TTL and how to use it in your tables.
- **PITR** – Protect your Amazon Keyspaces tables from accidental write or delete operations by creating continuous backups of your table data. Learn how to configure PITR on your tables and how to restore a table to a specific point in time or how to restore a table that has been accidentally deleted.
- **Working with multi-Region tables** – Multi-Region tables in Amazon Keyspaces must have write throughput capacity configured in either on-demand or provisioned capacity mode with auto scaling. Plan the throughput capacity needs by estimating the required write capacity units (WCUs) for each Region, and provision the sum of writes from all Regions to ensure sufficient capacity for replicated writes.
- **Amazon Keyspaces change data capture (CDC)** – Amazon Keyspaces CDC streams record row-level change events from your table in near-real time. Learn how to use the Kinesis Client Library (KCL) to consume and process data from Amazon Keyspaces CDC streams.
- **Queries and pagination** – Amazon Keyspaces supports advanced querying capabilities like using the `IN` operator with `SELECT` statements, ordering results with `ORDER BY`, and automatic pagination of large result sets. This section explains how Amazon Keyspaces processes these queries and provides examples.
- **Partitioners** – Amazon Keyspaces provides three partitioners: `Murmur3Partitioner` (default), `RandomPartitioner`, and `DefaultPartitioner`. You can change the partitioner per Region at the account level using the AWS Management Console or Cassandra Query Language (CQL).
- **Client-side timestamps** – Client-side timestamps are Cassandra-compatible timestamps that Amazon Keyspaces persists for each cell in your table. Use client-side timestamps for conflict resolution and to let your client application determine the order of writes.
- **User-defined types (UDTs)** – With UDTs you can define data structures in your applications that represent real-world data hierarchies.
- **Tagging resources** – You can label Amazon Keyspaces resources like keyspaces and tables using tags. Tags help categorize resources, enable cost tracking, and let you configure access control

based on tags. This section covers tagging restrictions, operations, and best practices for Amazon Keyspaces.

- **CloudFormation templates** – CloudFormation helps you model and set up your Amazon Keyspaces keyspaces and tables so that you can spend less time creating and managing your resources and infrastructure.

Topics

- System keyspaces in Amazon Keyspaces
- User-defined types (UDTs) in Amazon Keyspaces
- Working with CQL queries in Amazon Keyspaces
- Working with change data capture (CDC) streams in Amazon Keyspaces
- Working with partitioners in Amazon Keyspaces
- Client-side timestamps in Amazon Keyspaces
- Multi-Region replication for Amazon Keyspaces (for Apache Cassandra)
- Backup and restore data with point-in-time recovery for Amazon Keyspaces
- Expire data with Time to Live (TTL) for Amazon Keyspaces (for Apache Cassandra)
- Using this service with an AWS SDK
- Working with tags and labels for Amazon Keyspaces resources
- Create Amazon Keyspaces resources with AWS CloudFormation
- Using NoSQL Workbench with Amazon Keyspaces (for Apache Cassandra)

System keyspaces in Amazon Keyspaces

System keyspaces and system tables in Amazon Keyspaces (for Apache Cassandra) are read-only resources that store metadata about your Amazon Keyspaces resources. System keyspaces are present in every AWS account, regardless of whether you have created any keyspaces or tables. They are a compatibility feature with Apache Cassandra, and they are provided at no additional charge.

You cannot modify or delete system keyspaces. The Amazon Keyspaces console displays only user-created keyspaces. System keyspaces are accessible programmatically through CQL and appear in services such as AWS CloudFormation and AWS Config.

Amazon Keyspaces uses four system keyspaces:

- system
- system_schema
- system_schema_mcs
- system_multiregion_info

The following sections provide details about the system keyspaces and the system tables that are supported in Amazon Keyspaces.

system

This is a Cassandra keyspace. Amazon Keyspaces uses the following tables.

Table names	Column names	Comments
local	key, bootstrapped, broadcast_address, cluster_name, cql_version, data_center, gossip_generation, host_id, listen_address, native_protocol_version, partitioner, rack, release_version, rpc_address, schema_version, thrift_version, tokens, truncated_at	Information about the local keyspace.
peers	peer, data_center, host_id, preferred_ip, rack, release_version, rpc_address, schema_version, tokens	Query this table to see the available endpoints. For example, if you're connecting through a public endpoint, you see a list of nine available IP addresses.

Table names	Column names	Comments
		If you're connecting through a FIPS endpoint, you see a list of three IP addresses. If you're connecting through an AWS PrivateLink VPC endpoint, you see the list of IP addresses that you have configured. For more information, see the section called “Populating `system.peers` table entries with interface VPC endpoint information”.
`size_estimates`	`keyspace_name, table_name, range_start, range_end, mean_partition_size, partitions_count`	This table defines the total size and number of partitions for each token range for every table. This is needed for the Apache Cassandra Spark Connector, which uses the estimated partition size to distribute the work.
`prepared_statements`	`prepared_id, logged_keyspace, query_string`	This table contains information about saved queries.

`system_schema`

This is a Cassandra keyspace. Amazon Keyspaces uses the following tables.

Table names	Column names	Comments
keyspaces	keyspace_name, durable_writes, replication	Information about a specific keyspace.
tables	keyspace_name, table_name, bloom_filter_fp_chance, caching, comment, compaction, compression, crc_check_chance, dclocal_read_repair_chance, default_time_to_live, extensions, flags, gc_grace_seconds, id, max_index_interval, memtable_flush_period_in_ms, min_index_interval, read_repair_chance, speculative_retry	Information about a specific table.
types	keyspace_name, type_name, field_names, field_types	Information about a specific user-defined type (UDT).
columns	keyspace_name, table_name, column_name, clustering_order, column_name_bytes, kind, position, type	Information about a specific column.

system_schema_mcs

This is an Amazon Keyspaces keyspace that stores information about AWS or Amazon Keyspaces specific settings.

Table names	Column names	Comments
keyspaces	keyspace_name, durable_writes, replication	Query this table to find out programmatically if a keyspace has been created. For more information, see the section called "Check keyspace creation status".
tables	keyspace_name, creation_time, speculative_retry, cdc, gc_grace_seconds, crc_check_chance, min_index_interval, bloom_filter_fp_chance, flags, custom_properties, dclocal_read_repair_chance, table_name, caching, default_time_to_live, read_repair_chance, max_index_interval, extensions, compaction, comment, id, compression, memtable_flush_period_in_ms, cdc_specification,	Query this table to find out the status of a specific table. For more information, see the section called "Check table creation status". You can also query this table to list settings that are specific to Amazon Keyspaces and are stored as custom_properties . For example: • capacity_mode • cdc_specification • client_side_timestamps • encryption_specification • point_in_time_recovery • ttl

Table names	Column names	Comments
	latest_stream_arn status	
tables_history	keyspace_name, table_name, event_time, creation_time, custom_properties, event	Query this table to learn about schema changes for a specific table.
columns	keyspace_name, table_name, column_name, clustering_order, column_name_bytes, kind, position, type	This table is identical to the Cassandra table in the system_schema keyspace.
tags	resource_id, keyspace_name, resource_name, resource_type, tags	Query this table to find out if a keyspace has tags. For more information, see the section called "View table tags".
types	keyspace_name, type_name, field_names, field_types, max_nesting_depth, last_modified_timestamp, status, direct_referring_tables, direct_parent_types	Query this table to find out information about user-defined types (UDTs). For example you can query this table to list all UDTs for a given keyspace. For more information, see the section called "User-defined types (UDTs)".

Table names	Column names	Comments
`autoscaling`	`keyspace_name, table_name, provisioned_read_capacity_autoscaling_update, provisioned_write_capacity_autoscaling_update`	Query this table to get the auto scaling settings of a provisioned table. Note that these settings won't be available until the table is active. To query this table, you have to specify `keyspace_name` and `table_name` in the `WHERE` clause. For more information, see the section called "View your table's Amazon Keyspaces auto scaling configuration".

system_multiregion_info

This is an Amazon Keyspaces keyspace that stores information about multi-Region replication.

Table names	Column names	Comments
`tables`	`keyspace_name, table_name, region, status`	This table contains information about multi-Region tables—for example, the AWS Regions that the table is replicated in and the table's status. You can also query this table to list settings that are specific to Amazon Keyspaces that are stored as `custom_properties`. For example: • `capacity_mode`

Table names	Column names	Comments
		To query this table, you have to specify `keyspace_name` and `table_name` in the `WHERE` clause. For more information, see the section called "Create a multi-Region keyspace".
`keyspaces`	`keyspace_name, region, status, tables_replication_progress`	This table contains informati on about the progress of an `ALTER KEYSPACE` operation that adds a replica to a keyspace — for example, how many tables have already been created in the new Region, and how many tables are still in progress. For an examples, see the section called "Check replication progress".

Table names	Column names	Comments
`autoscaling`	`keyspace_name, table_name, provisioned_read_capacity_autoscaling_update, provisioned_write_capacity_autoscaling_update, region`	Query this table to get the auto scaling settings of a multi-Region provisioned table. Note that these settings won't be available until the table is active. To query this table, you have to specify `keyspace_name` and `table_name` in the `WHERE` clause. For more information, see the section called "Update provisioned capacity and auto scaling settings for a multi-Region table".
`types`	`keyspace_name, type_name, field_names, field_types, max_nesting_depth, last_modified_timestamp, status, direct_referring_tables, direct_parent_types, region`	Query this table to find out information about user-defined types (UDTs) in multi-Region keyspaces. For example, you can query this table to list all table replicas and their respective AWS Regions that use UDTs for a given keyspace. For more information, see the section called "User-defined types (UDTs)".

User-defined types (UDTs) in Amazon Keyspaces

A user-defined type (UDT) is a grouping of fields and data types that you can use to define a single column in Amazon Keyspaces. Valid data types for UDTs are all supported Cassandra data types, including collections and other UDTs that you've already created in the same keyspace. For more

information about supported Cassandra data types, see the section called “Cassandra data type support”.

You can use user-defined types (UDTs) in Amazon Keyspaces to organize data in a more efficient way. For example, you can create UDTs with nested collections which allows you to implement more complex data modeling in your applications. You can also use the frozen keyword for defining UDTs.

UDTs are bound to a keyspace and available to all tables and UDTs in the same keyspace. You can create UDTs in single-Region and multi-Region keyspaces.

You can create new tables or alter existing tables and add new columns that use a UDT. To create a UDT with a nested UDT, the nested UDT has to be frozen.

To review how many UDTs are supported per keyspace, supported levels of nesting, and other default values and quotas related to UDTs, see the section called “Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces”.

For information about how to calculate the encoded size of UDTs, see the section called “Estimate the encoded size of data values based on data type”.

For more information about CQL syntax, see the section called “Types”.

To learn more about UDTs and point-in time restore, see the section called “PITR and UDTs”.

Topics

- Configure permissions to work with user-defined types (UDTs) in Amazon Keyspaces
- Create a user-defined type (UDT) in Amazon Keyspaces
- View user-defined types (UDTs) in Amazon Keyspaces
- Delete a user-defined type (UDT) in Amazon Keyspaces

Configure permissions to work with user-defined types (UDTs) in Amazon Keyspaces

Like tables, UDTs are bound to a specific keyspace. But unlike tables, you can't define permissions directly for UDTs. UDTs are not considered resources in AWS and they have no unique identifiers in the format of an Amazon Resource Name (ARN). Instead, to give an IAM principal permissions to

perform specific actions on a UDT, you have to define permissions for the keyspace that the UDT is bound to. To work with UDTs in multi-Region keyspaces, additional permissions are required.

To be able to create, view, or delete UDTs, the principal, for example an IAM user or role, needs the same permissions that are required to perform the same action on the keyspace that the UDT is bound to.

For more information about AWS Identity and Access Management, see the section called “AWS Identity and Access Management”.

Permissions to create a UDT

To create a UDT in a single-Region keyspace, the principal needs `Create` permissions for the keyspace.

The following IAM policy is an example of this.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "cassandra:Create",
            "Resource": [
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/"
            ]
        }
    ]
}
```

To create a UDT in a multi-Region keyspace, in addition to `Create` permissions the principal also needs permissions for the action `CreateMultiRegionResource` for the specified keyspace.

The following IAM policy is an example of this.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action":  [ "cassandra:Create", "cassandra:CreateMultiRegionResource" ],
```

```
            "Resource": [
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/"
            ]
        }
    ]
}
```

Permissions to view a UDT

To view or list UDTs in a single-Region keyspace, the principal needs read permissions for the system keyspace. For more information, see the section called "system_schema_mcs".

The following IAM policy is an example of this.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":"cassandra:Select",
         "Resource":[
             "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

To view or list UDTs for a multi-Region keyspace, the principal needs permissions for the actions `SELECT` and `SelectMultiRegionResource` for the system keyspace. For more information, see the section called "system_multiregion_info".

The following IAM policy is an example of this.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action": ["cassandra:Select", "cassandra:SelectMultiRegionResource"],
         "Resource":[
             "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
```

```
      }
   ]
}
```

Permissions to delete a UDT

To delete a UDT from a single-Region keyspace, the principal needs permissions for the `Drop` action for the specified keyspace.

The following IAM policy is an example of this.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "cassandra:Drop",
            "Resource": [
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/"
            ]
        }
    ]
}
```

To delete a UDT from a multi-Region keyspace, the principal needs permissions for the `Drop` action and for the `DropMultiRegionResource` action for the specified keyspace.

The following IAM policy is an example of this.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action":  [ "cassandra:Drop", "cassandra:DropMultiRegionResource" ],
            "Resource": [
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/"
            ]
        }
    ]
}
```

Create a user-defined type (UDT) in Amazon Keyspaces

To create a UDT in a single-Region keyspace, you can use the `CREATE TYPE` statement in CQL, the `create-type` command with the AWS CLI, or the console.

UDT names must contain 48 characters or less, must begin with an alphabetic character, and can only contain alpha-numeric characters and underscores. Amazon Keyspaces converts upper case characters automatically into lower case characters.

Alternatively, you can declare a UDT name in double quotes. When declaring a UDT name inside double quotes, Amazon Keyspaces preserves upper casing and allows special characters.

You can also use double quotes as part of the name when you create the UDT, but you must escape each double quote character with an additional double quote character.

The following table shows examples of allowed UDT names. The first columns shows how to enter the name when you create the type, the second column shows how Amazon Keyspaces formats the name internally. Amazon Keyspaces expects the formatted name for operations like `GetType`.

Entered name	Formatted name	Note
`MY_UDT`	`my_udt`	Without double-quotes, Amazon Keyspaces converts all upper-case characters to lower-case.
`"MY_UDT"`	`MY_UDT`	With double-quotes, Amazon Keyspaces respects the upper-case characters, and removes the double-quotes from the formatted name.
`"1234"`	`1234`	With double-quotes, the name can begin with a number, and Amazon Keyspaces removes the double-quotes from the formatted name.
`"Special_Ch@r@cters<>!!"`	`Special_Ch@r@cters<>!!`	With double-quotes, the name can contain special characters, and Amazon Keyspaces removes the double-quotes from the formatted name.

Entered name	Formatted name	Note
`"nested"" """"quotes"`	`nested""" quotes`	Amazon Keyspaces removes the outer double-quotes and the escape double-quotes from the formatted name.

Console

Create a user-defined type (UDT) with the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**, and then choose a keyspace from the list.
3. Choose the **UDTs** tab.
4. Choose **Create UDT**
5. Under **UDT details**, enter the name for the UDT. Under **UDT fields** you define the schema of the UDT.
6. To finish, choose **Create UDT**.

Cassandra Query Language (CQL)

Create a user-defined type (UDT) with CQL

In this example we create a new version of the book awards table used in the section called "Create a table". In this table, we store all awards an author receives for a given book. We create two UDTs that are nested and contain information about the book that received an award.

1. Create a keyspace with the name `catalog`.

```
CREATE KEYSPACE catalog WITH REPLICATION = {'class': 'SingleRegionStrategy'};
```

2. Create the first type. This type stores *BISAC* codes, which are used to define the genre of books. A BISAC code consists out of an alpha-numeric code and up to four subject matter areas.

```
CREATE TYPE catalog.bisac (
```

```
    bisac_code text,
    subject1 text,
    subject2 text,
    subject3 text,
    subject4 text
);
```

3. Create a second type for book awards that uses the first UDT. The nested UDT has to be frozen.

```
CREATE TYPE catalog.book (
    award_title text,
    book_title text,
    publication_date date,
    page_count int,
    ISBN text,
    genre FROZEN <bisac>
);
```

4. Create a table with a column for the author's name and uses a list type for the book awards. Note that the UDT used in the list has to be frozen.

```
CREATE TABLE catalog.authors (
    author_name text PRIMARY KEY,
    awards list <FROZEN <book>>
);
```

5. In this step we insert one row of data into the new table.

```
CONSISTENCY LOCAL_QUORUM;
```

```
INSERT INTO catalog.authors (author_name, awards) VALUES (
'John Stiles' ,
[{
      award_title: 'Wolf',
      book_title: 'Yesterday',
      publication_date: '2020-10-10',
      page_count: 345,
      ISBN: '026204630X',
      genre: { bisac_code:'FIC014090', subject1: 'FICTION', subject2:
 'Historical', subject3: '20th Century', subject4: 'Post-World War II'}
      },
```

```
      {award_title: 'Richard Roe',
      book_title: 'Who ate the cake?',
      publication_date: '2019-05-13',
      page_count: 193,
      ISBN: '9780262046305',
      genre: { bisac_code:'FIC022130', subject1: 'FICTION', subject2: 'Mystery &
 Detective', subject3: 'Cozy', subject4: 'Culinary'}
      }]
);
```

6. In the last step we read the data from the table.

```
SELECT * FROM catalog.authors;
```

The output of the command should look like this.

```
 author_name | awards
-------------
+-------------------------------------------------------------------------------------
 John Stiles | [{award_title: 'Wolf', book_title: 'Yesterday', publication_date:
 2020-10-10, page_count: 345, isbn: '026204630X', genre: {bisac_code:
 'FIC014090', subject1: 'FICTION', subject2: 'Historical', subject3: '20th
 Century', subject4: 'Post-World War II'}}, {award_title: 'Richard Roe',
 book_title: 'Who ate the cake?', publication_date: 2019-05-13, page_count: 193,
 isbn: '9780262046305', genre: {bisac_code: 'FIC022130', subject1: 'FICTION',
 subject2: 'Mystery & Detective', subject3: 'Cozy', subject4: 'Culinary'}}]

(1 rows)
```

For more information about CQL syntax, see the section called “CREATE TYPE”.

CLI

Create a user-defined type (UDT) with the AWS CLI

1. To create a type you can use the following syntax.

```
aws keyspaces create-type
--keyspace-name 'my_keyspace'
--type-name 'my_udt'
--field-definitions
```

```
    '[
        {"name" : "field1", "type" : "int"},
        {"name" : "field2", "type" : "text"}
    ]'
```

2. The output of that command looks similar to this example. Note that `typeName` returns the formatted name of the UDT.

```
{
    "keyspaceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/",
    "typeName": "my_udt"
}
```

View user-defined types (UDTs) in Amazon Keyspaces

To view or list all UDTs in a single-Region keyspace, you can query the table `system_schema_mcs.types` in the system keyspace using a statement in CQL, or use the `get-type` and `list-type` commands with the AWS CLI, or the console.

For either option, the IAM principal needs read permissions to the system keyspace. For more information, see the section called “Configure permissions”.

Console

View user-defined types (UDT) with the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**, and then choose a keyspace from the list.
3. Choose the **UDTs** tab to review the list of all UDTs in the keyspace.
4. To review one UDT in detail, choose a **UDT** from the list.
5. On the **Schema**tab you can review the schema. On the **Used in** tab you can see if this UDT is used in tables or other UDTs. Note that you can only delete UDTs that are not in use by either tables or other UDTs.

View the user-defined types (UDTs) of a single-Region keyspace with CQL

1. To see the types that are available in a given keyspace, you can use the following statement.

```
SELECT type_name
FROM system_schema_mcs.types
WHERE keyspace_name = 'my_keyspace';
```

2. To view the details about a specific type, you can use the following statement.

```
SELECT
    keyspace_name,
    type_name,
    field_names,
    field_types,
    max_nesting_depth,
    last_modified_timestamp,
    status,
    direct_referring_tables,
    direct_parent_types
FROM system_schema_mcs.types
WHERE keyspace_name = 'my_keyspace' AND type_name = 'my_udt';
```

3. You can list all UDTs that exist in the account using `DESC TYPE`.

```
DESC TYPES;

 Keyspace my_keyspace
 ---------------------------
 my_udt1  my_udt2

 Keyspace my_keyspace2
 ---------------------------
 my_udt1
```

4. You can list all UDTs in the current selected keyspace using `DESC TYPE`.

```
USE my_keyspace;
my_keyspace DESC TYPES;
```

```
my_udt1  my_udt2
```

5. To list all UDTs in a multi-Region keyspace, you can query the system table `types` in the `system_multiregion_info` keyspace. The following query is an example of this.

```
SELECT keyspace_name, type_name, region, status FROM
 system_multiregion_info.types WHERE keyspace_name = 'mykeyspace' AND table_name
 = 'mytable';
```

The output of this command looks similar to this.

```
keyspace_name     | table_name         | region                | status
mykeyspace        | mytable            | us-east-1             | ACTIVE
mykeyspace        | mytable            | ap-southeast-1        | ACTIVE
mykeyspace        | mytable            | eu-west-1             | ACTIVE
```

CLI

View user-defined types (UDTs) with the AWS CLI

1. To list the types available in a keyspace, you can use the `list-types` command.

```
aws keyspaces list-types
--keyspace-name 'my_keyspace'
```

The output of that command looks similar to this example.

```
{
    "types": [
        "my_udt",
        "parent_udt"
    ]
}
```

2. To view the details about a given type you can use the `get-type` command.

```
aws keyspaces get-type
--type-name 'my_udt'
--keyspace-name 'my_keyspace'
```

The output of this command looks similar to this example.

```
{
    "keyspaceName": "my_keyspace",
    "typeName": "my_udt",
    "fieldDefinitions": [
        {
            "name": "a",
            "type": "int"
        },
        {
            "name": "b",
            "type": "text"
        }
    ],
    "lastModifiedTimestamp": 1721328225776,
    "maxNestingDepth": 3
    "status": "ACTIVE",
    "directReferringTables": [],
    "directParentTypes": [
        "parent_udt"
    ],
    "keyspaceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/"
}
```

Delete a user-defined type (UDT) in Amazon Keyspaces

To delete a UDT in a keyspace, you can use the `DROP TYPE` statement in CQL, the `delete-type` command with the AWS CLI, or the console.

Console

Delete a user-defined type (UDT) with the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**, and then choose a keyspace from the list.
3. Choose the **UDTs** tab.

4. Choose the UDT that you want to delete. On the **Used in** you can confirm that the type you want to delete isn't currently used by a table or other UDT.
5. Choose **Delete** above the **Summary**.
6. Type `Delete` in the dialog that appears, and choose **Delete UDT**.

Cassandra Query Language (CQL)

Delete a user-defined type (UDT) with CQL

- To delete a type, you can use the following statement.

```
DROP TYPE my_keyspace.my_udt;
```

For more information about CQL syntax, see the section called “DROP TYPE”.

CLI

Delete a user-defined type (UDT) with the AWS CLI

1. To delete a type, you can use the following command.

```
aws keyspaces delete-type
--keyspace-name 'my_keyspace'
--type-name 'my_udt'
```

2. The output of the command looks similar to this example.

```
{
    "keyspaceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/",
    "typeName": "my_udt"
}
```

Working with CQL queries in Amazon Keyspaces

This section gives an introduction into working with queries in Amazon Keyspaces (for Apache Cassandra). The CQL statements available to query, transform, and manage data are `SELECT`, `INSERT`, `UPDATE`, and `DELETE`. The following topics outline some of the more complex options

available when working with queries. For the complete language syntax with examples, see the section called “DML statements”.

Topics

- Use the IN operator with the SELECT statement in a query in Amazon Keyspaces
- Use batch statements in Amazon Keyspaces
- Order results with ORDER BY in Amazon Keyspaces
- Paginate results in Amazon Keyspaces

Use the IN operator with the SELECT statement in a query in Amazon Keyspaces

SELECT IN

You can query data from tables using the SELECT statement, which reads one or more columns for one or more rows in a table and returns a result-set containing the rows matching the request. A SELECT statement contains a `select_clause` that determines which columns to read and to return in the result-set. The clause can contain instructions to transform the data before returning it. The optional WHERE clause specifies which rows must be queried and is composed of relations on the columns that are part of the primary key. Amazon Keyspaces supports the IN keyword in the WHERE clause. This section uses examples to show how Amazon Keyspaces processes SELECT statements with the IN keyword.

This examples demonstrates how Amazon Keyspaces breaks down the SELECT statement with the IN keyword into *subqueries*. In this example we use a table with the name `my_keyspace.customers`. The table has one primary key column `department_id`, two clustering columns `sales_region_id` and `sales_representative_id`, and one column that contains the name of the customer in the `customer_name` column.

```
SELECT * FROM my_keyspace.customers;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  0            |        0        |            0            |    a
  0            |        0        |            1            |    b
  0            |        1        |            0            |    c
  0            |        1        |            1            |    d
```

```
          1           |       0       |           0           |    e
          1           |       0       |           1           |    f
          1           |       1       |           0           |    g
          1           |       1       |           1           |    h
```

Using this table, you can run the following SELECT statement to find the customers in the departments and sales regions that you are interested in with the IN keyword in the WHERE clause. The following statement is an example of this.

```
SELECT * FROM my_keyspace.customers WHERE department_id IN (0, 1) AND sales_region_id
 IN (0, 1);
```

Amazon Keyspaces divides this statement into four subqueries as shown in the following output.

```
SELECT * FROM my_keyspace.customers WHERE department_id = 0 AND sales_region_id = 0;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  0            |       0         |           0             |    a
  0            |       0         |           1             |    b

SELECT * FROM my_keyspace.customers WHERE department_id = 0 AND sales_region_id = 1;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  0            |       1         |           0             |    c
  0            |       1         |           1             |    d

SELECT * FROM my_keyspace.customers WHERE department_id = 1 AND sales_region_id = 0;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  1            |       0         |           0             |    e
  1            |       0         |           1             |    f

SELECT * FROM my_keyspace.customers WHERE department_id = 1 AND sales_region_id = 1;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  1            |       1         |           0             |    g
  1            |       1         |           1             |    h
```

When the IN keyword is used, Amazon Keyspaces automatically paginates the results in any of the following cases:

- After every 10th subquery is processed.
- After processing 1MB of logical IO.
- If you configured a PAGE SIZE, Amazon Keyspaces paginates after reading the number of queries for processing based on the set PAGE SIZE.
- When you use the LIMIT keyword to reduce the number of rows returned, Amazon Keyspaces paginates after reading the number of queries for processing based on the set LIMIT.

The following table is used to illustrate this with an example.

For more information about pagination, see the section called “Paginate results”.

```
SELECT * FROM my_keyspace.customers;

 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  2            |        0        |          0              |    g
  2            |        1        |          1              |    h
  2            |        2        |          2              |    i
  0            |        0        |          0              |    a
  0            |        1        |          1              |    b
  0            |        2        |          2              |    c
  1            |        0        |          0              |    d
  1            |        1        |          1              |    e
  1            |        2        |          2              |    f
  3            |        0        |          0              |    j
  3            |        1        |          1              |    k
  3            |        2        |          2              |    l
```

You can run the following statement on this table to see how pagination works.

```
SELECT * FROM my_keyspace.customers WHERE department_id IN (0, 1, 2, 3) AND
 sales_region_id IN (0, 1, 2) AND sales_representative_id IN (0, 1);
```

Amazon Keyspaces processes this statement as 24 subqueries, because the cardinality of the Cartesian product of all the IN terms contained in this query is 24.

```
 department_id | sales_region_id | sales_representative_id | customer_name
```

```
---------------+-----------------+-------------------------+--------------
  0            |        0        |          0              |    a
  0            |        1        |          1              |    b
  1            |        0        |          0              |    d
  1            |        1        |          1              |    e

---MORE---
 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  2            |        0        |          0              |    g
  2            |        1        |          1              |    h
  3            |        0        |          0              |    j

---MORE---
 department_id | sales_region_id | sales_representative_id | customer_name
---------------+-----------------+-------------------------+--------------
  3            |        1        |          1              |    k
```

This example shows how you can use the `ORDER BY` clause in a `SELECT` statement with the `IN` keyword.

```
SELECT * FROM my_keyspace.customers WHERE department_id IN (3, 2, 1) ORDER BY
 sales_region_id DESC;

         department_id | sales_region_id | sales_representative_id | customer_name
        ---------------+-----------------+-------------------------+--------------
          3            |        2        |          2              |    l
          3            |        1        |          1              |    k
          3            |        0        |          0              |    j
          2            |        2        |          2              |    i
          2            |        1        |          1              |    h
          2            |        0        |          0              |    g
          1            |        2        |          2              |    f
          1            |        1        |          1              |    e
          1            |        0        |          0              |    d
```

Subqueries are processed in the order in which the partition key and clustering key columns are presented in the query. In the example below, subqueries for partition key value ”2“ are processed first, followed by subqueries for partition key value ”3“ and ”1“. Results of a given subquery are ordered according to the query's ordering clause, if present, or the table's clustering order defined during table creation.

```
SELECT * FROM my_keyspace.customers WHERE department_id IN (2, 3, 1) ORDER BY
 sales_region_id DESC;

         department_id | sales_region_id | sales_representative_id | customer_name
        ---------------+-----------------+-------------------------+--------------
          2            |        2        |          2              |    i
          2            |        1        |          1              |    h
          2            |        0        |          0              |    g
          3            |        2        |          2              |    l
          3            |        1        |          1              |    k
          3            |        0        |          0              |    j
          1            |        2        |          2              |    f
          1            |        1        |          1              |    e
          1            |        0        |          0              |    d
```

Use batch statements in Amazon Keyspaces

You can combine multiple INSERT, UPDATE, and DELETE operations into a BATCH statement. LOGGED batches are the default.

```
batch_statement ::=     BEGIN [ UNLOGGED ] BATCH
                        [ USING update_parameter( AND update_parameter)* ]
                        modification_statement ( ';' modification_statement )*
                        APPLY BATCH
modification_statement ::= insert_statement | update_statement | delete_statement
```

When you run a batch statement, the driver combines all statements in the batch into a single batch operation.

To decide which type of batch operation to use, you can consider the following guidelines.

Use logged batches when:

- You need atomic transaction guarantees.
- Slightly higher latencies are an acceptable trade-off.

Use unlogged batches when:

- You need to optimize single-partition operations.
- You want to reduce network overhead.
- You have high-throughput requirements.

For information about batch statement quotas, see *Quotas*.

Unlogged batches

With **unlogged batches**, Amazon Keyspaces processes multiple operations as a single request without maintaining a batch log. With an unlogged batch operation, it's possible that some of the actions succeed while others fail. Unlogged batches are useful when you want to:

- Optimize operations within a single partition.
- Reduce network traffic by grouping related requests.

The syntax for an unlogged batch is similar to that of a logged batch, with the addition of the `UNLOGGED` keyword.

```
BEGIN UNLOGGED BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'John', 'Doe');
    INSERT INTO users (id, firstname, lastname) VALUES (2, 'Jane', 'Smith');
APPLY BATCH;
```

Logged batches

A **logged** batch combines multiple write actions into a single atomic operation. When you run a logged batch:

- All actions either succeed together or fail together.
- The operation is synchronous and idempotent.
- You can write to multiple Amazon Keyspaces tables, as long as they are in the same AWS account and AWS Region.

Logged batches may have slightly higher latencies. For high-throughput applications, consider using unlogged batches.

There is no additional cost to use logged batches in Amazon Keyspaces. You pay only for the writes that are part of your batch operations. Amazon Keyspaces performs two underlying writes of every row in the batch: one to prepare the row for the batch and one to commit the batch. When planning capacity for tables that use logged batches, remember that each row in a batch requires twice the capacity of a standard write operation. For example, if your application runs one

logged batch per second with three 1KB rows, you need to provision six write capacity units (WCUs) compared to only three WCUs for individual writes or unlogged batches.

For information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

Use prepared statements in logged batches

Logged batches support prepared (bound) statements with full atomic (all-or-nothing) execution. You can combine the performance of prepared statements with the atomicity guarantees of a logged batch.

You can construct a logged batch of prepared statements in two ways. The following examples use a Java driver that is compatible with Apache Cassandra.

In the first approach, you prepare each statement individually and add the bound statements to a `BatchStatement`. This approach supports batches that span multiple tables in the same AWS account and AWS Region. The following Java code example shows this approach:

```
import com.datastax.driver.core.BatchStatement;
import com.datastax.driver.core.PreparedStatement;
import com.datastax.driver.core.Session;

PreparedStatement psInsert = session.prepare(
    "INSERT INTO my_keyspace.orders (order_id, status) VALUES (?, ?)");
PreparedStatement psUpdate = session.prepare(
    "UPDATE my_keyspace.inventory SET qty = ? WHERE sku = ?");

BatchStatement batch = new BatchStatement(BatchStatement.Type.LOGGED);
batch.add(psInsert.bind(orderId, "CONFIRMED"));
batch.add(psUpdate.bind(newQty, sku));

try {
    session.execute(batch);
} catch (Exception e) {
    // Handle the batch execution error.
}
```

In the second approach, you prepare an entire `BEGIN BATCH ... APPLY BATCH` block as a single statement, and then bind and run it. This approach is best suited to a batch whose statements target a single table. To prepare a batch that spans multiple tables, use the first approach. The following Java code example shows how to prepare a whole batch block as a single statement:

```
import com.datastax.driver.core.PreparedStatement;
import com.datastax.driver.core.Session;

PreparedStatement psBatch = session.prepare(
    "BEGIN BATCH " +
    "  INSERT INTO my_keyspace.orders (order_id, status) VALUES (?, ?); " +
    "  INSERT INTO my_keyspace.orders (order_id, status) VALUES (?, ?); " +
    "APPLY BATCH");

try {
    session.execute(psBatch.bind(orderId1, "CONFIRMED", orderId2, "PENDING"));
} catch (Exception e) {
    // Handle the batch execution error.
}
```

You can also use prepared statements in a logged batch with the following:

- Conditional statements (`IF NOT EXISTS` or `IF`)
- Named bind markers
- A mix of prepared and unprepared statements in the same batch
- Reuse of a single prepared statement with different bound values across the batch

Best practices for batch operations

Consider the following recommended practices when using Amazon Keyspaces batch operations.

- Enable automatic scaling so that you have sufficient throughput capacity for your tables to handle batch operations and the additional throughput requirements of logged batches.
- Use individual operations or unlogged batches when operations can run independently without affecting application correctness.
- Design your application to minimize concurrent updates to the same rows, as simultaneous batch operations can conflict and fail.
- For high-throughput bulk data ingestion without atomicity requirements, use individual write operations or unlogged batches.

Consistency and concurrency

Amazon Keyspaces enforces the following consistency and concurrency rules for logged batches:

- All batch operations use `LOCAL_QUORUM` consistency level.
- Concurrent batches affecting different rows can execute simultaneously.
- Concurrent `INSERT`, `UPDATE`, or `DELETE` operations on rows involved in an ongoing batch fail with a conflict.

Supported operators and conditions

Supported `WHERE` clause operators:

- Equality (=)

Unsupported operators:

- Range operators (>, <, >=, <=)
- `IN` operator
- `LIKE` operator
- `BETWEEN` operator

Not supported in logged batches:

- Multiple statements affecting the same row
- Counter operations
- Range deletes

A `DELETE` statement in a logged batch must target a single row by specifying the full primary key (all partition key and clustering columns) with equality conditions. A range delete, such as a delete by partition key alone or across a range of clustering columns, isn't supported in a logged batch. To run a range delete, use a standalone `DELETE` statement or an unlogged batch.

Failure conditions of logged batch statements

A logged batch operation may fail in any of the following cases:

- Condition expressions (like `IF NOT EXISTS` or `IF`) evaluate to false.
- One or more operations contain invalid parameters.
- The request conflicts with another batch operation running on the same rows.
- The table lacks sufficient provisioned capacity.
- A row exceeds the maximum size limit.
- The input data format is invalid.

Batch statements and multi-Region replication

In multi-Region deployments:

- Source Region operations are synchronous and atomic.
- Destination Region operations are asynchronous.
- All batch operations replicate to destination Regions, but may not maintain isolation during application.

Monitor batch operations

You can monitor batch operations using Amazon CloudWatch metrics to track performance, errors, and usage patterns. Amazon Keyspaces provides the following CloudWatch metrics for monitoring batch operations per table:

- `SuccessfulRequestCount` – Track successful batch operations.
- `Latency` – Measure batch operation performance.
- `ConsumedWriteCapacityUnits` – Monitor capacity consumption of batch operations.

For more information, see the section called “Amazon Keyspaces metrics”.

In addition to CloudWatch metrics, you can use AWS CloudTrail to log all Amazon Keyspaces API actions. Each API action in the batch is logged in CloudTrail making it easier to track and audit batch operations in your Amazon Keyspaces tables.

Batch operation examples

The following is an example of a basic logged batch statement.

```
BEGIN BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'John', 'Doe');
    INSERT INTO users (id, firstname, lastname) VALUES (2, 'Jane', 'Smith');
APPLY BATCH;
```

This is an example of a batch that includes `INSERT`, `UPDATE`, and `DELETE` statements.

```
BEGIN BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'John', 'Doe');
```

```
    UPDATE users SET firstname = 'Johnny' WHERE id = 2;
    DELETE FROM users WHERE id = 3;
APPLY BATCH;
```

This is an example of a batch using client-side timestamps.

```
BEGIN BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'John', 'Stiles') USING
 TIMESTAMP 1669069624;
    INSERT INTO users (id, firstname, lastname) VALUES (2, 'Jane', 'Doe') USING
 TIMESTAMP 1669069624;
APPLY BATCH;

BEGIN BATCH
    UPDATE users USING TIMESTAMP 1669069624 SET firstname = 'Carlos' WHERE id = 1;
    UPDATE users USING TIMESTAMP 1669069624 SET firstname = 'Diego' WHERE id = 2;
APPLY BATCH;
```

This is an example of a conditional batch.

```
BEGIN BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'Jane', 'Doe') IF NOT
 EXISTS;
    INSERT INTO users (id, firstname, lastname) VALUES (2, 'John', 'Doe') IF NOT
 EXISTS;
APPLY BATCH;


BEGIN BATCH
    UPDATE users SET lastname = 'Stiles' WHERE id = 1 IF lastname = 'Doe';
    UPDATE users SET lastname = 'Stiles' WHERE id = 2 IF lastname = 'Doe';
APPLY BATCH;
```

This is an example of a batch using Time to Live (TTL).

```
BEGIN BATCH
    INSERT INTO users (id, firstname, lastname) VALUES (1, 'John', 'Doe') USING TTL
 3600;
    INSERT INTO users (id, firstname, lastname) VALUES (2, 'Jane', 'Smith') USING TTL
 7200;
APPLY BATCH;
```

This is an example of a batch statement that updates multiple tables.

```
BEGIN BATCH
    INSERT INTO users (id, firstname) VALUES (1, 'John');
    INSERT INTO user_emails (user_id, email) VALUES (1, 'john@example.com');
APPLY BATCH;
```

This is an example of a batch operation using user-defined types (UDTs). The example assumes that the UDT `address` exists.

```
BEGIN BATCH
    INSERT INTO users (id, firstname, address)
    VALUES (1, 'John', {street: '123 Main St', city: 'NYC', zip: '10001'});
    INSERT INTO users (id, firstname, address)
    VALUES (2, 'Jane', {street: '456 Oak Ave', city: 'LA', zip: '90210'});
APPLY BATCH;

BEGIN BATCH
    UPDATE users SET address.zip = '10002' WHERE id = 1;
    UPDATE users SET address.city = 'Boston' WHERE id = 2;
APPLY BATCH;
```

Order results with `ORDER BY` in Amazon Keyspaces

The `ORDER BY` clause specifies the sort order of the results returned in a `SELECT` statement. The statement takes a list of column names as arguments and for each column you can specify the sort order for the data. You can only specify clustering columns in ordering clauses, non-clustering columns are not allowed.

The two available sort order options for the returned results are `ASC` for ascending and `DESC` for descending sort order.

```
SELECT * FROM my_keyspace.my_table ORDER BY (col1 ASC, col2 DESC, col3 ASC);

 col1 | col2 | col3
------+------+------
  0   |  6   |  a
  1   |  5   |  b
  2   |  4   |  c
  3   |  3   |  d
  4   |  2   |  e
```

```
 5   |  1   |  f
 6   |  0   |  g
```

```
SELECT * FROM my_keyspace.my_table ORDER BY (col1 DESC, col2 ASC, col3 DESC);

 col1 | col2 | col3
------+------+------
 6   |  0   |  g
 5   |  1   |  f
 4   |  2   |  e
 3   |  3   |  d
 2   |  4   |  c
 1   |  5   |  b
 0   |  6   |  a
```

If you don't specify the sort order in the query statement, the default ordering of the clustering column is used.

The possible sort orders you can use in an ordering clause depend on the sort order assigned to each clustering column at table creation. Query results can only be sorted in the order defined for all clustering columns at table creation or the inverse of the defined sort order. Other possible combinations are not allowed.

For example, if the table's `CLUSTERING ORDER` is (col1 ASC, col2 DESC, col3 ASC), then the valid parameters for `ORDER BY` are either (col1 ASC, col2 DESC, col3 ASC) or (col1 DESC, col2 ASC, col3 DESC). For more information on `CLUSTERING ORDER`, see `table_options` under the section called “CREATE TABLE”.

Paginate results in Amazon Keyspaces

Amazon Keyspaces automatically *paginates* the results from `SELECT` statements when the data read to process the `SELECT` statement exceeds 1 MB. With pagination, the `SELECT` statement results are divided into "pages" of data that are 1 MB in size (or less). An application can process the first page of results, then the second page, and so on. Clients should always check for pagination tokens when processing `SELECT` queries that return multiple rows.

If a client supplies a `PAGE SIZE` that requires reading more than 1 MB of data, Amazon Keyspaces breaks up the results automatically into multiple pages based on the 1 MB data-read increments.

For example, if the average size of a row is 100 KB and you specify a `PAGE SIZE` of 20, Amazon Keyspaces paginates data automatically after it reads 10 rows (1000 KB of data read).

Because Amazon Keyspaces paginates results based on the number of rows that it reads to process a request and not the number of rows returned in the result set, some pages may not contain any rows if you are running filtered queries.

For example, if you set `PAGE SIZE` to 10 and Keyspaces evaluates 30 rows to process your `SELECT` query, Amazon Keyspaces will return three pages. If only a subset of the rows matched your query, some pages may have less than 10 rows. For an example how the `PAGE SIZE` of `LIMIT` queries can affect read capacity, see the section called “Estimate the read capacity consumption of limit queries”.

For a comparison with Apache Cassandra pagination, see the section called “Pagination”.

Working with change data capture (CDC) streams in Amazon Keyspaces

Amazon Keyspaces change data capture (CDC) records row-level change events from an Amazon Keyspaces table in near-real time.

Amazon Keyspaces CDC enables event-driven use cases such as industrial IoT and fraud detection as well as data processing use cases like full-text search and data archival. The change events that Amazon Keyspaces CDC captures in streams can be consumed by downstream applications that perform business-critical functions such as data analytics, text search, ML training/inference, and continuous data backups for archival. For example, you can transfer stream data to AWS analytics and storage services like Amazon OpenSearch Service, Amazon Redshift, and Amazon S3 for further processing.

Amazon Keyspaces CDC offers time-ordered and de-duplicated change records for tables, with automatic scaling of data throughput and retention time of up to 24 hours.

Amazon Keyspaces CDC streams are completely serverless, and you don't need to manage the data infrastructure for capturing change events. In addition, Amazon Keyspaces CDC doesn't consume any table capacity for either compute or storage. For more information, see the section called “How CDC streams work”.

You can use the Amazon Keyspaces Streams API to build applications that consume Amazon Keyspaces CDC streams and take action based on the contents. For available endpoints, see the section called “Access CDC stream endpoints”.

For a complete listing of all operations available for Amazon Keyspaces in the Streams API, see *Amazon Keyspaces Streams API Reference*.

Topics

- How change data capture (CDC) streams work in Amazon Keyspaces
- How to use change data capture (CDC) streams in Amazon Keyspaces

How change data capture (CDC) streams work in Amazon Keyspaces

This section provides an overview of how change data capture (CDC) streams work in Amazon Keyspaces.

Amazon Keyspaces change data capture (CDC) records an ordered sequence of row-level modifications in Amazon Keyspaces tables and stores this information in a log called *stream* for up to 24 hours. Every row-level modification generates a new CDC record that holds the primary key column information as well as the “before” and “after” states of the row including all the columns. Applications can access the stream and view the mutations in near-real time.

When you enable CDC on your table, Amazon Keyspaces creates a new CDC stream and starts to capture information about every modification in the table. The CDC stream has an Amazon Resource Name (ARN) with the following format:

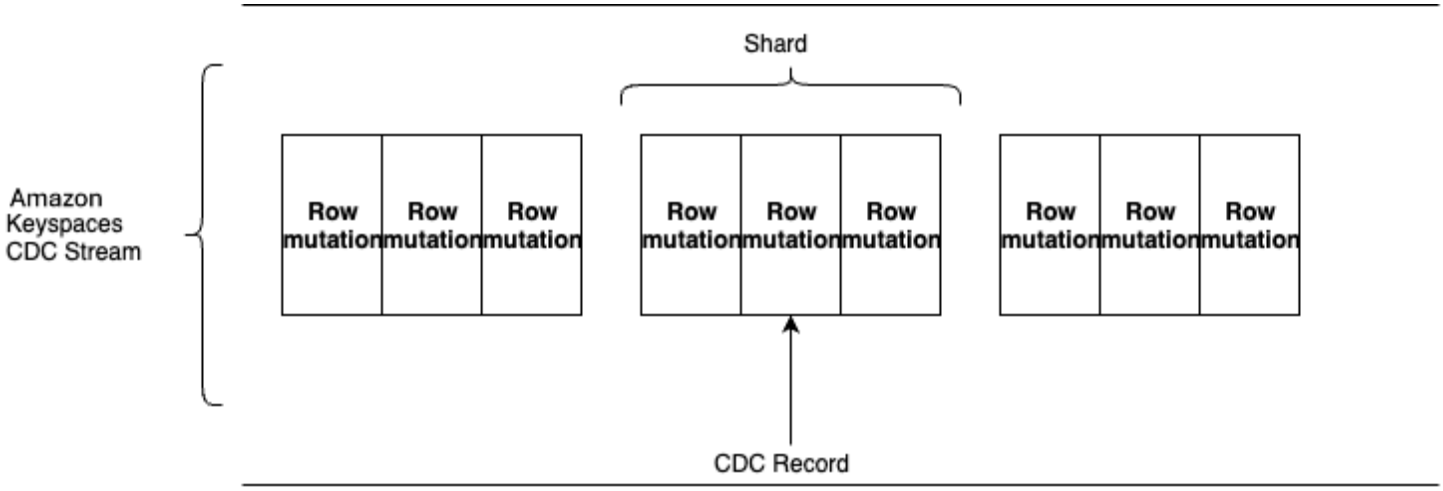
```
arn:${Partition}:cassandra:{Region}:${Account}:/keyspace/${keyspaceName}/table/
${tableName}/stream/${streamLabel}
```

You can select the type of information or the *view type* that the CDC stream collects for each record when you first enable the CDC stream. You can't change the view type of the stream afterward. Amazon Keyspaces supports the following view types:

- `NEW_AND_OLD_IMAGES` – Captures the versions of the row before as well as after the mutation. This is the default.
- `NEW_IMAGE` – Captures the version of the row after the mutation.
- `OLD_IMAGE` – Captures the version of the row before the mutation.
- `KEYS_ONLY` – Captures the partition and clustering keys of the row that was mutated.

Every CDC stream consists of records. Each record represents a single row modification in an Amazon Keyspaces table. Records are logically organized into groups known as *shards*. These

groups are logically organized by ranges of the primary key (combination of partition key, clustering key ranges) and are an internal construct of Amazon Keyspaces. Each shard acts as a container for multiple records, and contains information required for accessing and iterating through these records.



Each CDC record is assigned a sequence number, reflecting the order in which the record was published within the shard. The sequence number is guaranteed to be increasing and unique within each shard.

Amazon Keyspaces creates and deletes shards automatically. Based on traffic loads Amazon Keyspaces can also split or merge shards over time. For example, Amazon Keyspaces can split one shard into multiple new shards or merge shards into a new single shard. Amazon Keyspaces APIs publish the shard and CDC stream information to allow consuming applications to process records in the right order by accessing the entire lineage graph of a shard.

Amazon Keyspaces CDC is based on the following principles that you can rely on when building your application:

- Each row-level mutation record appears exactly once in the CDC stream.
- When you consume shards in order of lineage, each row-level mutation record appears in the same sequence as the actual mutation order on the primary key.

Topics

- How data retention works for CDC streams in Amazon Keyspaces
- How Time to Live (TTL) data expiration works with CDC streams in Amazon Keyspaces
- How batch operations work for CDC streams in Amazon Keyspaces

- How static columns work in CDC streams in Amazon Keyspaces
- How encryption at rest works for CDC streams in Amazon Keyspaces
- How multi-Region replication works for CDC streams in Amazon Keyspaces
- CDC streams and integration with AWS services

How data retention works for CDC streams in Amazon Keyspaces

Amazon Keyspaces retains the records in the CDC stream for a period of 24 hours. You can't change the retention period. If you disable CDC on a table, the data in the stream continues to be readable for 24 hours. After this time, the data expires and the records are automatically deleted.

How Time to Live (TTL) data expiration works with CDC streams in Amazon Keyspaces

Amazon Keyspaces shows the expiration time at the column/cell level as well as the row level in a metadata field called `expirationTime` in the CDC change records. When Amazon Keyspaces TTL detects expiration of a cell, CDC creates a new change record that shows TTL as the origin of the change. For more information about TTL, see the section called “Expire data with Time to Live”.

How batch operations work for CDC streams in Amazon Keyspaces

Batch operations are internally divided into individual row-level modifications. Amazon Keyspaces retains all records within CDC streams at the row-level, even if the modification occurred in a batch operation. Amazon Keyspaces maintains the order of records within the CDC stream in the same sequence as the mutation order that occurred at the row-level or on the primary key.

How static columns work in CDC streams in Amazon Keyspaces

Static column values are shared among all rows in a partition in Cassandra. Due to this behavior, Amazon Keyspaces captures any updates to a static column as a separate record in the CDC stream. The following examples summarize the behavior of static column mutations:

- When only the static column is updated, the CDC stream contains a row-modification for the static column as the only column in the row.
- When a row is updated without any change to the static column, the CDC stream contains a row-modification that contains all columns except the static column.
- When a row is updated along with the static column, the CDC stream contains two separate row-modifications, one for the static column and the other for the rest of the row.

How encryption at rest works for CDC streams in Amazon Keyspaces

To encrypt the data at rest in the CDC ordered log, Amazon Keyspaces uses the same encryption key that is already used for the table. For more information about encryption at rest, see the section called “Encryption at rest”.

How multi-Region replication works for CDC streams in Amazon Keyspaces

You can enable and disable CDC streams for individual replicas of a multi-Region table by using either the `update-table` API or the `ALTER TABLE` CQL command. Due to asynchronous replication and conflict resolution, CDC streams for multi-Region tables are not consistent across AWS Regions. Therefore, the records that Amazon Keyspaces captures in the stream might appear in a different order in different Regions.

For more information about multi-Region replication, see the section called “Multi-Region replication”.

CDC streams and integration with AWS services

How to work with VPC endpoints for CDC streams in Amazon Keyspaces

You can use VPC endpoints to access Amazon Keyspaces CDC streams. For information about how to create and access VPC endpoints for streams, see the section called “Using interface VPC endpoints with streams”.

How monitoring with CloudWatch works for CDC streams in Amazon Keyspaces

You can use Amazon CloudWatch to monitor API calls made to the Amazon Keyspaces CDC endpoint. For more information about the available metrics, see the section called “Metrics for Amazon Keyspaces change data capture (CDC)”.

How logging with CloudTrail works for CDC streams in Amazon Keyspaces

Amazon Keyspaces CDC is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Amazon Keyspaces. CloudTrail captures Data Definition Language (DDL) API calls and Data Manipulation Language (DML) API calls for Amazon Keyspaces as events. The calls that are captured include calls from the Amazon Keyspaces console and programmatic calls to the Amazon Keyspaces API operations.

For more information about the CDC events captured by CloudTrail, see the section called “Logging with CloudTrail”.

How tagging works for CDC streams in Amazon Keyspaces

Amazon Keyspaces CDC streams are a taggable resource. You can tag a stream when you create a table programmatically using CQL, the AWS SDK, or the AWS CLI. You can also tag existing streams, delete tags, or view tags of a stream. For more information, see the section called “Tag keyspaces, tables, and streams”.

How to use change data capture (CDC) streams in Amazon Keyspaces

Topics

- Configure permissions to work with CDC streams in Amazon Keyspaces
- How to access CDC stream endpoints in Amazon Keyspaces
- Enable a CDC stream when creating a new table in Amazon Keyspaces
- Enable a CDC stream for an existing table in Amazon Keyspaces
- Disable a CDC stream in Amazon Keyspaces
- View CDC streams in Amazon Keyspaces
- Access records in CDC streams in Amazon Keyspaces
- Use the Kinesis Client Library (KCL) to process Amazon Keyspaces streams

Configure permissions to work with CDC streams in Amazon Keyspaces

To enable CDC streams, the principal, for example an IAM user or role, needs the following permissions.

For more information about AWS Identity and Access Management, see the section called “AWS Identity and Access Management”.

Permissions to enable a CDC stream for a table

To enable a CDC stream for an Amazon Keyspaces table, the principal first needs permissions to create or alter a table and second the permissions to create the service linked role AWSServiceRoleForAmazonKeyspacesCDC. Amazon Keyspaces uses the service linked role to publish CloudWatch metrics into your account on your behalf

The following IAM policy is an example of this.

```
{
    "Version":"2012-10-17",
```

```
    "Statement":[
        {
            "Effect":"Allow",
            "Action":[
                "cassandra:Create",
                "cassandra:CreateMultiRegionResource",
                "cassandra:Alter",
                "cassandra:AlterMultiRegionResource"
            ],
            "Resource":[
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/*",
                "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
            ]
        },
        {
            "Sid": "KeyspacesCDCServiceLinkedRole",
            "Effect": "Allow",
            "Action": "iam:CreateServiceLinkedRole",
            "Resource": "arn:aws:iam::*:role/aws-service-role/cassandra-
streams.amazonaws.com/AWSServiceRoleForAmazonKeyspacesCDC",
            "Condition": {
              "StringLike": {
                "iam:AWSServiceName": "cassandra-streams.amazonaws.com"
              }
            }
        }
    ]
}
```

To disable a stream, only `ALTER TABLE` permissions are required.

Permissions to view a CDC stream

To view or list CDC streams, the principal needs read permissions for the system keyspace. For more information, see the section called “system_schema_mcs”.

The following IAM policy is an example of this.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
```

```
         "Action":"cassandra:Select",
         "Resource":[
             "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

To view or list CDC streams with the AWS CLI or the Amazon Keyspaces API, the principal needs additional permissions for the actions `cassandra:ListStreams` and `cassandra:GetStream`.

The following IAM policy is an example of this.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "cassandra:Select",
        "cassandra:ListStreams",
        "cassandra:GetStream"
      ],
      "Resource": "*"
    }
  ]
}
```

Permissions to read a CDC stream

To read CDC streams, the principal needs the following permissions.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:GetStream",
            "cassandra:GetShardIterator",
            "cassandra:GetRecords"
         ],
         "Resource":[
```

```
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/
table/my_table/stream/stream_label"
         ]
      }
   ]
}
```

Permissions to process Amazon Keyspaces CDC streams with the Kinesis Client Library (KCL)

To process Amazon Keyspaces CDC streams with KCL, the IAM principal needs the following permissions.

- `Amazon Keyspaces` – Read-only access to a specified Amazon Keyspaces CDC stream.
- `DynamoDB` – Permissions to create `shard lease` tables, read and write access to the tables, and read-access to the index as required for KCL stream processing.
- `CloudWatch` – Permissions to publish metric data from Amazon Keyspaces CDC streams processing with KCL into the namespace of your KCL client application in your CloudWatch account. For more information about monitoring, see Monitor the Kinesis Client Library with Amazon CloudWatch.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:GetStream",
            "cassandra:GetShardIterator",
            "cassandra:GetRecords"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/
table/my_table/stream/stream_label"
         ]
      },
      {
         "Effect":"Allow",
         "Action":[
            "dynamodb:CreateTable",
            "dynamodb:DescribeTable",
            "dynamodb:UpdateTable",
```

```
            "dynamodb:GetItem",
            "dynamodb:UpdateItem",
            "dynamodb:PutItem",
            "dynamodb:DeleteItem",
            "dynamodb:Scan"
         ],
         "Resource":[
            "arn:aws:dynamodb:us-east-1:111122223333:table/KCL_APPLICATION_NAME"
         ]
      },
      {
         "Effect":"Allow",
         "Action":[
            "dynamodb:CreateTable",
            "dynamodb:DescribeTable",
            "dynamodb:GetItem",
            "dynamodb:UpdateItem",
            "dynamodb:PutItem",
            "dynamodb:DeleteItem",
            "dynamodb:Scan"
         ],
         "Resource":[
            "arn:aws:dynamodb:us-east-1:111122223333:table/KCL_APPLICATION_NAME-
WorkerMetricStats",
            "arn:aws:dynamodb:us-east-1:111122223333:table/KCL_APPLICATION_NAME-
CoordinatorState"
         ]
      },
      {
         "Effect":"Allow",
         "Action":[
            "dynamodb:Query"
         ],
         "Resource":[
            "arn:aws:dynamodb:us-east-1:111122223333:table/KCL_APPLICATION_NAME/index/
*"
         ]
      },
      {
         "Effect":"Allow",
         "Action":[
            "cloudwatch:PutMetricData"
         ],
         "Resource":"*"
```

```
      }
   ]
}
```

How to access CDC stream endpoints in Amazon Keyspaces

Amazon Keyspaces maintains separate endpoints for keyspaces/tables and for CDC streams in each AWS Region where Amazon Keyspaces is available. To access a CDC stream, select the Region of the table and replace the `cassandra` prefix with `cassandra-streams` in the endpoint name as shown in the following example:

Region name	Region	Endpoint for keyspaces and tables	Endpoint for streams
US East (N. Virginia)	us-east-1	*cassandra* .us-east-1.api.aws	*cassandra-streams* .us-east-1.api.aws

The following table contains a complete list of available public endpoints for Amazon Keyspaces change data capture streams. Amazon Keyspaces CDC streams supports both IPv4 and IPv6. All public endpoints, for example `cassandra-streams.us-east-1.api.aws`, are dual stack endpoints that can be configured for IPv4 and IPv6.

Region Name	Region	Endpoint	Protocol
US East (Ohio)	us-east-2	cassandra-streams.us-east-2.api.aws	HTTPS
US East (N. Virginia)	us-east-1	cassandra-streams.us-east-1.api.aws	HTTPS
US West (N. California)	us-west-1	cassandra-streams.us-west-1.api.aws	HTTPS

Region Name	Region	Endpoint	Protocol
US West (Oregon)	us-west-2	cassandra-streams.us-west-2.api.aws	HTTPS
Africa (Cape Town)	af-south-1	cassandra-streams.af-south-1.api.aws	HTTPS
Asia Pacific (Hong Kong)	ap-east-1	cassandra-streams.ap-east-1.api.aws	HTTPS
Asia Pacific (Hyderabad)	ap-south-2	cassandra-streams.ap-south-2.api.aws	HTTPS
Asia Pacific (Jakarta)	ap-southeast-3	cassandra-streams.ap-southeast-3.api.aws	HTTPS
Asia Pacific (Malaysia)	ap-southeast-5	cassandra-streams.ap-southeast-5.api.aws	HTTPS
Asia Pacific (Melbourne)	ap-southeast-4	cassandra-streams.ap-southeast-4.api.aws	HTTPS
Asia Pacific (Mumbai)	ap-south-1	cassandra-streams.ap-south-1.api.aws	HTTPS

Region Name	Region	Endpoint	Protocol	
Asia Pacific (New Zealand)	ap-southeast-6	cassandra-streams.ap-southeast-6.api.aws	HTTPS	
Asia Pacific (Osaka)	ap-northeast-3	cassandra-streams.ap-northeast-3.api.aws	HTTPS	
Asia Pacific (Seoul)	ap-northeast-2	cassandra-streams.ap-northeast-2.api.aws	HTTPS	
Asia Pacific (Singapore)	ap-southeast-1	cassandra-streams.ap-southeast-1.api.aws	HTTPS	
Asia Pacific (Sydney)	ap-southeast-2	cassandra-streams.ap-southeast-2.api.aws	HTTPS	
Asia Pacific (Taipei)	ap-east-2	cassandra-streams.ap-east-2.api.aws	HTTPS	
Asia Pacific (Thailand)	ap-southeast-7	cassandra-streams.ap-southeast-7.api.aws	HTTPS	
Asia Pacific (Tokyo)	ap-northeast-1	cassandra-streams.ap-northeast-1.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
Canada (Central)	ca-central-1	cassandra-streams.ca-central-1.api.aws	HTTPS	
Canada West (Calgary)	ca-west-1	cassandra-streams.ca-west-1.api.aws	HTTPS	
Europe (Frankfurt)	eu-central-1	cassandra-streams.eu-central-1.api.aws	HTTPS	
Europe (Ireland)	eu-west-1	cassandra-streams.eu-west-1.api.aws	HTTPS	
Europe (London)	eu-west-2	cassandra-streams.eu-west-2.api.aws	HTTPS	
Europe (Milan)	eu-south-1	cassandra-streams.eu-south-1.api.aws	HTTPS	
Europe (Paris)	eu-west-3	cassandra-streams.eu-west-3.api.aws	HTTPS	
Europe (Spain)	eu-south-2	cassandra-streams.eu-south-2.api.aws	HTTPS	
Europe (Stockholm)	eu-north-1	cassandra-streams.eu-north-1.api.aws	HTTPS	
Europe (Zurich)	eu-central-2	cassandra-streams.eu-central-2.api.aws	HTTPS	
Israel (Tel Aviv)	il-central-1	cassandra-streams.il-central-1.api.aws	HTTPS	

Region Name	Region	Endpoint	Protocol	
Mexico (Central)	mx-central-1	cassandra-streams.mx-central-1.api.aws	HTTPS	
Middle East (Bahrain)	me-south-1	cassandra-streams.me-south-1.api.aws	HTTPS	
Middle East (UAE)	me-central-1	cassandra-streams.me-central-1.api.aws	HTTPS	
South America (São Paulo)	sa-east-1	cassandra-streams.sa-east-1.api.aws	HTTPS	
AWS GovCloud (US-East)	us-gov-east-1	cassandra-streams.us-gov-east-1.api.aws	HTTPS	
AWS GovCloud (US-West)	us-gov-west-1	cassandra-streams.us-gov-west-1.api.aws	HTTPS	

Enable a CDC stream when creating a new table in Amazon Keyspaces

To enable a CDC stream when you create a table, you can use the `CREATE TABLE` statement in CQL or the `create-table` command with the AWS CLI.

For each changed row in the table, Amazon Keyspaces can capture the following changes based on the `view_type` of the `cdc_specification` you select:

- `NEW_AND_OLD_IMAGES` – both versions of the row, before and after the change. This is the default.

- `NEW_IMAGE` – the version of the row after the change.
- `OLD_IMAGE` – the version of the row before the change.
- `KEYS_ONLY` – the partition and clustering keys of the row that was changed.

For information about how to tag a stream, see the section called “Create stream with tags with new table”.

> **Note**
>
> Amazon Keyspaces CDC requires the presence of a service-linked role (`AWSServiceRoleForAmazonKeyspacesCDC`) that publishes metric data from Amazon Keyspaces CDC streams into the `"cloudwatch:namespace": "AWS/Cassandra"` in your CloudWatch account on your behalf. This role is created automatically for you. For more information, see the section called “CDC streams”.

Cassandra Query Language (CQL)

Enable a CDC stream when you create a table with CQL

1.
```
CREATE TABLE mykeyspace.mytable (a text, b text, PRIMARY KEY(a))
WITH CUSTOM_PROPERTIES={'cdc_specification': {'view_type': 'NEW_IMAGE'}} AND CDC
 = TRUE;
```

2. To confirm the stream settings, you can use the following statement.

```
SELECT keyspace_name, table_name, cdc, custom_properties FROM
 system_schema_mcs.tables WHERE keyspace_name = 'mykeyspace' AND table_name =
 'mytable';
```

The output of that statement should look similar to this.

```
SELECT keyspace_name, table_name, cdc, custom_properties FROM
 system_schema_mcs.tables WHERE keyspace_name = 'mykeyspace' AND table_name =
 'mytable';keyspace_name | table_name | cdc  | custom_properties
--------------+------------+------
+-------------------------------------------------------------------------------------------
    mykeyspace |   mytable  | True | {'capacity_mode':
 {'last_update_to_pay_per_request_timestamp': '1741383893782',
```

```
 'throughput_mode': 'PAY_PER_REQUEST'}, 'cdc_specification':
 {'latest_stream_arn': 'arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable/stream/2025-03-07T21:44:53.783', 'status': 'ENABLED',
 'view_type': 'NEW_IMAGE'}, 'encryption_specification': {'encryption_type':
 'AWS_OWNED_KMS_KEY'}, 'point_in_time_recovery': {'status': 'disabled'}}>
```

CLI

Enable a CDC stream when you create a table with the AWS CLI

1. To create a stream you can use the following syntax.

```
aws keyspaces create-table \
--keyspace-name 'mykeyspace' \
--table-name 'mytable' \
--schema-definition 'allColumns=[{name=a,type=text},
{name=b,type=text}],partitionKeys=[{name=a}]' \
--cdc-specification status=ENABLED,viewType=NEW_IMAGE
```

2. The output of that command shows the standard `create-table` response and looks similar to this example.

```
{ "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/mytable" }
```

Enable a CDC stream for an existing table in Amazon Keyspaces

To enable a CDC stream for an existing table, you can use the `ALTER TABLE` statement in CQL, the `update-table` command with the AWS CLI, or you can use the console.

For each changed row in the table, Amazon Keyspaces can capture the following changes based on the `view_type` of the `cdc_specification` you select:

- `NEW_AND_OLD_IMAGES` – both versions of the row, before and after the change. This is the default.
- `NEW_IMAGE` – the version of the row after the change.
- `OLD_IMAGE` – the version of the row before the change.
- `KEYS_ONLY` – the partition and clustering keys of the row that was changed.

For information about how to tag a stream, see the section called “Add new tags to a stream”.

> **Note**
>
> Amazon Keyspaces CDC requires the presence of a service-linked role (`AWSServiceRoleForAmazonKeyspacesCDC`) that publishes metric data from Amazon Keyspaces CDC streams into the `"cloudwatch:namespace": "AWS/Cassandra"` in your CloudWatch account on your behalf. This role is created automatically for you. For more information, see the section called “CDC streams”.

Cassandra Query Language (CQL)

Enable a stream (CDC stream) with CQL

You can use `ALTER TABLE` to enable a stream for an existing table.

1. The following example creates a stream that only captures changes to partition and clustering keys of a changed row.

```
ALTER TABLE mykeyspace.mytable
WITH cdc = TRUE
AND CUSTOM_PROPERTIES={'cdc_specification': {'view_type': 'KEYS_ONLY'}};
```

2. To verify the stream settings, you can use the following statement.

```
SELECT keyspace_name, table_name, cdc, custom_properties FROM
 system_schema_mcs.tables WHERE keyspace_name = 'mykeyspace' AND table_name =
 'mytable';
```

The output of the statement looks similar to this.

```
 keyspace_name | table_name | cdc  | custom_properties
---------------+------------+------
+-------------------------------------------------------------------------------------------
    mykeyspace |    mytable | True | {'capacity_mode':
 {'last_update_to_pay_per_request_timestamp': '1741385897045',
 'throughput_mode': 'PAY_PER_REQUEST'}, 'cdc_specification':
 {'latest_stream_arn': 'arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable/stream/2025-03-07T22:20:10.454', 'status': 'ENABLED',
```

```
 'view_type': 'KEYS_ONLY'}, 'encryption_specification': {'encryption_type':
 'AWS_OWNED_KMS_KEY'}, 'point_in_time_recovery': {'status': 'disabled'}}
```

CLI

Create a CDC stream with the AWS CLI

1. To create a stream for an existing table you can use the following syntax.

```
aws keyspaces update-table \
--keyspace-name 'mykeyspace' \
--table-name 'mytable' \
--cdc-specification status=ENABLED,viewType=NEW_AND_OLD_IMAGES
```

2. The output of that command shows the standard `create-table` response and looks similar to this example.

```
{ "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/mytable" }
```

Console

Enable a CDC stream with the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose a table from the list.
3. Choose the **Streams** tab.
4. Choose **Edit** to enable a stream.
5. Select **Turn on streams**.
6. Choose **View type** of the stream. The following options are available. Note that you can't change the view type of a stream after it's been created.

   - **New and old images** – Amazon Keyspaces captures both versions of the row, before and after the change. This is the default.
   - **New image** – Amazon Keyspaces captures only the version of the row after the change.
   - **Old image** – Amazon Keyspaces captures only the version of the row before the change.

- **Primary key only** – Amazon Keyspaces captures only the partition and clustering key columns of the row that was changed.

7. To finish, choose **Save changes**.

Disable a CDC stream in Amazon Keyspaces

To disable a CDC stream in a keyspace, you can use the `ALTER TABLE` statement in CQL, the `update-table` command with the AWS CLI, or the console.

Cassandra Query Language (CQL)

Disable a stream (CDC stream) with CQL

1. To disable a stream, you can use the following statement.

```
ALTER TABLE mykeyspace.mytable
WITH cdc = FALSE;
```

2. To confirm that the stream is disabled, you can use the following statement.

```
SELECT keyspace_name, table_name, cdc, custom_properties FROM
 system_schema_mcs.tables WHERE keyspace_name = 'mykeyspace' AND table_name =
 'mytable';
```

The output of that statement looks similar to this.

```
 keyspace_name | table_name | cdc   | custom_properties
---------------+------------+-------
+-------------------------------------------------------------------------------------------
   mykeyspace  |   mytable  | False | {'capacity_mode':
 {'last_update_to_pay_per_request_timestamp': '1741385668642',
 'throughput_mode': 'PAY_PER_REQUEST'}, 'encryption_specification':
 {'encryption_type': 'AWS_OWNED_KMS_KEY'}, 'point_in_time_recovery': {'status':
 'disabled'}}
```

CLI

Disable a stream (CDC stream) with the AWS CLI

1. To disable a stream, you can use the following command.

```
aws keyspaces update-table \
--keyspace-name 'mykeyspace' \
--table-name 'mytable' \
--cdc-specification status=DISABLED
```

2. The output of the command looks similar to this example.

```
{
    "keyspaceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/",
    "streamName": "my_stream"
}
```

Console

Disable a stream (CDC stream) with the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose a table from the list.
3. Choose the **Streams** tab.
4. Choose **Edit**.
5. Unselect **Turn on streams**.
6. Choose **Save changes** to disable the stream.

View CDC streams in Amazon Keyspaces

To view or list all streams in keyspace, you can query the table `system_schema_mcs.streams` in the system keyspace using a statement in CQL, or use the `get-stream` and `list-stream` commands with the AWS CLI, or the console.

For the required permissions, see the section called “Configure permissions”.

Cassandra Query Language (CQL)

View CDC streams with CQL

- To monitor the CDC status of your table, you can use the following statement.

```
SELECT custom_properties
FROM system_schema_mcs.tables
WHERE keyspace_name='my_keyspace' and table_name='my_table';
```

The output of the command looks similar to this.

```
...
custom_properties
--------------------------------------------------------------------------------
{'cdc_specification':{'status': 'Enabled', 'view_type': 'NEW_IMAGE',
 'latest_stream_arn': 'arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/table/my_table/stream/stream_label''}}
...
```

CLI

View CDC streams with the AWS CLI

1. This example shows how to see the stream information for a table.

```
aws keyspaces get-table \
--keyspace-name 'my_keyspace' \
--table-name 'my_table'
```

The output of the command looks like this.

```
{
    "keyspaceName": "my_keyspace",
    "tableName": "my_table",
    ... Other fields ...,
    "latestStreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/table/my_table/stream/stream_label",
    "cdcSpecification": {
        "status": "ENABLED",
```

```
        "viewType": "NEW_AND_OLD_IMAGES"
    }
}
```

2. You can list all streams in your account in a specified AWS Region. The following command is an example of this.

```
aws keyspacesstreams list-streams --region us-east-1
```

The output of the command could look similar to this.

```
{
    "Streams": [
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_1/table/t1/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_1"
            "TableName": "t1",
        },
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_1/table/t2/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_1"Create a keyspace with the name catalog. Note
                                that streams are not supported in multi-Region
 keyspaces.
            "TableName": "t2",
        },
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_2/table/t1/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_3"
            "TableName": "t1",
        }
    ]
}
```

3. You can also list the CDC streams for a given keyspace using the following parameters.

```
aws keyspacesstreams list-streams --keyspace-name ks_1 --region us-east-1
```

The output of the command looks similar to this.

```
{
    "Streams": [
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_1/table/t1/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_1"
            "TableName": "t1",
        },
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_1/table/t2/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_1"
            "TableName": "t2",
        }
    ]
}
```

4. You can also list the CDC streams for a given table using the following parameters.

```
aws keyspacesstreams list-streams --keyspace-name ks_1 --table-name t2 --
region us-east-1
```

The output of the command looks similar to this.

```
{
    "Streams": [
        {
            "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
ks_1/table/t2/stream/2023-05-11T21:21:33.291",
            "StreamLabel": "2023-05-11T21:21:33.291",
            "KeyspaceName": "ks_1"
            "TableName": "t2",
        }
    ]
}
```

Console

View CDC streams in the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose a table from the list.
3. Choose the **Streams** tab to review the stream details.

Access records in CDC streams in Amazon Keyspaces

To access the records in a stream, you use the Amazon Keyspaces Streams API. The following section contains examples on how to access records using the AWS CLI.

For the required permissions, see the section called "Configure permissions".

Access records in a stream using the AWS CLI

1. You can use the Amazon Keyspaces Streams API to access the change records of the stream. For more information, see *Amazon Keyspaces Streams API Reference*. To retrieve the shards within the stream, you can use the `get-stream` API as shown in the following example.

```
aws keyspacesstreams get-stream \
--stream-arn 'arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable/stream/STREAM_LABEL'
```

The following is an example of the output.

```
{
   "StreamArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/mytable/stream/2023-05-11T21:21:33.291",
   "StreamStatus": "ENABLED",
   "StreamViewType": "NEW_AND_OLD_IMAGES",
   "CreationRequestDateTime": "<CREATION_TIME>",
   "KeyspaceName": "mykeyspace",
   "TableName": "mytable",
   "StreamLabel": "2023-05-11T21:21:33.291",
    "Shards": [
        {
            "SequenceNumberRange": {
```

```
                "EndingSequenceNumber": "<END_SEQUENCE_NUMBER>",
                "StartingSequenceNumber": "<START_SEQUENCE_NUMBER>"
            },
            "ShardId": "<SHARD_ID>"
        },
    ]
}
```

2. To retrieve records from the stream, you start with getting an iterator that provides you with the starting point for accessing records. To do this, you can use the shards within the CDC stream returned by the API in the previous step. To gather the iterator, you can use the `get-shard-iterator` API. For this example, you use an iterator of type `TRIM_HORIZON` that retrieves from the last trimmed point or beginning) of the shard.

```
aws keyspacesstreams get-shard-iterator \
--stream-arn 'arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable/stream/STREAM_LABEL' \
--shard-id 'SHARD_ID' \
--shard-iterator-type 'TRIM_HORIZON'
```

The output of the command looks like in the following example.

```
{
    "ShardIterator": "<SHARD_ITERATOR>"
}
```

3. To retrieve the CDC records using the `get-records` API, you can use the iterator returned in the last step. The following command is an example of this.

```
aws keyspacesstreams get-records \
--shard-iterator 'SHARD_ITERATOR' \
--limit 100
```

The following is an example of the output.

```
{
    "changeRecords": [...],
    "nextShardIterator": "<NEXT_SHARD_ITERATOR>",
    "iteratorDescription": {
        "iteratorPosition": "BEHIND_TIP"
    }
```

```
}
```

Optimize polling frequency with iterator position

The `GetRecords` response includes an `iteratorDescription` field that indicates your consumer's current position within the shard:

- `AT_TIP` — No more records are currently available. Consider reducing your polling frequency to optimize costs.
- `BEHIND_TIP` — The stream tip advances continuously. Additional records may be available. Continue polling at your normal frequency.

`BEHIND_TIP` with an empty `changeRecords` list indicates the stream is progressing but no customer records are available at this position. Continue polling normally.

Use the Kinesis Client Library (KCL) to process Amazon Keyspaces streams

This topic describes how to use the Kinesis Client Library (KCL) to consume and process data from Amazon Keyspaces change data capture (CDC) streams.

Instead of working directly with the Amazon Keyspaces Streams API, working with the Kinesis Client Library (KCL) provides many benefits, for example:

- Built in shard lineage tracking and iterator handling.
- Automatic load balancing across workers.
- Fault tolerance and recovery from worker failures.
- Checkpointing to track processing progress.
- Adaptation to changes in stream capacity.
- Simplified distributed computing for processing CDC records.

The following section outlines why and how to use the Kinesis Client Library (KCL) to process streams and provides an example for processing an Amazon Keyspaces CDC stream with the KCL.

For information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

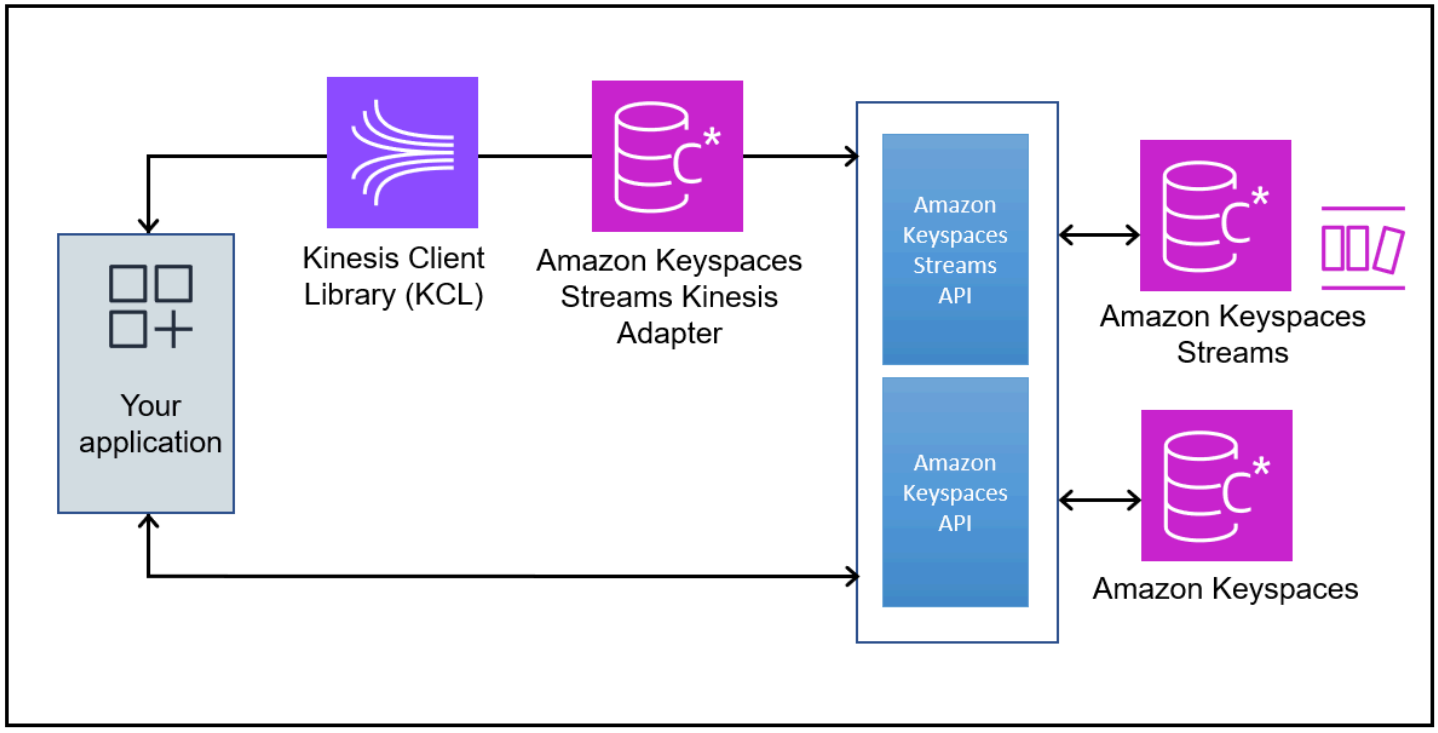
What is the Kinesis Client Library?

The Kinesis Client Library (KCL) is a standalone Java software library designed to simplify the process of consuming and processing data from streams. KCL handles many of the complex tasks associated with distributed computing, letting you focus on implementing your business logic when processing stream data. KCL manages activities such as load balancing across multiple workers, responding to worker failures, checkpointing processed records, and responding to changes in the number of shards in the stream.

To process Amazon Keyspaces CDC streams, you can use the design patterns found in the KCL for working with stream shards and stream records. The KCL simplifies coding by providing useful abstractions above the low-level Kinesis Data Streams API. For more information about the KCL, see Develop consumers with KCL in the *Amazon Kinesis Data Streams Developer Guide*.

To write applications using the KCL, you use the Amazon Keyspaces Streams Kinesis Adapter. The Kinesis Adapter implements the Kinesis Data Streams interface so that you can use the KCL for consuming and processing records from Amazon Keyspaces streams. For instructions on how to set up and install the Amazon Keyspaces streams Kinesis adapter, visit the GitHub repository.

The following diagram shows how these libraries interact with each other.



KCL is frequently updated to incorporate newer versions of underlying libraries, security improvements, and bug fixes. We recommend that you use the latest version of KCL to avoid

known issues and benefit from all latest improvements. To find the latest KCL version, see KCL GitHub repository.

KCL concepts

Before you implement a consumer application using KCL, you should understand the following concepts:

KCL consumer application

A KCL consumer application is a program that processes data from an Amazon Keyspaces CDC stream. The KCL acts as an intermediary between your consumer application code and the Amazon Keyspaces CDC stream.

Worker

A worker is an execution unit of your KCL consumer application that processes data from the Amazon Keyspaces CDC stream. Your application can run multiple workers distributed across multiple instances.

Record processor

A record processor is the logic in your application that processes data from a shard in the Amazon Keyspaces CDC stream. A record processor is instantiated by a worker for each shard it manages.

Lease

A lease represents the processing responsibility for a shard. Workers use leases to coordinate which worker is processing which shard. KCL stores lease data in a table in Amazon DynamoDB.

Checkpoint

A checkpoint is a record of the position in the shard up to which the record processor has successfully processed records. Checkpointing enables your application to resume processing from where it left off if a worker fails.

With the Amazon Keyspaces Kinesis adapter in place, you can begin developing against the KCL interface, with the API calls seamlessly directed at the Amazon Keyspaces stream endpoint. For a list of available endpoints, see the section called “Access CDC stream endpoints”.

When your application starts, it calls the KCL to instantiate a worker. You must provide the worker with configuration information for the application, such as the stream descriptor and AWS

credentials, and the name of a record processor class that you provide. As it runs the code in the record processor, the worker performs the following tasks:

- Connects to the stream
- Enumerates the shards within the stream
- Coordinates shard associations with other workers (if any)
- Instantiates a record processor for every shard it manages
- Pulls records from the stream
- Pushes the records to the corresponding record processor
- Checkpoints processed records
- Balances shard-worker associations when the worker instance count changes
- Balances shard-worker associations when shards are split

Implement a KCL consumer application for Amazon Keyspaces CDC streams

This topic provides a step-by-step guide to implementing a KCL consumer application to process Amazon Keyspaces CDC streams.

1. Prerequisites: Before you begin, ensure you have:
   - An Amazon Keyspaces table with a CDC stream
   - Required IAM permissions for the IAM principal to access the Amazon Keyspaces CDC stream, create and access DynamoDB tables for KCL stream processing, and permissions to publish metrics to CloudWatch. For more information and a policy example, see the section called "Permissions for KCL".
   - Ensure that valid AWS credentials are set up in your local configuration. For more information, see the section called "Manage access keys".
   - Java Development Kit (JDK) 8 or later
   - Requirements listed in the Readme on Github.
2. In this step, you add the KCL dependency to your project. For Maven, add the following to your pom.xml:

```
<dependencies>
        <dependency>
            <groupId>software.amazon.kinesis</groupId>
            <artifactId>amazon-kinesis-client</artifactId>
```

```
            <version>3.1.0</version>
        </dependency>
        <dependency>
            <groupId>software.amazon.keyspaces</groupId>
            <artifactId>keyspaces-streams-kinesis-adapter</artifactId>
            <version>1.0.0</version>
        </dependency>
    </dependencies>
```

> **Note**
>
> Always check for the latest version of KCL at the KCL GitHub repository.

3. Create a factory class that produces record processor instances:

```
import software.amazon.awssdk.services.keyspacesstreams.model.Record;
import
 software.amazon.keyspaces.streamsadapter.adapter.KeyspacesStreamsClientRecord;
import
 software.amazon.keyspaces.streamsadapter.model.KeyspacesStreamsProcessRecordsInput;
import
 software.amazon.keyspaces.streamsadapter.processor.KeyspacesStreamsShardRecordProcessor;
import software.amazon.kinesis.lifecycle.events.InitializationInput;
import software.amazon.kinesis.lifecycle.events.LeaseLostInput;
import software.amazon.kinesis.lifecycle.events.ShardEndedInput;
import software.amazon.kinesis.lifecycle.events.ShutdownRequestedInput;
import software.amazon.kinesis.processor.RecordProcessorCheckpointer;

public class RecordProcessor implements KeyspacesStreamsShardRecordProcessor {
    private String shardId;

    @Override
    public void initialize(InitializationInput initializationInput) {
        this.shardId = initializationInput.shardId();
        System.out.println("Initializing record processor for shard: " + shardId);
    }

    @Override
    public void processRecords(KeyspacesStreamsProcessRecordsInput
 processRecordsInput) {
        try {
```

```
            for (KeyspacesStreamsClientRecord record :
processRecordsInput.records()) {
                Record keyspacesRecord = record.getRecord();
                System.out.println("Received record: " + keyspacesRecord);
            }

            if (!processRecordsInput.records().isEmpty()) {
                RecordProcessorCheckpointer checkpointer =
processRecordsInput.checkpointer();
                try {
                    checkpointer.checkpoint();
                    System.out.println("Checkpoint successful for shard: " +
shardId);
                } catch (Exception e) {
                    System.out.println("Error while checkpointing for shard: " +
shardId + " " + e);
                }
            }
        } catch (Exception e) {
            System.out.println("Error processing records for shard: " + shardId + "
" + e);
        }
    }

    @Override
    public void leaseLost(LeaseLostInput leaseLostInput) {
        System.out.println("Lease lost for shard: " + shardId);
    }

    @Override
    public void shardEnded(ShardEndedInput shardEndedInput) {
        System.out.println("Shard ended: " + shardId);
        try {
            // This is required. Checkpoint at the end of the shard
            shardEndedInput.checkpointer().checkpoint();
            System.out.println("Final checkpoint successful for shard: " +
shardId);
        } catch (Exception e) {
            System.out.println("Error while final checkpointing for shard: " +
shardId + " " + e);
            throw new RuntimeException("Error while final checkpointing", e);
        }
    }
```

```
    @Override
    public void shutdownRequested(ShutdownRequestedInput shutdownRequestedInput) {
        System.out.println("Shutdown requested for shard " + shardId);
        try {
            shutdownRequestedInput.checkpointer().checkpoint();
        } catch (Exception e) {
            System.out.println("Error while checkpointing on shutdown for shard: "
 + shardId + " " + e);
        }
    }
}
```

4. Create a record factory as shown in the following example.

```
import software.amazon.kinesis.processor.ShardRecordProcessor;
import software.amazon.kinesis.processor.ShardRecordProcessorFactory;

import java.util.Queue;
import java.util.concurrent.ConcurrentLinkedQueue;

public class RecordProcessorFactory implements ShardRecordProcessorFactory {
    private final Queue<RecordProcessor> processors = new
 ConcurrentLinkedQueue<>();

    @Override
    public ShardRecordProcessor shardRecordProcessor() {
        System.out.println("Creating new RecordProcessor");
        RecordProcessor processor = new RecordProcessor();
        processors.add(processor);
        return processor;
    }
}
```

5. In this step you create the base class to configure KCLv3 and the Amazon Keyspaces adapter.

```
import com.example.KCLExample.utils.RecordProcessorFactory;
import
 software.amazon.keyspaces.streamsadapter.AmazonKeyspacesStreamsAdapterClient;
import software.amazon.keyspaces.streamsadapter.StreamsSchedulerFactory;
import java.util.Arrays;
import java.util.List;
import java.util.concurrent.ExecutionException;
```

```
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.cloudwatch.CloudWatchAsyncClient;
import software.amazon.awssdk.services.dynamodb.DynamoDbAsyncClient;
import software.amazon.awssdk.services.dynamodb.model.DeleteTableRequest;
import software.amazon.awssdk.services.dynamodb.model.DeleteTableResponse;
import software.amazon.awssdk.services.keyspacesstreams.KeyspacesStreamsClient;
import software.amazon.awssdk.services.kinesis.KinesisAsyncClient;
import software.amazon.kinesis.common.ConfigsBuilder;
import software.amazon.kinesis.common.InitialPositionInStream;
import software.amazon.kinesis.common.InitialPositionInStreamExtended;
import software.amazon.kinesis.coordinator.CoordinatorConfig;
import software.amazon.kinesis.coordinator.Scheduler;
import software.amazon.kinesis.leases.LeaseManagementConfig;
import software.amazon.kinesis.processor.ProcessorConfig;
import software.amazon.kinesis.processor.StreamTracker;
import software.amazon.kinesis.retrieval.polling.PollingConfig;

public class KCLTestBase {

    protected KeyspacesStreamsClient streamsClient;
    protected KinesisAsyncClient adapterClient;
    protected DynamoDbAsyncClient dynamoDbAsyncClient;
    protected CloudWatchAsyncClient cloudWatchClient;
    protected Region region;
    protected RecordProcessorFactory recordProcessorFactory;
    protected Scheduler scheduler;
    protected Thread schedulerThread;

    public void baseSetUp() {
        recordProcessorFactory = new RecordProcessorFactory();
        setupKCLBase();
    }

    protected void setupKCLBase() {
        region = Region.US_EAST_1;

        streamsClient = KeyspacesStreamsClient.builder()
                .region(region)
                .build();
        adapterClient = new AmazonKeyspacesStreamsAdapterClient(
                streamsClient,
                region);
        dynamoDbAsyncClient = DynamoDbAsyncClient.builder()
                .region(region)
```

```
                .build();
        cloudWatchClient = CloudWatchAsyncClient.builder()
                .region(region)
                .build();
    }

    protected void startScheduler(Scheduler scheduler) {
        this.scheduler = scheduler;
        schedulerThread = new Thread(() -> scheduler.run());
        schedulerThread.start();
    }

    protected void shutdownScheduler() {
        if (scheduler != null) {
            scheduler.shutdown();
            try {
                schedulerThread.join(30000);
            } catch (InterruptedException e) {
                System.out.println("Error while shutting down scheduler " + e);
            }
        }
    }

    protected Scheduler createScheduler(String streamArn, String leaseTableName) {
        String workerId = "worker-" + System.currentTimeMillis();

        // Create ConfigsBuilder
        ConfigsBuilder configsBuilder = createConfigsBuilder(streamArn, workerId,
leaseTableName);

        // Configure retrieval config for polling
        PollingConfig pollingConfig = new PollingConfig(streamArn, adapterClient);

        // Create the Scheduler
        return StreamsSchedulerFactory.createScheduler(
                configsBuilder.checkpointConfig(),
                configsBuilder.coordinatorConfig(),
                configsBuilder.leaseManagementConfig(),
                configsBuilder.lifecycleConfig(),
                configsBuilder.metricsConfig(),
                configsBuilder.processorConfig(),

configsBuilder.retrievalConfig().retrievalSpecificConfig(pollingConfig),
                streamsClient,
```

```
                region
        );
    }

    private ConfigsBuilder createConfigsBuilder(String streamArn, String workerId,
String leaseTableName) {
        ConfigsBuilder configsBuilder = new ConfigsBuilder(
                streamArn,
                leaseTableName,
                adapterClient,
                dynamoDbAsyncClient,
                cloudWatchClient,
                workerId,
                recordProcessorFactory);

        configureCoordinator(configsBuilder.coordinatorConfig());
        configureLeaseManagement(configsBuilder.leaseManagementConfig());
        configureProcessor(configsBuilder.processorConfig());
        configureStreamTracker(configsBuilder, streamArn);

        return configsBuilder;
    }

    private void configureCoordinator(CoordinatorConfig config) {
        config.skipShardSyncAtWorkerInitializationIfLeasesExist(true)
                .parentShardPollIntervalMillis(1000)
                .shardConsumerDispatchPollIntervalMillis(500);
    }

    private void configureLeaseManagement(LeaseManagementConfig config) {
        config.shardSyncIntervalMillis(0)
                .leasesRecoveryAuditorInconsistencyConfidenceThreshold(0)
                .leasesRecoveryAuditorExecutionFrequencyMillis(5000)
                .leaseAssignmentIntervalMillis(1000L);
    }

    private void configureProcessor(ProcessorConfig config) {
        config.callProcessRecordsEvenForEmptyRecordList(true);
    }

    private void configureStreamTracker(ConfigsBuilder configsBuilder, String
streamArn) {
        StreamTracker streamTracker =
StreamsSchedulerFactory.createSingleStreamTracker(
```

```
                streamArn,

 InitialPositionInStreamExtended.newInitialPosition(InitialPositionInStream.TRIM_HORIZON)
        );
        configsBuilder.streamTracker(streamTracker);
    }

    public void deleteAllDdbTables(String baseTableName) {
        List<String> tablesToDelete = Arrays.asList(
                baseTableName,
                baseTableName + "-CoordinatorState",
                baseTableName + "-WorkerMetricStats"
        );

        for (String tableName : tablesToDelete) {
            deleteTable(tableName);
        }
    }

    private void deleteTable(String tableName) {
        DeleteTableRequest deleteTableRequest = DeleteTableRequest.builder()
                .tableName(tableName)
                .build();

        try {
            DeleteTableResponse response =
 dynamoDbAsyncClient.deleteTable(deleteTableRequest).get();
            System.out.println("Table deletion response " + response);
        } catch (InterruptedException | ExecutionException e) {
            System.out.println("Error deleting table: " + tableName + " " + e);
        }
    }
}
```

6. In this step you implement the record processor class for your application to start processing change events.

```
 import software.amazon.kinesis.coordinator.Scheduler;

public class KCLTest {

    private static final int APP_RUNTIME_SECONDS = 1800;
    private static final int SLEEP_INTERNAL_MS = 60*1000;
```

```
    public static void main(String[] args) {
        KCLTestBase kclTestBase;

        kclTestBase = new KCLTestBase();
        kclTestBase.baseSetUp();

        // Create and start scheduler
        String leaseTableName = generateUniqueApplicationName();

        // Update below to your Stream ARN
        String streamArn = "arn:aws:cassandra:us-east-1:759151643516:/keyspace/
cdc_sample_test/table/test_kcl_bool/stream/2025-07-01T15:52:57.529";
        Scheduler scheduler = kclTestBase.createScheduler(streamArn,
 leaseTableName);
        kclTestBase.startScheduler(scheduler);

        // Wait for specified time before shutting down - KCL applications are
 designed to run forever, however in this
        // example we will shut it down after APP_RUNTIME_SECONDS
        long startTime = System.currentTimeMillis();
        long endTime = startTime + (APP_RUNTIME_SECONDS * 1000);
        while (System.currentTimeMillis() < endTime) {
            try {
                // Print and sleep every minute
                Thread.sleep(SLEEP_INTERNAL_MS);
                System.out.println("Application is running");
            } catch (InterruptedException e) {
                System.out.println("Interrupted while waiting for records");
                Thread.currentThread().interrupt();
                break;
            }
        }

        // Stop the scheduler
        kclTestBase.shutdownScheduler();
        kclTestBase.deleteAllDdbTables(leaseTableName);
    }

    public static String generateUniqueApplicationName() {
        String timestamp = String.valueOf(System.currentTimeMillis());
        String randomString = java.util.UUID.randomUUID().toString().substring(0,
 8);
        return String.format("KCL-App-%s-%s", timestamp, randomString);
```

```
    }
}
```

Best practices

Follow these best practices when using KCL with Amazon Keyspaces CDC streams:

Error handling

Implement robust error handling in your record processor to handle exceptions gracefully. Consider implementing retry logic for transient failures.

Checkpointing frequency

Balance checkpointing frequency to minimize duplicate processing while ensuring reasonable progress tracking. Too frequent checkpointing can impact performance, while too infrequent checkpointing can lead to more reprocessing if a worker fails.

Worker scaling

Scale the number of workers based on the number of shards in your CDC stream. A good starting point is to have one worker per shard, but you may need to adjust based on your processing requirements.

Monitoring

Use CloudWatch metrics provided by KCL to monitor the health and performance of your consumer application. Key metrics include processing latency, checkpoint age, and lease counts.

Testing

Test your consumer application thoroughly, including scenarios like worker failures, stream resharding, and varying load conditions.

Using KCL with non-Java languages

While KCL is primarily a Java library, you can use it with other programming languages through the MultiLangDaemon. The MultiLangDaemon is a Java-based daemon that manages the interaction between your non-Java record processor and the KCL.

KCL provides support for the following languages:

- Python
- Ruby
- Node.js
- .NET

For more information about using KCL with non-Java languages, see the KCL MultiLangDaemon documentation.

Troubleshooting

This section provides solutions to common issues you might encounter when using KCL with Amazon Keyspaces CDC streams.

Slow processing

If your consumer application is processing records slowly, consider:

- Increasing the number of worker instances
- Optimizing your record processing logic
- Checking for bottlenecks in downstream systems

Duplicate processing

If you're seeing duplicate processing of records, check your checkpointing logic. Ensure you're checkpointing after successfully processing records.

Worker failures

If workers are failing frequently, check:

- Resource constraints (CPU, memory)
- Network connectivity issues
- Permissions issues

Lease table issues

If you're experiencing issues with the KCL lease table:

- Check that your application has appropriate permissions to access the Amazon Keyspaces table
- Verify that the table has sufficient provisioned throughput

Working with partitioners in Amazon Keyspaces

In Apache Cassandra, partitioners control which nodes data is stored on in the cluster. Partitioners create a numeric token using a hashed value of the partition key. Cassandra uses this token to distribute data across nodes. Clients can also use these tokens in `SELECT` operations and `WHERE` clauses to optimize read and write operations. For example, clients can efficiently perform parallel queries on large tables by specifying distinct token ranges to query in each parallel job.

Amazon Keyspaces provides three different partitioners.

Murmur3Partitioner (Default)

Apache Cassandra-compatible `Murmur3Partitioner`. The `Murmur3Partitioner` is the default Cassandra partitioner in Amazon Keyspaces and in Cassandra 1.2 and later versions.

RandomPartitioner

Apache Cassandra-compatible `RandomPartitioner`. The `RandomPartitioner` is the default Cassandra partitioner for versions earlier than Cassandra 1.2.

Keyspaces Default Partitioner

The `DefaultPartitioner` returns the same `token` function results as the `RandomPartitioner`.

The partitioner setting is applied per Region at the account level. For example, if you change the partitioner in US East (N. Virginia), the change is applied to all tables in the same account in this Region. You can safely change your partitioner at any time. Note that the configuration change takes approximately 10 minutes to complete. You do not need to reload your Amazon Keyspaces data when you change the partitioner setting. Clients will automatically use the new partitioner setting the next time they connect.

How to change the partitioner in Amazon Keyspaces

You can change the partitioner by using the AWS Management Console or Cassandra Query Language (CQL).

AWS Management Console

To change the partitioner using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Configuration**.
3. On the **Configuration** page, go to **Edit partitioner**.
4. Select the partitioner compatible with your version of Cassandra. The partitioner change takes approximately 10 minutes to apply.

> **Note**
>
> After the configuration change is complete, you have to disconnect and reconnect to Amazon Keyspaces for requests to use the new partitioner.

Cassandra Query Language (CQL)

1. To see which partitioner is configured for the account, you can use the following query.

```
SELECT partitioner from system.local;
```

If the partitioner hasn't been changed, the query has the following output.

```
partitioner
-----------------------------------------
com.amazonaws.cassandra.DefaultPartitioner
```

2. To update the partitioner to the `Murmur3` partitioner, you can use the following statement.

```
UPDATE system.local set
 partitioner='org.apache.cassandra.dht.Murmur3Partitioner' where key='local';
```

3. Note that this configuration change takes approximately 10 minutes to complete. To confirm that the partitioner has been set, you can run the `SELECT` query again. Note that due to eventual read consistency, the response might not reflect the results of the recently completed partitioner change yet. If you repeat the `SELECT` operation again after a short time, the response should return the latest data.

```
SELECT partitioner from system.local;
```

> **Note**
>
> You have to disconnect and reconnect to Amazon Keyspaces so that requests use the new partitioner.

Client-side timestamps in Amazon Keyspaces

In Amazon Keyspaces, client-side timestamps are Cassandra-compatible timestamps that are persisted for each cell in your table. You can use client-side timestamps for conflict resolution by letting your client applications determine the order of writes. For example, when clients of a globally distributed application make updates to the same data, client-side timestamps persist the order in which the updates were made on the clients. Amazon Keyspaces uses these timestamps to process the writes.

Amazon Keyspaces client-side timestamps are fully managed. You don't have to manage low-level system settings such as clean-up and compaction strategies.

When you delete data, the rows are marked for deletion with a tombstone. Amazon Keyspaces removes tombstoned data automatically (typically within 10 days) without impacting your application performance or availability. Tombstoned data isn't available for data manipulation language (DML) statements. As you continue to perform reads and writes on rows that contain tombstoned data, the tombstoned data continues to count towards storage, read capacity units (RCUs), and write capacity units (WCUs) until it's deleted from storage.

After client-side timestamps have been turned on for a table, you can specify a timestamp with the `USING TIMESTAMP` clause in your Data Manipulation Language (DML) CQL query. For more information, see the section called "Use client-side timestamps in queries". If you do not specify a timestamp in your CQL query, Amazon Keyspaces uses the timestamp passed by your client driver. If the client driver doesn't supply timestamps, Amazon Keyspaces assigns a cell-level timestamp automatically, because timestamps can't be `NULL`. To query for timestamps, you can use the `WRITETIME` function in your DML statement.

Amazon Keyspaces doesn't charge extra to turn on client-side timestamps. However, with client-side timestamps you store and write additional data for each value in your row. This can lead to

additional storage usage and in some cases additional throughput usage. For more information about Amazon Keyspaces pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

When client-side timestamps are turned on in Amazon Keyspaces, additional metadata is stored alongside your row data. The per-row overhead depends on your column types, whether the row uses TTL, and (for multi-Region tables) the number of replicating Regions. Overhead can range from a few bytes for rows of simple scalar columns to tens of bytes or more for rows with non-frozen collections or multi-Region counters. This metadata counts toward both your storage cost and your 1-MB row size quota.

To determine the overall impact on storage and throughput, consider the number of columns in your table, the data types used, and the number of collection elements in each row. For example, rows with many non-frozen collection columns containing large numbers of elements will have higher overhead than rows with only scalar columns. The additional metadata also affects the number of write capacity units (WCUs) consumed per write. For more information on how to estimate the overhead for your specific schema, see the section called “Estimate row size”. For more information on how to calculate read and write capacity, see the section called “Configure read/write capacity modes”.

After client-side timestamps have been turned on for a table, you can't turn it off.

To learn more about how to use client-side timestamps in queries, see the section called “Use client-side timestamps in queries”.

Topics

- How Amazon Keyspaces client-side timestamps integrate with AWS services
- Create a new table with client-side timestamps in Amazon Keyspaces
- Configure client-side timestamps for a table in Amazon Keyspaces
- Use client-side timestamps in queries in Amazon Keyspaces

How Amazon Keyspaces client-side timestamps integrate with AWS services

The following client-side timestamps metric is available in Amazon CloudWatch to enable continuous monitoring.

- `SystemReconciliationDeletes` – The number of delete operations required to remove tombstoned data.

For more information about how to monitor CloudWatch metrics, see the section called "Monitoring with CloudWatch".

When you use CloudFormation, you can enable client-side timestamps when creating a Amazon Keyspaces table. For more information, see the AWS CloudFormation User Guide.

Create a new table with client-side timestamps in Amazon Keyspaces

Follow these examples to create a new Amazon Keyspaces table with client-side timestamps enabled using the Amazon Keyspaces AWS Management Console, Cassandra Query Language (CQL), or the AWS Command Line Interface

Console

Create a new table with client-side timestamps (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
4. In the **Schema** section, create the schema for your table.
5. In the **Table settings** section, choose **Customize settings**.
6. Continue to **Client-side timestamps**.

   Choose **Turn on client-side timestamps** to turn on client-side timestamps for the table.
7. Choose **Create table**. Your table is created with client-side timestamps turned on.

Cassandra Query Language (CQL)

Create a new table using CQL

1. To create a new table with client-side timestamps enabled using CQL, you can use the following example.

```
CREATE TABLE my_keyspace.my_table (
   userid uuid,
   time timeuuid,
   subject text,
```

```
   body text,
   user inet,
   PRIMARY KEY (userid, time)
) WITH CUSTOM_PROPERTIES = {'client_side_timestamps': {'status': 'enabled'}};
```

2. To confirm the client-side timestamps settings for the new table, use a SELECT statement to review the `custom_properties` as shown in the following example.

```
SELECT custom_properties from system_schema_mcs.tables where keyspace_name =
 'my_keyspace' and table_name = 'my_table';
```

The output of this statement shows the status for client-side timestamps.

```
'client_side_timestamps': {'status': 'enabled'}
```

AWS CLI

Create a new table using the AWS CLI

1. To create a new table with client-side timestamps enabled, you can use the following example.

```
./aws keyspaces create-table \
--keyspace-name my_keyspace \
--table-name my_table \
--client-side-timestamps 'status=ENABLED' \
--schema-definition 'allColumns=[{name=id,type=int},{name=date,type=timestamp},
{name=name,type=text}],partitionKeys=[{name=id}]'
```

2. To confirm that client-side timestamps are turned on for the new table, run the following code.

```
./aws keyspaces get-table \
--keyspace-name my_keyspace \
--table-name my_table
```

The output should look similar to this example.

```
{
    "keyspaceName": "my_keyspace",
```

```
    "tableName": "my_table",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/table/my_table",
    "creationTimestamp": 1662681206.032,
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "id",
                "type": "int"
            },
            {
                "name": "date",
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": 1662681206.032
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "clientSideTimestamps": {
        "status": "ENABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
```

```
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    }
}
```

Configure client-side timestamps for a table in Amazon Keyspaces

Follow these examples to turn on client-side timestamps for existing tables using the Amazon Keyspaces AWS Management Console, Cassandra Query Language (CQL), or the AWS Command Line Interface.

Console

To turn on client-side timestamps for an existing table (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose the table that you want to update, and then choose **Additional settings** tab.
3. On the **Additional settings** tab, go to **Modify client-side timestamps** and select **Turn on client-side timestamps**
4. Choose **Save changes** to change the settings of the table.

Cassandra Query Language (CQL)

Using a CQL statement

1. Turn on client-side timestamps for an existing table with the `ALTER TABLE` CQL statement.

```
ALTER TABLE my_table WITH custom_properties = {'client_side_timestamps':
 {'status': 'enabled'}};;
```

2. To confirm the client-side timestamps settings for the new table, use a `SELECT` statement to review the `custom_properties` as shown in the following example.

```
SELECT custom_properties from system_schema_mcs.tables where keyspace_name =
 'my_keyspace' and table_name = 'my_table';
```

The output of this statement shows the status for client-side timestamps.

```
'client_side_timestamps': {'status': 'enabled'}
```

AWS CLI

Using the AWS CLI

1. You can turn on client-side timestamps for an existing table using the AWS CLI using the following example.

```
./aws keyspaces update-table \
--keyspace-name my_keyspace \
--table-name my_table \
--client-side-timestamps 'status=ENABLED'
```

2. To confirm that client-side timestamps are turned on for the table, run the following code.

```
./aws keyspaces get-table \
--keyspace-name my_keyspace \
--table-name my_table
```

The output should look similar to this example and state the status for client-side timestamps as ENABLED.

```
{
    "keyspaceName": "my_keyspace",
    "tableName": "my_table",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/table/my_table",
    "creationTimestamp": 1662681312.906,
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "id",
                "type": "int"
            },
            {
                "name": "date",
```

```
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": 1662681312.906
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "clientSideTimestamps": {
        "status": "ENABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    }
}
```

Use client-side timestamps in queries in Amazon Keyspaces

After you have turned on client-side timestamps, you can pass the timestamp in your `INSERT`, `UPDATE`, and `DELETE` statements with the `USING TIMESTAMP` clause.

The timestamp value is a `bigint` representing a number of microseconds since the standard base time known as the epoch: January 1 1970 at 00:00:00 GMT. A timestamp that is supplied by the client has to fall between the range of 2 days in the past and 5 minutes in the future from the current wall clock time.

Amazon Keyspaces keeps timestamp metadata for the life of the data. You can use the `WRITETIME` function to look up timestamps that occurred years in the past. For more information about CQL syntax, see the section called “DML statements”.

The following CQL statement is an example of how to use a timestamp as an `update_parameter`.

```
INSERT INTO catalog.book_awards (year, award, rank, category, book_title, author,
 publisher)
   VALUES (2022, 'Wolf', 4, 'Non-Fiction', 'Science Update', 'Ana Carolina Silva',
 'SomePublisher')
   USING TIMESTAMP 1669069624;
```

If you do not specify a timestamp in your CQL query, Amazon Keyspaces uses the timestamp passed by your client driver. If no timestamp is supplied by the client driver, Amazon Keyspaces assigns a server-side timestamp for your write operation.

To see the timestamp value that is stored for a specific column, you can use the `WRITETIME` function in a `SELECT` statement as shown in the following example.

```
SELECT year, award, rank, category, book_title, author, publisher, WRITETIME(year),
 WRITETIME(award), WRITETIME(rank),
  WRITETIME(category), WRITETIME(book_title), WRITETIME(author), WRITETIME(publisher)
 from catalog.book_awards;
```

Multi-Region replication for Amazon Keyspaces (for Apache Cassandra)

You can use Amazon Keyspaces multi-Region replication to replicate your data with automated, fully managed, *active-active* replication across the AWS Regions of your choice. With active-active replication, each Region is able to perform reads and writes in isolation. You can improve both availability and resiliency from Regional degradation, while also benefiting from low-latency local reads and writes for global applications.

With multi-Region replication, Amazon Keyspaces asynchronously replicates data between Regions, and data is typically propagated across Regions within a second. Also, with multi-Region replication, you no longer have the difficult work of resolving conflicts and correcting data divergence issues, so you can focus on your application.

By default, Amazon Keyspaces replicates data across three Availability Zones within the same AWS Region for durability and high availability. With multi-Region replication, you can create multi-Region keyspaces that replicate your tables in different geographic AWS Regions of your choice.

Topics

- Benefits of using multi-Region replication
- Capacity modes and pricing
- How multi-Region replication works in Amazon Keyspaces
- Amazon Keyspaces multi-Region replication usage notes
- Configure multi-Region replication for Amazon Keyspaces (for Apache Cassandra)

Benefits of using multi-Region replication

Multi-Region replication provides the following benefits.

- **Global reads and writes with single-digit millisecond latency** – In Amazon Keyspaces, replication is active-active. You can serve both reads and writes locally from the Regions closest to your customers with single-digit millisecond latency at any scale. You can use Amazon Keyspaces multi-Region tables for global applications that need a fast response time anywhere in the world.
- **Improved business continuity and protection from single-Region degradation** – With multi-Region replication, you can recover from degradation in a single AWS Region by redirecting your application to a different Region in your multi-Region keyspace. Because Amazon Keyspaces offers active-active replication, there is no impact to your reads and writes.

  Amazon Keyspaces keeps track of any writes that have been performed on your multi-Region keyspace but haven't been propagated to all replica Regions. After the Region comes back online, Amazon Keyspaces automatically syncs any missing changes so that you can recover without any application impact.

- **High-speed replication across Regions** – Multi-Region replication uses fast, storage-based physical replication of data across Regions, with a replication lag that is typically less than 1 second.

  Replication in Amazon Keyspaces has little to no impact on your database queries because it doesn't share compute resources with your application. This means that you can address high-write throughput use cases or use cases with sudden spikes or bursts in throughput without any application impact.

- **Consistency and conflict resolution** – Any changes made to data in any Region are replicated to the other Regions in a multi-Region keyspace. If applications update the same data in different Regions at the same time, conflicts can arise.

  To help provide eventual consistency, Amazon Keyspaces uses cell-level timestamps and a *last writer wins* reconciliation between concurrent updates. Conflict resolution is fully managed and happens in the background without any application impact.

For more information about supported configurations and features, see the section called "Usage notes".

Capacity modes and pricing

For a multi-Region keyspace, you can either use *on-demand capacity mode* or *provisioned capacity mode*. For more information, see the section called "Configure read/write capacity modes".

For on-demand mode, you're billed 1 write request unit (WRU) to write up to 1 KB of data per row the same way as for single-Region tables. But you're billed for writes in each Region of your multi-Region keyspace. For example, writing a row of 3 KB of data in a multi-Region keyspace with two Regions requires 6 WRUs: 3 * 2 = 6 WRUs. Additionally, writes that include both static and non-static data require additional write operations.

For provisioned mode, you're billed 1 write capacity unit (WCU) to write up to 1 KB of data per row, the same way as for single-Region tables. But you're billed for writes in each Region of your multi-Region keyspace. For example, writing a row of 3 KB of data per second in a multi-Region keyspace with two Regions requires 6 WCUs: 3 * 2 = 6 WCUs. Additionally, writes that include both static and non-static data require additional write operations.

For more information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

How multi-Region replication works in Amazon Keyspaces

This section provides an overview of how Amazon Keyspaces multi-Region replication works. For more information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

Topics

- How multi-Region replication works in Amazon Keyspaces
- Multi-Region replication conflict resolution
- Multi-Region replication disaster recovery
- Multi-Region replication in AWS Regions disabled by default
- Multi-Region replication and integration with point-in-time recovery (PITR)
- Multi-Region replication and integration with AWS services

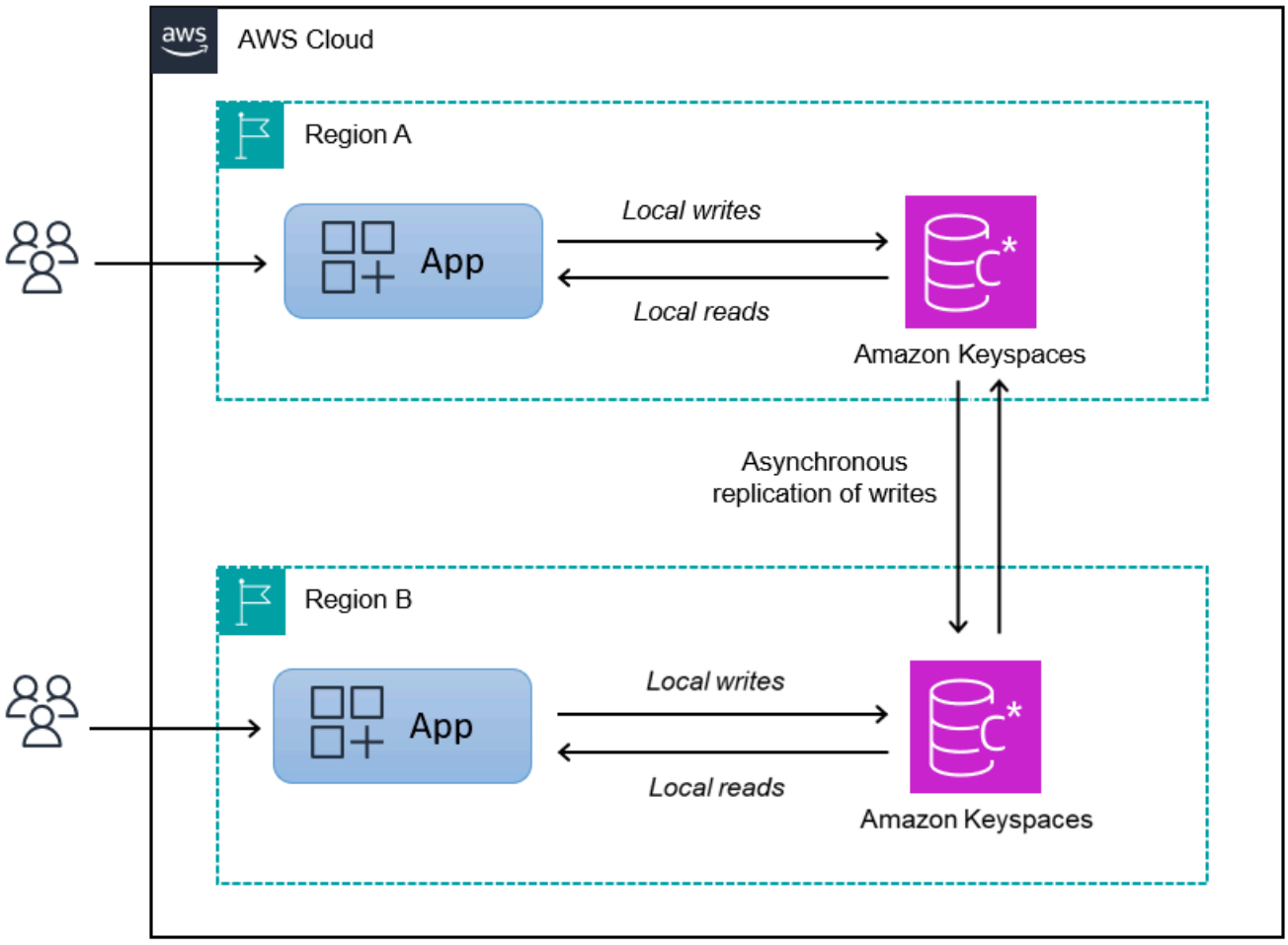
How multi-Region replication works in Amazon Keyspaces

Amazon Keyspaces multi-Region replication implements a data resiliency architecture that distributes your data across independent and geographically distributed AWS Regions. It uses *active-active replication*, which provides local low latency with each Region being able to perform reads and writes in isolation.

When you create an Amazon Keyspaces multi-Region keyspace, you can select additional Regions where the data is going to be replicated to. Each table you create in a multi-Region keyspace consists of multiple replica tables (one per Region) that Amazon Keyspaces considers as a single unit.

Every replica has the same table name and the same primary key schema. When an application writes data to a local table in one Region, the data is durably written using the `LOCAL_QUORUM` consistency level. Amazon Keyspaces automatically replicates the data asynchronously to the other replication Regions. The replication lag across Regions is typically less than one second and doesn't impact your application's performance or throughput.

After the data is written, you can read it from the multi-Region table in another replication Region with the `LOCAL_ONE/LOCAL_QUORUM` consistency levels. For more information about supported configurations and features, see the section called "Usage notes".



Multi-Region replication conflict resolution

Amazon Keyspaces multi-Region replication is fully managed, which means that you don't have to perform replication tasks such as regularly running repair operations to clean-up data synchronization issues. Amazon Keyspaces monitors data consistency between tables in different AWS Regions by detecting and repairing conflicts, and synchronizes replicas automatically.

Amazon Keyspaces uses the *last writer wins* method of data reconciliation. With this conflict resolution mechanism, all of the Regions in a multi-Region keyspace agree on the latest update and converge toward a state in which they all have identical data. The reconciliation process has no impact on application performance. To support conflict resolution, client-side timestamps are automatically turned on for multi-Region tables and can't be turned off. For more information, see the section called “Client-side timestamps”.

Multi-Region replication disaster recovery

With Amazon Keyspaces multi-Region replication, writes are replicated asynchronously across each Region. In the rare event of a single Region degradation or failure, multi-Region replication helps you to recover from disaster with little to no impact to your application. Recovery from disaster is typically measured using values for Recovery time objective (RTO) and Recovery point objective (RPO).

Recovery time objective – The time it takes a system to return to a working state after a disaster. RTO measures the amount of downtime your workload can tolerate, measured in time. For disaster recovery plans that use multi-Region replication to fail over to an unaffected Region, the RTO can be nearly zero. The RTO is limited by how quickly your application can detect the failure condition and redirect traffic to another Region.

Recovery point objective – The amount of data that can be lost (measured in time). For disaster recovery plans that use multi-Region replication to fail over to an unaffected Region, the RPO is typically single-digit seconds. The RPO is limited by replication latency to the failover target replica.

In the event of a Regional failure or degradation, you don't need to promote a secondary Region or perform database failover procedures because replication in Amazon Keyspaces is active-active. Instead, you can use Amazon Route 53 to route your application to the nearest healthy Region. To learn more about Route 53, see What is Amazon Route 53?.

If a single AWS Region becomes isolated or degraded, your application can redirect traffic to a different Region using Route 53 to perform reads and writes against a different replica table. You can also apply custom business logic to determine when to redirect requests to other Regions. An example of this is making your application aware of the multiple endpoints that are available.

When the Region comes back online, Amazon Keyspaces resumes propagating any pending writes from that Region to the replica tables in other Regions. It also resumes propagating writes from other replica tables to the Region that is now back online.

Multi-Region replication in AWS Regions disabled by default

Amazon Keyspaces multi-Region replication is supported in the following AWS Regions that are disabled by default:

- Africa (Cape Town) Region
- Middle East (UAE) Region

- Asia Pacific (Hong Kong) Region
- Middle East (Bahrain) Region

Before you can use a Region that's disabled by default with Amazon Keyspaces multi-Region replication, you first have to enable the Region. For more information, see Enable or disable AWS Regions in your account in the *AWS Organizations User Guide*.

After you've enabled a Region, you can create new Amazon Keyspaces resources in the Region and add the Region to a multi-Region keyspace.

When you disable a Region that is used by Amazon Keyspaces multi-Region replication, Amazon Keyspaces initiates a 24-hour grace period. During this time window, you can expect the following behavior:

- Amazon Keyspaces continues to perform data manipulation language (DML) operations in enabled Regions.
- Amazon Keyspaces pauses replicating data updates from enabled Regions to the disabled Region.
- Amazon Keyspaces blocks all data definition language (DDL) requests in the disabled Region.

If you disabled the Region in error, you can re-enable the Region within 24 hours. If you re-enable the Region during the 24-hour grace period, Amazon Keyspaces is going to take the following actions:

- Automatically resume all replications to the re-enabled Region.
- Replicate any data updates that took place in enabled Regions while the Region was disabled to ensure data consistency.
- Continue all additional multi-Region replication operations automatically.

In the case that the Region remains disabled after the 24-hour window closes, Amazon Keyspaces takes the following actions to permanently remove the Region from multi-Region replication:

- Remove the disabled Region from all multi-Region replication keyspaces.
- Convert multi-Region replication table replicas in the disabled Region into single-Region keyspaces and tables.
- Amazon Keyspaces doesn't delete any resources from the disabled Region.

After Amazon Keyspaces has permanently removed the disabled Region from the multi-Region keyspace, you can't add the disabled Region back.

Multi-Region replication and integration with point-in-time recovery (PITR)

Point-in-time recovery is supported for multi-Region tables. To successfully restore a multi-Region table with PITR, the following conditions have to be met.

- The source and the target table must be configured as multi-Region tables.
- The replication Regions for the keyspace of the source table and for the keyspace of the target table must be the same.
- PITR has to be enabled on all replicas of the source table.

You can run the restore statement from any of the Regions that the source table is available in. Amazon Keyspaces automatically restores the target table in each Region. For more information about PITR, see the section called “How it works”.

When you create a multi-Region table, the PITR settings that you define during the creation process are automatically applied to all tables in all Regions. When you change PITR settings using `ALTER TABLE`, Amazon Keyspaces applies the update only to the local table and not to the replicas in other Regions. To enable PITR for an existing multi-Region table, you have to repeat the `ALTER TABLE` statement for all replicas.

Multi-Region replication and integration with AWS services

You can monitor replication performance between tables in different AWS Regions by using Amazon CloudWatch metrics. The following metric provides continuous monitoring of multi-Region keyspaces.

- `ReplicationLatency` – This metric measures the time it took to replicate `updates`, `inserts`, or `deletes` from one replica table to another replica table in a multi-Region keyspace.

For more information about how to monitor CloudWatch metrics, see the section called “Monitoring with CloudWatch”.

Amazon Keyspaces multi-Region replication usage notes

Consider the following when you're using multi-Region replication with Amazon Keyspaces.

- You can select any of the available public AWS Regions. For more information about AWS Regions that are disabled by default, see the section called “Regions disabled by default”.
- AWS GovCloud (US) Regions and China Regions are not supported.
- Consider the following workarounds until the features become available:

  Configure Time to Live (TTL) when creating the multi-Region table. You won't be able to enable and disable TTL, or adjust the TTL value later. For more information, see the section called “Expire data with Time to Live”.

  - For encryption at rest, use an AWS owned key. Customer managed keys are currently not supported for multi-Region tables. For more information, see

    the section called “How it works”.
- You can use `ALTER KEYSPACE` to add a Region to a single-Region or a multi-Region keyspace. For more information, see the section called “Add a Region to a keyspace”.
  - Before adding a Region to a single-Region keyspace, ensure that no tables under the keyspace are configured with customer managed keys.
  - Any existing tags configured for keyspaces or tables are not replicated to the new Region.
- When you're using provisioned capacity management with Amazon Keyspaces auto scaling, make sure to use the Amazon Keyspaces API operations to create and configure your multi-Region tables. The underlying Application Auto Scaling API operations that Amazon Keyspaces calls on your behalf don't have multi-Region capabilities.

  For more information, see the section called “Update provisioned capacity and auto scaling settings for a multi-Region table”. For more information on how to estimate the write capacity throughput of provisioned multi-Region tables, see the section called “Estimate capacity for a multi-Region table”.
- Although data is automatically replicated across the selected Regions of a multi-Region table, when a client connects to an endpoint in one Region and queries the `system.peers` table, the query returns only local information. The query result appears like a single data center cluster to the client.
- Amazon Keyspaces multi-Region replication is asynchronous, and it supports `LOCAL_QUORUM` consistency for writes. `LOCAL_QUORUM` consistency requires that an update to a row is durably persisted on two replicas in the local Region before returning success to the client. The propagation of writes to the replicated Region (or Regions) is then performed asynchronously.

Amazon Keyspaces multi-Region replication doesn't support synchronous replication or `QUORUM` consistency.

- When you create a multi-Region keyspace or table, any tags that you define during the creation process are automatically applied to all keyspaces and tables in all Regions. When you change the existing tags using `ALTER KEYSPACE` or `ALTER TABLE`, the update is only applied to the keyspace or table in the Region where you're making the change.
- Amazon CloudWatch provides a `ReplicationLatency` metric for each replicated Region. It calculates this metric by tracking arriving rows, comparing their arrival time with their initial write time, and computing an average. Timings are stored within CloudWatch in the source Region. For more information, see the section called “Monitoring with CloudWatch”.

  It can be useful to view the average and maximum timings to determine the average and worst-case replication lag. There is no SLA on this latency.
- When using a multi-Region table in on-demand mode, you may observe an increase in latency for asynchronous replication of writes if a table replica experiences a new traffic peak. Similar to how Amazon Keyspaces automatically adapts the capacity of a single-Region on-demand table to the application traffic it receives, Amazon Keyspaces automatically adapts the capacity of a multi-Region on-demand table replica to the traffic that it receives. The increase in replication latency is transient because Amazon Keyspaces automatically allocates more capacity as your traffic volume increases. Once all replicas have adapted to your traffic volume, replication latency should return back to normal. For more information, see the section called “Peak traffic and scaling properties”.
- When using a multi-Region table in provisioned mode, if your application exceeds your provisioned throughput capacity, you may observe insufficient capacity errors and an increase in replication latency. To ensure that there's always enough read and write capacity for all table replicas in all AWS Regions of a multi-Region table, we recommend that you configure Amazon Keyspaces auto scaling. Amazon Keyspaces auto scaling helps you provision throughput capacity efficiently for variable workloads by adjusting throughput capacity automatically in response to actual application traffic. For more information, see the section called “How auto scaling works for multi-Region tables”.

Configure multi-Region replication for Amazon Keyspaces (for Apache Cassandra)

You can use the console, Cassandra Query Language (CQL), or the AWS Command Line Interface to create and manage multi-Region keyspaces and tables in Amazon Keyspaces.

This section provides examples of how to create and manage multi-Region keyspaces and tables. All tables that you create in a multi-Region keyspace automatically inherit the multi-Region settings from the keyspace.

For more information about supported configurations and features, see the section called "Usage notes".

Topics

- Configure the IAM permissions required to create multi-Region keyspaces and tables
- Configure the IAM permissions required to add an AWS Region to a keyspace
- Create a multi-Region keyspace in Amazon Keyspaces
- Add an AWS Region to a keyspace in Amazon Keyspaces
- Check the replication progress when adding a new Region to a keyspace
- Create a multi-Region table with default settings in Amazon Keyspaces
- Create a multi-Region table in provisioned mode with auto scaling in Amazon Keyspaces
- Update the provisioned capacity and auto scaling settings for a multi-Region table in Amazon Keyspaces
- View the provisioned capacity and auto scaling settings for a multi-Region table in Amazon Keyspaces
- Turn off auto scaling for a table in Amazon Keyspaces
- Set the provisioned capacity of a multi-Region table manually in Amazon Keyspaces

Configure the IAM permissions required to create multi-Region keyspaces and tables

To successfully create multi-Region keyspaces and tables, the IAM principal needs to be able to create a service-linked role. This service-linked role is a unique type of IAM role that is predefined by Amazon Keyspaces. It includes all the permissions that Amazon Keyspaces requires to perform

actions on your behalf. For more information about the service-linked role, see the section called "Multi-Region Replication".

To create the service-linked role required by multi-Region replication, the policy for the IAM principal requires the following elements:

- `iam:CreateServiceLinkedRole` – The **action** the principal can perform.
- `arn:aws:iam::*:role/aws-service-role/replication.cassandra.amazonaws.com/AWSServiceRoleForKeyspacesReplication` – The **resource** that the action can be performed on.
- `iam:AWSServiceName": "replication.cassandra.amazonaws.com` – The only AWS service that this role can be attached to is Amazon Keyspaces.

The following is an example of the policy that grants the minimum required permissions to a principal to create multi-Region keyspaces and tables.

```
{
            "Effect": "Allow",
            "Action": "iam:CreateServiceLinkedRole",
            "Resource": "arn:aws:iam::*:role/aws-service-role/
replication.cassandra.amazonaws.com/AWSServiceRoleForKeyspacesReplication",
            "Condition": {"StringLike": {"iam:AWSServiceName":
 "replication.cassandra.amazonaws.com"}}
}
```

For additional IAM permissions for multi-Region keyspaces and tables, see the Actions, resources, and condition keys for Amazon Keyspaces (for Apache Cassandra) in the *Service Authorization Reference*.

Configure the IAM permissions required to add an AWS Region to a keyspace

To add a Region to a keyspace, the IAM principal needs the following permissions:

- `cassandra:Alter`
- `cassandra:AlterMultiRegionResource`
- `cassandra:Create`
- `cassandra:CreateMultiRegionResource`
- `cassandra:Select`

- `cassandra:SelectMultiRegionResource`
- `cassandra:Modify`
- `cassandra:ModifyMultiRegionResource`

If the table is configured in provisioned mode with auto scaling enabled, the following additional permissions are needed.

- `application-autoscaling:RegisterScalableTarget`
- `application-autoscaling:DeregisterScalableTarget`
- `application-autoscaling:DescribeScalableTargets`
- `application-autoscaling:PutScalingPolicy`
- `application-autoscaling:DescribeScalingPolicies`

To successfully add a Region to a single-Region keyspace, the IAM principal also needs to be able to create a service-linked role. This service-linked role is a unique type of IAM role that is predefined by Amazon Keyspaces. It includes all the permissions that Amazon Keyspaces requires to perform actions on your behalf. For more information about the service-linked role, see the section called "Multi-Region Replication".

To create the service-linked role required by multi-Region replication, the policy for the IAM principal requires the following elements:

- `iam:CreateServiceLinkedRole` – The **action** the principal can perform.
- `arn:aws:iam::*:role/aws-service-role/replication.cassandra.amazonaws.com/AWSServiceRoleForKeyspacesReplication` – The **resource** that the action can be performed on.
- `iam:AWSServiceName": "replication.cassandra.amazonaws.com` – The only AWS service that this role can be attached to is Amazon Keyspaces.

The following is an example of the policy that grants the minimum required permissions to a principal to add a Region to a keyspace.

```
{
            "Effect": "Allow",
            "Action": "iam:CreateServiceLinkedRole",
```

```
            "Resource": "arn:aws:iam::*:role/aws-service-role/
replication.cassandra.amazonaws.com/AWSServiceRoleForKeyspacesReplication",
            "Condition": {"StringLike": {"iam:AWSServiceName":
 "replication.cassandra.amazonaws.com"}}
}
```

Create a multi-Region keyspace in Amazon Keyspaces

This section provides examples of how to create a multi-Region keyspace. You can do this on the Amazon Keyspaces console, using CQL or the AWS CLI. All tables that you create in a multi-Region keyspace automatically inherit the multi-Region settings from the keyspace.

> **Note**
>
> When creating a multi-Region keyspace, Amazon Keyspaces creates a service-linked role with the name `AWSServiceRoleForAmazonKeyspacesReplication` in your account. This role allows Amazon Keyspaces to replicate writes to all replicas of a multi-Region table on your behalf. To learn more, see the section called “Multi-Region Replication”.

Console

Create a multi-Region keyspace (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**, and then choose **Create keyspace**.
3. For **Keyspace name**, enter the name for the keyspace.
4. In the **Multi-Region replication** section, you can add the additional Regions that are available in the list.
5. To finish, choose **Create keyspace**.

Cassandra Query Language (CQL)

Create a multi-Region keyspace using CQL

1. To create a multi-Region keyspace, use `NetworkTopologyStrategy` to specify the AWS Regions that the keyspace is going to be replicated in. You must include your current Region and at least one additional Region.

   All tables in the keyspace inherit the replication strategy from the keyspace. You can't change the replication strategy at the table level.

   `NetworkTopologyStrategy` – The replication factor for each Region is three because Amazon Keyspaces replicates data across three Availability Zones within the same AWS Region, by default.

   The following CQL statement is an example of this.

   ```
   CREATE KEYSPACE mykeyspace
   WITH REPLICATION = {'class':'NetworkTopologyStrategy', 'us-east-1':'3', 'ap-
   southeast-1':'3','eu-west-1':'3' };
   ```

2. You can use a CQL statement to query the `tables` table in the `system_multiregion_info` keyspace to programmatically list the Regions and the status of the multi-Region table that you specify. The following code is an example of this.

   ```
   SELECT * from system_multiregion_info.tables WHERE keyspace_name = 'mykeyspace'
    AND table_name = 'mytable';
   ```

   The output of the statement looks like the following:

   ```
    keyspace_name  | table_name     | region         | status
   ----------------+----------------+----------------+--------
    mykeyspace     | mytable        | us-east-1      | ACTIVE
    mykeyspace     | mytable        | ap-southeast-1 | ACTIVE
    mykeyspace     | mytable        | eu-west-1      | ACTIVE
   ```

CLI

Create a new multi-Region keyspace using the AWS CLI

- To create a multi-Region keyspace, you can use the following CLI statement. Specify your current Region and at least one additional Region in the `regionList`.

```
aws keyspaces create-keyspace --keyspace-name mykeyspace \
--replication-specification replicationStrategy=MULTI_REGION,regionList=us-
east-1,eu-west-1
```

To create a multi-Region table, see the section called “Create a multi-Region table with default settings” and the section called “Create a multi-Region table in provisioned mode”.

Add an AWS Region to a keyspace in Amazon Keyspaces

You can add a new AWS Region to a keyspace that is either a single or a multi-Region keyspace. The new replica Region is applied to all tables in the keyspace.

To change a single-Region to a multi-Region keyspace, you have to enable client-side timestamps for all tables in the keyspace. For more information, see the section called “Client-side timestamps”.

If you're adding an additional Region to a multi-Region keyspace, Amazon Keyspaces has to replicate the existing table(s) into the new Region using a one-time cross-Region restore for each existing table. The restore charges for each table are billed per GB, for more information see Backup and restore on the Amazon Keyspaces (for Apache Cassandra) pricing page. There's no charge for data transfer across Regions for this restore operation. In addition to data, all table properties with the exception of tags are going to be replicated to the new Region.

You can use the `ALTER KEYSPACE` statement in CQL, the `update-keyspace` command with the AWS CLI, or the console to add a new Region to a single or to a multi-Region keyspace in Amazon Keyspaces. In order to run the statement successfully, the account you're using has to be located in one of the Regions where the keyspace is already available. While the replica is being added, you can't perform any other data definition language (DDL) operations on the resources that are being updated and replicated.

For more information about the permissions required to add a Region, see the section called “Configure IAM permissions for add Region”.

> **Note**
>
> When adding an additional Region to a single-Region keyspace, Amazon Keyspaces creates a service-linked role with the name `AWSServiceRoleForAmazonKeyspacesReplication` in your account. This role allows Amazon Keyspaces to replicate tables to new Regions and to replicate writes from one table to all replicas of a multi-Region table on your behalf. To learn more, see the section called “Multi-Region Replication”.

Console

Follow these steps to add a Region to a keyspace using the Amazon Keyspaces console.

Add a Region to a keyspace (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**, and then choose a keyspace from the list.
3. Choose the **AWS Regions** tab.
4. On the **AWS Regions** tab, choose **Add Region**.
5. In the **Add Region** dialog, choose the additional Region that you want to add to the keyspace.
6. To finish, choose **Add**.

Cassandra Query Language (CQL)

Add a Region to a keyspace using CQL

- To add a new Region to a keyspace, you can use the following statement. In this example, the keyspace is already available in the US East (N. Virginia) Region and US West (Oregon) Region Regions, and the CQL statement is adding the Region US West (N. California) Region.

```
ALTER KEYSPACE my_keyspace
WITH REPLICATION = {
    'class': 'NetworkTopologyStrategy',
```

```
    'us-east-1': '3',
    'us-west-2': '3',
    'us-west-1': '3'
} AND CLIENT_SIDE_TIMESTAMPS = {'status': 'ENABLED'};
```

CLI

Add a Region to a keyspace using the AWS CLI

- To add a new Region to a keyspace using the CLI, you can use the following example. Note that the default value for `client-side-timestamps` is `DISABLED`. With the `update-keyspace` command, you must change the value to `ENABLED`.

```
aws keyspaces update-keyspace \
--keyspace-name my_keyspace \
--replication-specification '{"replicationStrategy": "MULTI_REGION",
 "regionList": ["us-east-1", "eu-west-1", "eu-west-3"] }' \
--client-side-timestamps '{"status": "ENABLED"}'
```

Check the replication progress when adding a new Region to a keyspace

Adding a new Region to an Amazon Keyspaces keyspace is a long running operation. To track progress you can use the queries shown in this section.

Cassandra Query Language (CQL)

Using CQL to verify the add Region progress

- To verify the progress of the creation of the new table replicas in a given keyspace, you can query the `system_multiregion_info.keyspaces` table. The following CQL statement is an example of this.

```
SELECT keyspace_name, region, status, tables_replication_progress
FROM system_multiregion_info.keyspaces
WHERE keyspace_name = 'my_keyspace';
```

  While a replication operation is in progress, the status shows the progress of table creation in the new Region. This is an example where 5 out of 10 tables have been replicated to the new Region.

```
 keyspace_name | region    | status    | tables_replication_progress
---------------+-----------+-----------+-------------------------
   my_keyspace | us-east-1 | Updating  |
   my_keyspace | us-west-2 | Updating  |
   my_keyspace | eu-west-1 | Creating  | 50%
```

After the replication process has completed successfully, the output should look like this example.

```
 keyspace_name | region    | status
---------------+-----------+-----------
   my_keyspace | us-east-1 | Active
   my_keyspace | us-west-2 | Active
   my_keyspace | eu-west-1 | Active
```

CLI

Using the AWS CLI to verify the add Region progress

- To confirm the status of table replica creation for a given keyspace, you can use the following example.

```
aws keyspaces get-keyspace \
--keyspace-name my_keyspace
```

The output should look similar to this example.

```
{
    "keyspaceName": "my_keyspace",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
my_keyspace/",
    "replicationStrategy": "MULTI_REGION",
    "replicationRegions": [
        "us-east-1",
        "eu-west-1"
    ]
    "replicationGroupStatus": [
        {
            "RegionName": "us-east-1",
```

```
            "KeyspaceStatus": "Active"
        },
        {
            "RegionName": "eu-west-1",
            "KeyspaceStatus": "Creating",
            "TablesReplicationProgress": "50.0%"
        }
    ]
}
```

Create a multi-Region table with default settings in Amazon Keyspaces

This section provides examples of how to create a multi-Region table in on-demand mode with all default settings. You can do this on the Amazon Keyspaces console, using CQL or the AWS CLI. All tables that you create in a multi-Region keyspace automatically inherit the multi-Region settings from the keyspace.

To create a multi-Region keyspace, see the section called “Create a multi-Region keyspace”.

Console

Create a multi-Region table with default settings (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose a multi-Region keyspace.
3. On the **Tables** tab, choose **Create table**.
4. For **Table name**, enter the name for the table. The AWS Regions that this table is being replicated in are shown in the info box.
5. Continue with the table schema.
6. Under **Table settings**, continue with the **Default settings** option. Note the following default settings for multi-Region tables.

   - **Capacity mode** – The default capacity mode is **On-demand**. For more information about configuring **provisioned** mode, see the section called “Create a multi-Region table in provisioned mode”.
   - **Encryption key management** – Only the **AWS owned key** option is supported.
   - **Client-side timestamps** – This feature is required for multi-Region tables.

- Choose **Customize settings** if you need to turn on Time to Live (TTL) for the table and all its replicas.

> **Note**
>
> You won't be able to change TTL settings on an existing multi-Region table.

7. To finish, choose **Create table**.

Cassandra Query Language (CQL)

Create a multi-Region table in on-demand mode with default settings

- To create a multi-Region table with default settings, you can use the following CQL statement.

```
CREATE TABLE mykeyspace.mytable(pk int, ck int, PRIMARY KEY (pk, ck))
    WITH CUSTOM_PROPERTIES = {
 'capacity_mode':{
  'throughput_mode':'PAY_PER_REQUEST'
 },
 'point_in_time_recovery':{
  'status':'enabled'
 },
 'encryption_specification':{
  'encryption_type':'AWS_OWNED_KMS_KEY'
 },
 'client_side_timestamps':{
  'status':'enabled'
 }
};
```

CLI

Using the AWS CLI

1. To create a multi-Region table with default settings, you only need to specify the schema. You can use the following example.

```
aws keyspaces create-table --keyspace-name mykeyspace --table-name mytable \
--schema-definition 'allColumns=[{name=pk,type=int}],partitionKeys={name= pk}'
```

The output of the command is:

```
{
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable"
}
```

2. To confirm the table's settings, you can use the following statement.

```
aws keyspaces get-table --keyspace-name mykeyspace --table-name mytable
```

The output shows all default settings of a multi-Region table.

```
{
    "keyspaceName": "mykeyspace",
    "tableName": "mytable",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable",
    "creationTimestamp": "2023-12-19T16:50:37.639000+00:00",
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "pk",
                "type": "int"
            }
        ],
        "partitionKeys": [
            {
                "name": "pk"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2023-12-19T16:50:37.639000+00:00"
```

```
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    },
    "clientSideTimestamps": {
        "status": "ENABLED"
    },
    "replicaSpecifications": [
        {
            "region": "us-east-1",
            "status": "ACTIVE",
            "capacitySpecification": {
                "throughputMode": "PAY_PER_REQUEST",
                "lastUpdateToPayPerRequestTimestamp": 1702895811.469
            }
        },
        {
            "region": "eu-north-1",
            "status": "ACTIVE",
            "capacitySpecification": {
                "throughputMode": "PAY_PER_REQUEST",
                "lastUpdateToPayPerRequestTimestamp": 1702895811.121
            }
        }
    ]
}
```

Create a multi-Region table in provisioned mode with auto scaling in Amazon Keyspaces

This section provides examples of how to create a multi-Region table in provisioned mode with auto scaling. You can do this on the Amazon Keyspaces console, using CQL or the AWS CLI.

For more information about supported configurations and multi-Region replication features, see the section called “Usage notes”.

To create a multi-Region keyspace, see the section called “Create a multi-Region keyspace”.

When you create a new multi-Region table in provisioned mode with auto scaling settings, you can specify the general settings for the table that are valid for all AWS Regions that the table is replicated in. You can then overwrite read capacity settings and read auto scaling settings for each replica. The write capacity, however, remains synchronized between all replicas to ensure that there's enough capacity to replicate writes across all Regions.

> **Note**
>
> Amazon Keyspaces automatic scaling requires the presence of a service-linked role (`AWSServiceRoleForApplicationAutoScaling_CassandraTable`) that performs automatic scaling actions on your behalf. This role is created automatically for you. For more information, see the section called “Using service-linked roles”.

Console

Create a new multi-Region table with automatic scaling enabled

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose a multi-Region keyspace.
3. On the **Tables** tab, choose **Create table**.
4. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
5. In the **Columns** section, create the schema for your table.
6. In the **Primary key** section, define the primary key of the table and select optional clustering columns.
7. In the **Table settings** section, choose **Customize settings**.
8. Continue to **Read/write capacity settings**.
9. For **Capacity mode**, choose **Provisioned**.
10. In the **Read capacity** section, confirm that **Scale automatically** is selected.

    You can select to configure the same read capacity units for all AWS Regions that the table is replicated in. Alternatively, you can clear the check box and configure the read capacity for each Region differently.

If you choose to configure each Region differently, you select the minimum and maximum read capacity units for each table replica, as well as the target utilization.

- **Minimum capacity units** – Enter the value for the minimum level of throughput that the table should always be ready to support. The value must be between 1 and the maximum throughput per second quota for your account (40,000 by default).
- **Maximum capacity units** – Enter the maximum amount of throughput that you want to provision for the table. The value must be between 1 and the maximum throughput per second quota for your account (40,000 by default).
- **Target utilization** – Enter a target utilization rate between 20% and 90%. When traffic exceeds the defined target utilization rate, capacity is automatically scaled up. When traffic falls below the defined target, it is automatically scaled down again.

- Clear the **Scale automatically** check box if you want to provision the table's read capacity manually. This setting applies to all replicas of the table.

> **Note**
>
> To ensure that there's enough read capacity for all replicas, we recommend Amazon Keyspaces automatic scaling for provisioned multi-Region tables.

> **Note**
>
> To learn more about default quotas for your account and how to increase them, see *Quotas*.

11. In the **Write capacity** section, confirm that **Scale automatically** is selected. Then configure the capacity units for the table. The write capacity units stay synced across all AWS Regions to ensure that there is enough capacity to replicate write events across the Regions.
    - Clear **Scale automatically** if you want to provision the table's write capacity manually. This setting applies to all replicas of the table.

> **Note**
>
> To ensure that there's enough write capacity for all replicas, we recommend Amazon Keyspaces automatic scaling for provisioned multi-Region tables.

12. Choose **Create table**. Your table is created with the specified automatic scaling parameters.

Cassandra Query Language (CQL)

Create a multi-Region table with provisioned capacity mode and auto scaling using CQL

- To create a multi-Region table in provisioned mode with auto scaling, you must first specify the capacity mode by defining `CUSTOM_PROPERTIES` for the table. After specifying provisioned capacity mode, you can configure the auto scaling settings for the table using `AUTOSCALING_SETTINGS`.

  For detailed information about auto scaling settings, the target tracking policy, target value, and optional settings, see the section called “Create a new table with automatic scaling”.

  To define the read capacity for a table replica in a specific Region, you can configure the following parameters as part of the table's `replica_updates`:

  - The Region
  - The provisioned read capacity units (optional)
  - Auto scaling settings for read capacity (optional)

  The following example shows a `CREATE TABLE` statement for a multi-Region table in provisioned mode. The general write and read capacity auto scaling settings are the same. However, the read auto scaling settings specify additional cooldown periods of 60 seconds before scaling the table's read capacity up or down. In addition, the read capacity auto scaling settings for the Region US East (N. Virginia) are higher than those for other replicas. Also, the target value is set to 70% instead of 50%.

```
CREATE TABLE mykeyspace.mytable(pk int, ck int, PRIMARY KEY (pk, ck))
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
```

```
        'throughput_mode': 'PROVISIONED',
        'read_capacity_units': 5,
        'write_capacity_units': 5
    }
} AND AUTOSCALING_SETTINGS = {
    'provisioned_write_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50
            }
        }
    },
    'provisioned_read_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50,
                'scale_in_cooldown': 60,
                'scale_out_cooldown': 60
            }
        }
    },
    'replica_updates': {
        'us-east-1': {
            'provisioned_read_capacity_autoscaling_update': {
                'maximum_units': 20,
                'minimum_units': 5,
                'scaling_policy': {
                    'target_tracking_scaling_policy_configuration': {
                        'target_value': 70
                    }
                }
            }
        }
    }
};
```

CLI

Create a new multi-Region table in provisioned mode with auto scaling using the AWS CLI

- To create a multi-Region table in provisioned mode with auto scaling configuration, you can use the AWS CLI. Note that you must use the Amazon Keyspaces CLI `create-table` command to configure multi-Region auto scaling settings. This is because Application Auto Scaling, the service that Amazon Keyspaces uses to perform auto scaling on your behalf, doesn't support multiple Regions.

  For more information about auto scaling settings, the target tracking policy, target value, and optional settings, see the section called “Create a new table with automatic scaling”.

  To define the read capacity for a table replica in a specific Region, you can configure the following parameters as part of the table's `replicaSpecifications`:

  - The Region
  - The provisioned read capacity units (optional)
  - Auto scaling settings for read capacity (optional)

  When you're creating provisioned multi-Region tables with complex auto scaling settings and different configurations for table replicas, it's helpful to load the table's auto scaling settings and replica configurations from JSON files.

  To use the following code example, you can download the example JSON files from auto-scaling.zip, and extract `auto-scaling.json` and `replication.json`. Take note of the path to the files.

  In this example, the JSON files are located in the current directory. For different file path options, see How to load parameters from a file.

```
aws keyspaces create-table --keyspace-name mykeyspace --table-name mytable \
--schema-definition 'allColumns=[{name=pk,type=int},
{name=ck,type=int}],partitionKeys=[{name=pk},{name=ck}]' \
--capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=1,writeCapacityUnits=1 \
--auto-scaling-specification file://auto-scaling.json \
--replica-specifications file://replication.json
```

Update the provisioned capacity and auto scaling settings for a multi-Region table in Amazon Keyspaces

This section includes examples of how to use the console, CQL, and the AWS CLI to manage the Amazon Keyspaces auto scaling settings of provisioned multi-Region tables. For more information about general auto scaling configuration options and how they work, see the section called "Manage throughput capacity with auto scaling".

Note that if you're using provisioned capacity mode for multi-Region tables, you must always use Amazon Keyspaces API calls to configure auto scaling. This is because the underlying Application Auto Scaling API operations are not Region-aware.

For more information on how to estimate write capacity throughput of provisioned multi-Region tables, see the section called "Estimate capacity for a multi-Region table".

For more information about the Amazon Keyspaces API, see *Amazon Keyspaces API Reference*.

When you update the provisioned mode or auto scaling settings of a multi-Region table, you can update read capacity settings and the read auto scaling configuration for each replica of the table.

The write capacity, however, remains synchronized between all replicas to ensure that there's enough capacity to replicate writes across all Regions.

Cassandra Query Language (CQL)

Update the provisioned capacity and auto scaling settings of a multi-Region table using CQL

- You can use `ALTER TABLE` to update the capacity mode and auto scaling settings of an existing table. If you're updating a table that is currently in on-demand capacity mode, `capacity_mode` is required. If your table is already in provisioned capacity mode, this field can be omitted.

  For detailed information about auto scaling settings, the target tracking policy, target value, and optional settings, see the section called "Create a new table with automatic scaling".

  In the same statement, you can also update the read capacity and auto scaling settings of table replicas in specific Regions by updating the table's `replica_updates` property. The following statement is an example of this.

```
ALTER TABLE mykeyspace.mytable
```

```
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
        'throughput_mode': 'PROVISIONED',
        'read_capacity_units': 1,
        'write_capacity_units': 1
    }
} AND AUTOSCALING_SETTINGS = {
    'provisioned_write_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50
            }
        }
    },
    'provisioned_read_capacity_autoscaling_update': {
        'maximum_units': 10,
        'minimum_units': 5,
        'scaling_policy': {
            'target_tracking_scaling_policy_configuration': {
                'target_value': 50,
                'scale_in_cooldown': 60,
                'scale_out_cooldown': 60
            }
        }
    },
    'replica_updates': {
        'us-east-1': {
            'provisioned_read_capacity_autoscaling_update': {
                'maximum_units': 20,
                'minimum_units': 5,
                'scaling_policy': {
                    'target_tracking_scaling_policy_configuration': {
                        'target_value': 70
                    }
                }
            }
        }
    }
};
```

CLI

Update the provisioned capacity and auto scaling settings of a multi-Region table using the AWS CLI

- To update the provisioned mode and auto scaling configuration of an existing table, you can use the AWS CLI `update-table` command.

  Note that you must use the Amazon Keyspaces CLI commands to create or modify multi-Region auto scaling settings. This is because Application Auto Scaling, the service that Amazon Keyspaces uses to perform auto scaling of table capacity on your behalf, doesn't support multiple AWS Regions.

  To update the read capacity for a table replica in a specific Region, you can change one of the following optional parameters of the table's `replicaSpecifications`:

  - The provisioned read capacity units (optional)
  - Auto scaling settings for read capacity (optional)

  When you're updating multi-Region tables with complex auto scaling settings and different configurations for table replicas, it's helpful to load the table's auto scaling settings and replica configurations from JSON files.

  To use the following code example, you can download the example JSON files from auto-scaling.zip, and extract `auto-scaling.json` and `replication.json`. Take note of the path to the files.

  In this example, the JSON files are located in the current directory. For different file path options, see How to load parameters from a file.

```
aws keyspaces update-table --keyspace-name mykeyspace --table-name mytable \
--capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=1,writeCapacityUnits=1 \
--auto-scaling-specification file://auto-scaling.json \
--replica-specifications file://replication.json
```

View the provisioned capacity and auto scaling settings for a multi-Region table in Amazon Keyspaces

You can view a multi-Region table's provisioned capacity and auto scaling settings on the Amazon Keyspaces console, using CQL, or the AWS CLI. This section provides examples of how to do this using CQL and the AWS CLI.

Cassandra Query Language (CQL)

View the provisioned capacity and auto scaling settings of a multi-Region table using CQL

- To view the auto scaling configuration of a multi-Region table, use the following command.

```
SELECT * FROM system_multiregion_info.autoscaling WHERE keyspace_name =
 'mykeyspace' AND table_name = 'mytable';
```

The output for this command looks like the following:

```
 keyspace_name  | table_name | region         |
 provisioned_read_capacity_autoscaling_update

                                                                          |
 provisioned_write_capacity_autoscaling_update
---------------+------------+---------------
+-----------------------------------------------------------------------------------------
+-----------------------------------------------------------------------------------------
  mykeyspace    |  mytable   | ap-southeast-1 | {'minimum_units': 5,
 'maximum_units': 10, 'scaling_policy':
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown':
 60, 'disable_scale_in': false, 'target_value': 50, 'scale_in_cooldown':
 60}}} | {'minimum_units': 5, 'maximum_units': 10, 'scaling_policy':
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown': 0,
 'disable_scale_in': false, 'target_value': 50, 'scale_in_cooldown': 0}}}
  mykeyspace    |  mytable   | us-east-1      | {'minimum_units': 5,
 'maximum_units': 20, 'scaling_policy':
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown':
 60, 'disable_scale_in': false, 'target_value': 70, 'scale_in_cooldown':
 60}}} | {'minimum_units': 5, 'maximum_units': 10, 'scaling_policy':
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown': 0,
 'disable_scale_in': false, 'target_value': 50, 'scale_in_cooldown': 0}}}
  mykeyspace    |  mytable   | eu-west-1      | {'minimum_units': 5,
 'maximum_units': 10, 'scaling_policy':
```

```
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown':
 60, 'disable_scale_in': false, 'target_value': 50, 'scale_in_cooldown':
 60}}} | {'minimum_units': 5, 'maximum_units': 10, 'scaling_policy':
 {'target_tracking_scaling_policy_configuration': {'scale_out_cooldown': 0,
 'disable_scale_in': false, 'target_value': 50, 'scale_in_cooldown': 0}}}
```

CLI

View the provisioned capacity and auto scaling settings of a multi-Region table using the AWS CLI

- To view the auto scaling configuration of a multi-Region table, you can use the `get-table-auto-scaling-settings` operation. The following CLI command is an example of this.

```
aws keyspaces get-table-auto-scaling-settings --keyspace-name mykeyspace --
table-name mytable
```

You should see the following output.

```
{
    "keyspaceName": "mykeyspace",
    "tableName": "mytable",
    "resourceArn": "arn:aws:cassandra:us-east-1:777788889999:/keyspace/
mykeyspace/table/mytable",
    "autoScalingSpecification": {
        "writeCapacityAutoScaling": {
            "autoScalingDisabled": false,
            "minimumUnits": 5,
            "maximumUnits": 10,
            "scalingPolicy": {
                "targetTrackingScalingPolicyConfiguration": {
                    "disableScaleIn": false,
                    "scaleInCooldown": 0,
                    "scaleOutCooldown": 0,
                    "targetValue": 50.0
                }
            }
        },
        "readCapacityAutoScaling": {
            "autoScalingDisabled": false,
```

```
            "minimumUnits": 5,
            "maximumUnits": 20,
            "scalingPolicy": {
                "targetTrackingScalingPolicyConfiguration": {
                    "disableScaleIn": false,
                    "scaleInCooldown": 60,
                    "scaleOutCooldown": 60,
                    "targetValue": 70.0
                }
            }
        }
    },
    "replicaSpecifications": [
        {
            "region": "us-east-1",
            "autoScalingSpecification": {
                "writeCapacityAutoScaling": {
                    "autoScalingDisabled": false,
                    "minimumUnits": 5,
                    "maximumUnits": 10,
                    "scalingPolicy": {
                        "targetTrackingScalingPolicyConfiguration": {
                            "disableScaleIn": false,
                            "scaleInCooldown": 0,
                            "scaleOutCooldown": 0,
                            "targetValue": 50.0
                        }
                    }
                },
                "readCapacityAutoScaling": {
                    "autoScalingDisabled": false,
                    "minimumUnits": 5,
                    "maximumUnits": 20,
                    "scalingPolicy": {
                        "targetTrackingScalingPolicyConfiguration": {
                            "disableScaleIn": false,
                            "scaleInCooldown": 60,
                            "scaleOutCooldown": 60,
                            "targetValue": 70.0
                        }
                    }
                }
            },
```

```
        {
            "region": "eu-north-1",
            "autoScalingSpecification": {
                "writeCapacityAutoScaling": {
                    "autoScalingDisabled": false,
                    "minimumUnits": 5,
                    "maximumUnits": 10,
                    "scalingPolicy": {
                        "targetTrackingScalingPolicyConfiguration": {
                            "disableScaleIn": false,
                            "scaleInCooldown": 0,
                            "scaleOutCooldown": 0,
                            "targetValue": 50.0
                        }
                    }
                },
                "readCapacityAutoScaling": {
                    "autoScalingDisabled": false,
                    "minimumUnits": 5,
                    "maximumUnits": 10,
                    "scalingPolicy": {
                        "targetTrackingScalingPolicyConfiguration": {
                            "disableScaleIn": false,
                            "scaleInCooldown": 60,
                            "scaleOutCooldown": 60,
                            "targetValue": 50.0
                        }
                    }
                }
            }
        }
    ]
}
```

Turn off auto scaling for a table in Amazon Keyspaces

This section provides examples of how to turn off auto scaling for a multi-Region table in provisioned capacity mode. You can do this on the Amazon Keyspaces console, using CQL or the AWS CLI.

Important

We recommend using auto scaling for multi-Region tables that use provisioned capacity mode. For more information, see the section called "Estimate capacity for a multi-Region table".

Note

To delete the service-linked role that Application Auto Scaling uses, you must disable automatic scaling on all tables in the account across all AWS Regions.

Console

Turn off Amazon Keyspaces automatic scaling for an existing multi-Region table on the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose the table that you want to work with and choose the **Capacity** tab.
3. In the **Capacity settings** section, choose **Edit**.
4. To disable Amazon Keyspaces automatic scaling, clear the **Scale automatically** check box. Disabling automatic scaling deregisters the table as a scalable target with Application Auto Scaling. To delete the service-linked role that Application Auto Scaling uses to access your Amazon Keyspaces table, follow the steps in the section called "Deleting a service-linked role for Amazon Keyspaces".
5. When the automatic scaling settings are defined, choose **Save**.

Cassandra Query Language (CQL)

Turn off auto scaling for a multi-Region table using CQL

- You can use `ALTER TABLE` to turn off auto scaling for an existing table. Note that you can't turn off auto scaling for an individual table replica.

  In the following example, auto scaling is turned off for the table's read capacity.

```
ALTER TABLE mykeyspace.mytable
WITH AUTOSCALING_SETTINGS = {
    'provisioned_read_capacity_autoscaling_update': {
        'autoscaling_disabled': true
    }
};
```

CLI

Turn off auto scaling for a multi-Region table using the AWS CLI

- You can use the AWS CLI `update-table` command to turn off auto scaling for an existing table. Note that you can't turn off auto scaling for an individual table replica.

  In the following example, auto scaling is turned off for the table's read capacity.

```
aws keyspaces update-table --keyspace-name mykeyspace --table-name mytable
          \ --auto-scaling-specification
 readCapacityAutoScaling={autoScalingDisabled=true}
```

Set the provisioned capacity of a multi-Region table manually in Amazon Keyspaces

If you have to turn off auto scaling for a multi-Region table, you can provision the table's read capacity for a replica table manually using CQL or the AWS CLI.

> **Note**
>
> We recommend using auto scaling for multi-Region tables that use provisioned capacity mode. For more information, see the section called “Estimate capacity for a multi-Region table”.

Cassandra Query Language (CQL)

Setting the provisioned capacity of a multi-Region table manually using CQL

- You can use `ALTER TABLE` to provision the table's read capacity for a replica table manually.

```
ALTER TABLE mykeyspace.mytable
WITH CUSTOM_PROPERTIES = {
    'capacity_mode': {
        'throughput_mode': 'PROVISIONED',
        'read_capacity_units': 1,
        'write_capacity_units': 1
    },
    'replica_updates': {
        'us-east-1': {
            'read_capacity_units': 2
         }
    }
};
```

CLI

Set the provisioned capacity of a multi-Region table manually using the AWS CLI

- If you have to turn off auto scaling for a multi-Region table, you can use `update-table` to provision the table's read capacity for a replica table manually.

```
aws keyspaces update-table --keyspace-name mykeyspace --table-name mytable \
--capacity-specification
 throughputMode=PROVISIONED,readCapacityUnits=1,writeCapacityUnits=1 \
--replica-specifications region="us-east-1",readCapacityUnits=5
```

Backup and restore data with point-in-time recovery for Amazon Keyspaces

Point-in-time recovery (PITR) helps protect your Amazon Keyspaces tables from accidental write or delete operations by providing you continuous backups of your table data.

For example, suppose that a test script writes accidentally to a production Amazon Keyspaces table. With point-in-time recovery, you can restore that table's data to any second in time since PITR was enabled within the last 35 days. If you delete a table with point-in-time recovery enabled, you can query for the deleted table's data for 35 days (at no additional cost), and restore it to the state it was in just before the point of deletion.

You can restore an Amazon Keyspaces table to a point in time by using the console, the AWS SDK and the AWS Command Line Interface (AWS CLI), or Cassandra Query Language (CQL). For more information, see Use point-in-time recovery in Amazon Keyspaces.

Point-in-time operations have no performance or availability impact on the base table, and restoring a table doesn't consume additional throughput.

For information about PITR quotas, see *Quotas*.

For information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

Topics

- How point-in-time recovery works in Amazon Keyspaces
- Use point-in-time recovery in Amazon Keyspaces

How point-in-time recovery works in Amazon Keyspaces

This section provides an overview of how Amazon Keyspaces point-in-time recovery (PITR) works. For more information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

Topics

- Time window for PITR continuous backups
- PITR restore settings
- PITR restore of encrypted tables
- PITR restore of multi-Region tables
- PITR restore of tables with user-defined types (UDTs)
- Table restore time with PITR
- Amazon Keyspaces PITR and integration with AWS services

Time window for PITR continuous backups

Amazon Keyspaces PITR uses two timestamps to maintain the time frame for which restorable backups are available for a table.

- Earliest restorable time – Marks the time of the earliest restorable backup. The earliest restorable backup goes back up to 35 days or when PITR was enabled, whichever is more recent. The maximum backup window of 35 days can't be modified.
- Current time – The timestamp for the latest restorable backup is the current time. If no timestamp is provided during a restore, current time is used.

When PITR is enabled, you can restore to any point in time between `EarliestRestorableDateTime` and `CurrentTime`. You can only restore table data to a time when PITR was enabled.

If you disable PITR and later reenable it again, you reset the start time for the first available backup to when PITR was reenabled. This means that disabling PITR erases your backup history.

> **Note**
>
> Data definition language (DDL) operations on tables, such as schema changes, are performed asynchronously. You can only see completed operations in your restored table data, but you might see additional actions on your source table if they were in progress at the time of the restore. For a list of DDL statements, see the section called “DDL statements”.

A table doesn't have to be active to be restored. You can also restore deleted tables if PITR was enabled on the deleted table and the deletion occurred within the backup window (or within the last 35 days).

> **Note**
>
> If a new table is created with the same qualified name (for example, mykeyspace.mytable) as a previously deleted table, the deleted table will no longer be restorable. If you attempt to do this from the console, a warning is displayed.

PITR restore settings

When you restore a table using PITR, Amazon Keyspaces restores your source table's schema and data to the state based on the selected timestamp (`day:hour:minute:second`) to a new table. PITR doesn't overwrite existing tables.

In addition to the table's schema and data, PITR restores the `custom_properties` from the source table. Unlike the table's data, which is restored based on the selected timestamp between earliest restore time and current time, custom properties are always restored based on the table's settings as of the current time.

The settings of the restored table match the settings of the source table with the timestamp of when the restore was initiated. If you want to overwrite these settings during restore, you can do so using `WITH custom_properties`. Custom properties include the following settings.

- Read/write capacity mode
- Provisioned throughput capacity settings
- PITR settings

If the table is in provisioned capacity mode with auto scaling enabled, the restore operation also restores the table's auto scaling settings. You can overwrite them using the `autoscaling_settings` parameter in CQL or `autoScalingSpecification` with the CLI. For more information on auto scaling settings, see the section called “Manage throughput capacity with auto scaling”.

When you do a full table restore, all table settings for the restored table come from the current settings of the source table at the time of the restore.

For example, suppose that a table's provisioned throughput was recently lowered to 50 read capacity units and 50 write capacity units. You then restore the table's state to three weeks ago. At this time, its provisioned throughput was set to 100 read capacity units and 100 write capacity units. In this case, Amazon Keyspaces restores your table data to that point in time, but uses the current provisioned throughput settings (50 read capacity units and 50 write capacity units).

The following settings are not restored, and you must configure them manually for the new table.

- Amazon Keyspaces change data capture (CDC) streams
- AWS Identity and Access Management (IAM) policies
- Amazon CloudWatch metrics and alarms

- Tags (can be added to the CQL `RESTORE` statement using `WITH TAGS`)

PITR restore of encrypted tables

When you restore a table using PITR, Amazon Keyspaces restores your source table's encryption settings. If the table was encrypted with an AWS owned key (default), the table is restored with the same setting automatically. If the table you want to restore was encrypted using a customer managed key, the same customer managed key needs to be accessible to Amazon Keyspaces to restore the table data.

You can change the encryption settings of the table at the time of restore. To change from an AWS owned key to a customer managed key, you need to supply a valid and accessible customer managed key at the time of restore.

If you want to change from a customer managed key to an AWS owned key, confirm that Amazon Keyspaces has access to the customer managed key of the source table to restore the table with an AWS owned key. For more information about encryption at rest settings for tables, see the section called “How it works”.

> **Note**
>
> If the table was deleted because Amazon Keyspaces lost access to your customer managed key, you need to ensure the customer managed key is accessible to Amazon Keyspaces before trying to restore the table. A table that was encrypted with a customer managed key can't be restored if Amazon Keyspaces doesn't have access to that key. For more information, see Troubleshooting key access in the AWS Key Management Service Developer Guide.

PITR restore of multi-Region tables

You can restore a multi-Region table using PITR. For the restore operation to be successful, PITR has to be enabled on all replicas of the source table and both the source and the destination table have to be replicated to the same AWS Regions.

Amazon Keyspaces restores the settings of the source table in each of the replicated Regions that are part of the keyspace. You can also override settings during the restore operation. For more information about settings that can be changed during the restore, see the section called “Restore settings”.

For more information about multi-Region replication, see the section called “How it works”.

PITR restore of tables with user-defined types (UDTs)

You can restore a table that uses UDTs. For the restore operation to be successful, the referenced UDTs have to exist and be valid in the keyspace.

If any required UDT is missing when you attempt to restore a table, Amazon Keyspaces tries to restore the UDT schema automatically and then continues to restore the table.

If you removed and recreated the UDT, Amazon Keyspaces restores the UDT with the new schema of the UDT and rejects the request to restore the table using the original UDT schema. In this case, if you wish to restore the table with the old UDT schema, you can restore the table to a new keyspace. When you delete and recreate a UDT, even if the schema of the recreated UDT is the same as the schema of the deleted UDT, the recreated UDT is considered a new UDT. In this case, Amazon Keyspaces rejects the request to restore the table with the old UDT schema.

If the UDT is missing and Amazon Keyspaces attempts to restore the UDT, the attempt fails if you have reached the maximum number of UDTs for the account in the Region.

For more information about UDT quotas and default values, see the section called “Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces”. For more information about working with UDTs, see the section called “User-defined types (UDTs)”.

Table restore time with PITR

The time it takes you to restore a table is based on multiple factors and isn't always correlated directly to the size of the table.

The following are some considerations for restore times.

- You restore backups to a new table. It can take up to 20 minutes (even if the table is empty) to perform all the actions to create the new table and initiate the restore process.
- Restore times for large tables with well-distributed data models can be several hours or longer.
- If your source table contains data that is significantly skewed, the time to restore might increase. For example, if your table’s primary key is using the month of the year as a partition key, and all your data is from the month of December, you have skewed data.

A best practice when planning for disaster recovery is to regularly document average restore completion times and establish how these times affect your overall Recovery Time Objective.

Amazon Keyspaces PITR and integration with AWS services

The following PITR operations are logged using AWS CloudTrail to enable continuous monitoring and auditing.

- Create a new table with PITR enabled or disabled.
- Enable or disable PITR on an existing table.
- Restore an active or a deleted table.

For more information, see Logging Amazon Keyspaces API calls with AWS CloudTrail.

You can perform the following PITR actions using CloudFormation.

- Create a new table with PITR enabled or disabled.
- Enable or disable PITR on an existing table.

For more information, see the Cassandra Resource Type Reference in the CloudFormation User Guide.

Use point-in-time recovery in Amazon Keyspaces

With Amazon Keyspaces (for Apache Cassandra), you can restore tables to a specific point in time using Point-in-Time Restore (PITR). PITR enables you to restore a table to a prior state within the last 35 days, providing data protection and recovery capabilities. This feature is valuable in cases such as accidental data deletion, application errors, or for testing purposes. You can quickly and efficiently recover data, minimizing downtime and data loss. The following sections guide you through the process of restoring tables using PITR in Amazon Keyspaces, ensuring data integrity and business continuity.

Topics

- Configure restore table IAM permissions for Amazon Keyspaces PITR
- Configure PITR for a table in Amazon Keyspaces
- Turn off PITR for an Amazon Keyspaces table
- Restore a table from backup to a specified point in time in Amazon Keyspaces
- Restore a deleted table using Amazon Keyspaces PITR

Configure restore table IAM permissions for Amazon Keyspaces PITR

This section summarizes how to configure permissions for an AWS Identity and Access Management (IAM) principal to restore Amazon Keyspaces tables. In IAM, the AWS managed policy `AmazonKeyspacesFullAccess` includes the permissions to restore Amazon Keyspaces tables. To implement a custom policy with minimum required permissions, consider the requirements outlined in the next section.

To successfully restore a table, the IAM principal needs the following minimum permissions:

- `cassandra:Restore` – The restore action is required for the target table to be restored.
- `cassandra:Select` – The select action is required to read from the source table.
- `cassandra:TagResource` – The tag action is optional, and only required if the restore operation adds tags.

This is an example of a policy that grants minimum required permissions to a user to restore tables in keyspace `mykeyspace`.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Restore",
            "cassandra:Select"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/*",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

Additional permissions to restore a table might be required based on other selected features. For example, if the source table is encrypted at rest with a customer managed key, Amazon Keyspaces must have permissions to access the customer managed key of the source table to successfully restore the table. For more information, see the section called “PITR and encrypted tables”.

If you are using IAM policies with condition keys to restrict incoming traffic to specific sources, you must ensure that Amazon Keyspaces has permission to perform a restore operation on your principal's behalf. You must add an `aws:ViaAWSService` condition key to your IAM policy if your policy restricts incoming traffic to any of the following:

- VPC endpoints with `aws:SourceVpce`
- IP ranges with `aws:SourceIp`
- VPCs with `aws:SourceVpc`

The `aws:ViaAWSService` condition key allows access when any AWS service makes a request using the principal's credentials. For more information, see IAM JSON policy elements: Condition key in the *IAM User Guide*.

The following is an example of a policy that restricts source traffic to a specific IP address and allows Amazon Keyspaces to restore a table on the principal's behalf.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"CassandraAccessForCustomIp",
         "Effect":"Allow",
         "Action":"cassandra:*",
         "Resource":"*",
         "Condition":{
            "Bool":{
               "aws:ViaAWSService":"false"
            },
            "ForAnyValue:IpAddress":{
               "aws:SourceIp":[
                  "123.45.167.89"
               ]
            }
         }
      },
      {
         "Sid":"CassandraAccessForAwsService",
         "Effect":"Allow",
         "Action":"cassandra:*",
         "Resource":"*",
         "Condition":{
```

```
            "Bool":{
               "aws:ViaAWSService":"true"
            }
         }
      }
   ]
}
```

For an example policy using the `aws:ViaAWSService` global condition key, see the section called "VPC endpoint policies and Amazon Keyspaces point-in-time recovery (PITR)".

Configure PITR for a table in Amazon Keyspaces

You can configure a table in Amazon Keyspaces for backup and restore operations using PITR with the console, CQL, and the AWS CLI.

When creating a new table using CQL or the AWS CLI, you must explicitly enable PITR in the create table statement. When you create a new table using the console, PITR will be enable by default.

To learn how to restore a table, see the section called "Restore a table to a point in time".

Console

Configure PITR for a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables** and select the table you want to edit.
3. On the **Backups** tab, choose **Edit**.
4. In the **Edit point-in-time recovery settings** section, select **Enable Point-in-time recovery**.
5. Choose **Save changes**.

Cassandra Query Language (CQL)

Configure PITR for a table using CQL

1. You can manage PITR settings for tables by using the `point_in_time_recovery` custom property.

To enable PITR when you're creating a new table, you must set the status of `point_in_time_recovery` to `enabled`. You can use the following CQL command as an example.

```
CREATE TABLE "my_keyspace1"."my_table1"(
 "id" int,
 "name" ascii,
 "date" timestamp,
 PRIMARY KEY("id"))
WITH CUSTOM_PROPERTIES = {
 'capacity_mode':{'throughput_mode':'PAY_PER_REQUEST'},
 'point_in_time_recovery':{'status':'enabled'}
}
```

> **Note**
>
> If no point-in-time recovery custom property is specified, point-in-time recovery is disabled by default.

2. To enable PITR for an existing table using CQL, run the following CQL command.

```
ALTER TABLE mykeyspace.mytable
WITH custom_properties = {'point_in_time_recovery': {'status': 'enabled'}}
```

CLI

Configure PITR for a table using the AWS CLI

1. You can manage PITR settings for tables by using the `UpdateTable` API.

   To enable PITR when you're creating a new table, you must include `point-in-time-recovery 'status=ENABLED'` in the create table command. You can use the following AWS CLI command as an example. The command has been broken into separate lines to improve readability.

```
aws keyspaces create-table --keyspace-name 'myKeyspace' --table-name 'myTable'
            --schema-definition 'allColumns=[{name=id,type=int},
{name=name,type=text},{name=date,type=timestamp}],partitionKeys=[{name=id}]'
```

```
            --point-in-time-recovery 'status=ENABLED'
```

> **Note**
>
> If no point-in-time recovery value is specified, point-in-time recovery is disabled by default.

2. To confirm the point-in-time recovery setting for a table, you can use the following AWS CLI command.

```
aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
```

3. To enable PITR for an existing table using the AWS CLI, run the following command.

```
aws keyspaces update-table --keyspace-name 'myKeyspace' --table-name 'myTable'
 --point-in-time-recovery 'status=ENABLED'
```

Turn off PITR for an Amazon Keyspaces table

You can turn off PITR for an Amazon Keyspaces table at any time using the console, CQL, or the AWS CLI.

> **Important**
>
> Disabling PITR deletes your backup history immediately, even if you reenable PITR on the table within 35 days.

To learn how to restore a table, see the section called “Restore a table to a point in time”.

Console

Disable PITR for a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables** and select the table you want to edit.
3. On the **Backups** tab, choose **Edit**.

4. In the **Edit point-in-time recovery settings** section, clear the **Enable Point-in-time recovery** check box.
5. Choose **Save changes**.

Cassandra Query Language (CQL)

Disable PITR for a table using CQL

- To disable PITR for an existing table, run the following CQL command.

```
ALTER TABLE mykeyspace.mytable
WITH custom_properties = {'point_in_time_recovery': {'status': 'disabled'}}
```

CLI

Disable PITR for a table using the AWS CLI

- To disable PITR for an existing table, run the following AWS CLI command.

```
aws keyspaces update-table --keyspace-name 'myKeyspace' --table-name 'myTable'
 --point-in-time-recovery 'status=DISABLED'
```

Restore a table from backup to a specified point in time in Amazon Keyspaces

The following section demonstrates how to restore an existing Amazon Keyspaces table to a specified point in time.

> **Note**
>
> This procedure assumes that the table you're using has been configured with point-in-time recovery. To enable PITR for a table, see the section called “Configure PITR”.

> **Important**
>
> While a restore is in progress, don't modify or delete the AWS Identity and Access Management (IAM) policies that grant the IAM principal (for example, user, group, or

role) permission to perform the restore. Otherwise, unexpected behavior can result. For example, if you remove write permissions for a table while that table is being restored, the underlying `RestoreTableToPointInTime` operation can't write any of the restored data to the table.
You can modify or delete permissions only after the restore operation is complete.

Console

Restore a table to a specified point in time using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane on the left side of the console, choose **Tables**.
3. In the list of tables, choose the table you want to restore.
4. On the **Backups** tab of the table, in the **Point-in-time recovery** section, choose **Restore**.
5. For the new table name, enter a new name for the restored table, for example **`mytable_restored`**.
6. To define the point in time for the restore operation, you can choose between two options:
   - Select the preconfigured **Earliest** time.
   - Select **Specify date and time** and enter the date and time you want to restore the new table to.

   Note

   You can restore to any point in time within **Earliest** time and the current time. Amazon Keyspaces restores your table data to the state based on the selected date and time (day:hour:minute:second).
7. Choose **Restore** to start the restore process.

   The table that is being restored is shown with the status **Restoring**. After the restore process is finished, the status of the restored table changes to **Active**.

Cassandra Query Language (CQL)

Restore a table to a point in time using CQL

1. You can restore an active table to a point-in-time between `earliest_restorable_timestamp` and the current time. Current time is the default.

   To confirm that point-in-time recovery is enabled for the table, query the `system_schema_mcs.tables` as shown in this example.

   ```
   SELECT custom_properties
   FROM system_schema_mcs.tables
   WHERE keyspace_name = 'mykeyspace' AND table_name = 'mytable';
   ```

   Point-in-time recovery is enabled as shown in the following sample output.

   ```
   custom_properties
   -----------------
   {
     ...,
       "point_in_time_recovery": {
       "earliest_restorable_timestamp":"2020-06-30T19:19:21.175Z"
       "status":"enabled"
     }
   }
   ```

2. - Restore the table to the current time. When you omit the `WITH restore_timestamp = ...` clause, the current timestamp is used.

     ```
     RESTORE TABLE mykeyspace.mytable_restored
     FROM TABLE mykeyspace.mytable;
     ```

   - You can also restore to a specific point in time, defined by a `restore_timestamp` in ISO 8601 format. You can specify any point in time during the last 35 days. For example, the following command restores the table to the `EarliestRestorableDateTime`.

     ```
     RESTORE TABLE mykeyspace.mytable_restored
     FROM TABLE mykeyspace.mytable
     WITH restore_timestamp = '2020-06-30T19:19:21.175Z';
     ```

For a full syntax description, see the section called "RESTORE TABLE" in the language reference.

3. To verify that the restore of the table was successful, query the `system_schema_mcs.tables` to confirm the status of the table.

```
SELECT status
FROM system_schema_mcs.tables
WHERE keyspace_name = 'mykeyspace' AND table_name = 'mytable_restored'
```

The query shows the following output.

```
status
------
RESTORING
```

The table that is being restored is shown with the status **Restoring**. After the restore process is finished, the status of the table changes to **Active**.

CLI

Restore a table to a point in time using the AWS CLI

1. Create a simple table named `myTable` that has PITR enabled. The command has been broken up into separate lines for readability.

```
aws keyspaces create-table --keyspace-name 'myKeyspace' --table-name 'myTable'
            --schema-definition 'allColumns=[{name=id,type=int},
{name=name,type=text},{name=date,type=timestamp}],partitionKeys=[{name=id}]'
            --point-in-time-recovery 'status=ENABLED'
```

2. Confirm the properties of the new table and review the `earliestRestorableTimestamp` for PITR.

```
aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
```

The output of this command returns the following.

```
{
```

```
    "keyspaceName": "myKeyspace",
    "tableName": "myTable",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
myKeyspace/table/myTable",
    "creationTimestamp": "2022-06-20T14:34:57.049000-07:00",
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "id",
                "type": "int"
            },
            {
                "name": "date",
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2022-06-20T14:34:57.049000-07:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "ENABLED",
        "earliestRestorableTimestamp": "2022-06-20T14:35:13.693000-07:00"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    }
```

```
}
```

3.
   - To restore a table to a point in time, specify a `restore_timestamp` in ISO 8601 format. You can chose any point in time during the last 35 days in one second intervals. For example, the following command restores the table to the `EarliestRestorableDateTime`.

     ```
     aws keyspaces restore-table --source-keyspace-name 'myKeyspace' --source-
     table-name 'myTable' --target-keyspace-name 'myKeyspace' --target-table-name
      'myTable_restored' --restore-timestamp "2022-06-20 21:35:14.693"
     ```

     The output of this command returns the ARN of the restored table.

     ```
     {
         "restoredTableARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
     myKeyspace/table/myTable_restored"
     }
     ```

   - To restore the table to the current time, you can omit the `restore-timestamp` parameter.

     ```
     aws keyspaces restore-table --source-keyspace-name 'myKeyspace' --source-
     table-name 'myTable' --target-keyspace-name 'myKeyspace' --target-table-name
      'myTable_restored1'"
     ```

Restore a deleted table using Amazon Keyspaces PITR

The following procedure shows how to restore a deleted table from backup to the time of deletion. You can do this using CQL or the AWS CLI.

> **Note**
>
> This procedure assumes that PITR was enabled on the deleted table.

Cassandra Query Language (CQL)

Restore a deleted table using CQL

1. To confirm that point-in-time recovery is enabled for a deleted table, query the system table. Only tables with point-in-time recovery enabled are shown.

```
SELECT custom_properties
FROM system_schema_mcs.tables_history
WHERE keyspace_name = 'mykeyspace' AND table_name = 'my_table';
```

   The query shows the following output.

```
custom_properties
------------------
{
    ...,
   "point_in_time_recovery":{
      "restorable_until_time":"2020-08-04T00:48:58.381Z",
      "status":"enabled"
   }
}
```

2. Restore the table to the time of deletion with the following sample statement.

```
RESTORE TABLE mykeyspace.mytable_restored
FROM TABLE mykeyspace.mytable;
```

CLI

Restore a deleted table using the AWS CLI

1. Delete a table that you created previously that has PITR enabled. The following command is an example.

```
aws keyspaces delete-table --keyspace-name 'myKeyspace' --table-name 'myTable'
```

2. Restore the deleted table to the time of deletion with the following command.

```
aws keyspaces restore-table --source-keyspace-name 'myKeyspace' --source-
table-name 'myTable' --target-keyspace-name 'myKeyspace' --target-table-name
 'myTable_restored2'
```

The output of this command returns the ARN of the restored table.

```
{
    "restoredTableARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
myKeyspace/table/myTable_restored2"
}
```

Expire data with Time to Live (TTL) for Amazon Keyspaces (for Apache Cassandra)

Amazon Keyspaces (for Apache Cassandra) Time to Live (TTL) helps you simplify your application logic and optimize the price of storage by expiring data from tables automatically. Data that you no longer need is automatically deleted from your table based on the Time to Live value that you set.

This makes it easier to comply with data retention policies based on business, industry, or regulatory requirements that define how long data needs to be retained or specify when data must be deleted.

For example, you can use TTL in an AdTech application to schedule when data for specific ads expires and is no longer visible to clients. You can also use TTL to retire older data automatically and save on your storage costs.

You can set a default TTL value for the entire table, and overwrite that value for individual rows and columns. TTL operations don't impact your application's performance. Also, the number of rows and columns marked to expire with TTL doesn't affect your table's availability.

Amazon Keyspaces automatically filters out expired data so that expired data isn't returned in query results or available for use in data manipulation language (DML) statements. Amazon Keyspaces typically deletes expired data from storage within 10 days of the expiration date.

In rare cases, Amazon Keyspaces may not be able to delete data within 10 days if there is sustained activity on the underlying storage partition to protect availability. In these cases, Amazon Keyspaces continues to attempt to delete the expired data once traffic on the partition decreases.

After the data is permanently deleted from storage, you stop incurring storage fees.

You can set, modify, or disable default TTL settings for new and existing tables by using the console, Cassandra Query Language (CQL), or the AWS CLI.

On tables with default TTL configured, you can use CQL statements to override the default TTL settings of the table and apply custom TTL values to rows and columns. For more information, see the section called "Use `INSERT` to set custom TTL for new rows" and the section called "Use `UPDATE` to set custom TTL for rows and columns".

TTL pricing is based on the size of the rows being deleted or updated by using Time to Live. TTL operations are metered in units of `TTL deletes`. One TTL delete is consumed per KB of data per row that is deleted or updated.

For example, to update a row that stores 2.5 KB of data and to delete one or more columns within the row at the same time requires three TTL deletes. Or, to delete an entire row that contains 3.5 KB of data requires four TTL deletes.

One TTL delete is consumed per KB of deleted data per row. For more information about pricing, see Amazon Keyspaces (for Apache Cassandra) pricing.

Topics

- Amazon Keyspaces Time to Live and integration with AWS services
- Create a new table with default Time to Live (TTL) settings
- Update the default Time to Live (TTL) value of a table
- Create table with custom Time to Live (TTL) settings enabled
- Update table with custom Time to Live (TTL)
- Use the INSERT statement to set custom Time to Live (TTL) values for new rows
- Use the UPDATE statement to edit custom Time to Live (TTL) settings for rows and columns

Amazon Keyspaces Time to Live and integration with AWS services

The following TTL metric is available in Amazon CloudWatch to enable continuous monitoring.

- `TTLDeletes` – The units consumed to delete or update data in a row by using Time to Live (TTL).

For more information about how to monitor CloudWatch metrics, see the section called "Monitoring with CloudWatch".

When you use CloudFormation, you can turn on TTL when creating an Amazon Keyspaces table. For more information, see the AWS CloudFormation User Guide.

Create a new table with default Time to Live (TTL) settings

In Amazon Keyspaces, you can set a default TTL value for all rows in a table when the table is created.

The default TTL value for a table is zero, which means that data doesn't expire automatically. If the default TTL value for a table is greater than zero, an expiration timestamp is added to each row.

TTL values are set in seconds, and the maximum configurable value is 630,720,000 seconds, which is the equivalent of 20 years.

After table creation, you can overwrite the table's default TTL setting for specific rows or columns with CQL DML statements. For more information, see the section called "Use `INSERT` to set custom TTL for new rows" and the section called "Use `UPDATE` to set custom TTL for rows and columns".

When you enable TTL on a table, Amazon Keyspaces begins to store additional TTL-related metadata for each row. In addition, TTL uses expiration timestamps to track when rows or columns expire. The timestamps are stored as row metadata and contribute to the storage cost for the row.

After the TTL feature is enabled, you can't disable it for a table. Setting the table's `default_time_to_live` to 0 disables default expiration times for new data, but it doesn't deactivate the TTL feature or revert the table back to the original Amazon Keyspaces storage metadata or write behavior.

The following examples show how to create a new table with a default TTL value.

Console

Create a new table with a Time to Live default value using the console.

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.

2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
4. In the **Schema** section, create the schema for your table.
5. In the **Table settings** section, choose **Customize settings**.
6. Continue to **Time to Live (TTL)**.

   In this step, you select the default TTL settings for the table.

   For the **Default TTL period**, enter the expiration time and choose the unit of time you entered, for example seconds, days, or years. Amazon Keyspaces will store the value in seconds.
7. Choose **Create table**. Your table is created with the specified default TTL value.

Cassandra Query Language (CQL)

Create a new table with a default TTL value using CQL

1. The following statement creates a new table with the default TTL value set to 3,024,000 seconds, which represents 35 days.

```
CREATE TABLE my_table (
                userid uuid,
                time timeuuid,
                subject text,
                body text,
                user inet,
                PRIMARY KEY (userid, time)
                ) WITH default_time_to_live = 3024000;
```

2. To confirm the TTL settings for the new table, use the `cqlsh DESCRIBE` statement as shown in the following example. The output shows the default TTL setting for the table as `default_time_to_live`.

```
DESC TABLE my_table;
```

```
CREATE TABLE my_keyspace.my_table (
    userid uuid,
```

```
    time timeuuid,
    body text,
    subject text,
    user inet,
    PRIMARY KEY (userid, time)
) WITH CLUSTERING ORDER BY (time ASC)
    AND bloom_filter_fp_chance = 0.01
    AND caching = {'class': 'com.amazonaws.cassandra.DefaultCaching'}
    AND comment = ''
    AND compaction = {'class': 'com.amazonaws.cassandra.DefaultCompaction'}
    AND compression = {'class': 'com.amazonaws.cassandra.DefaultCompression'}
    AND crc_check_chance = 1.0
    AND dclocal_read_repair_chance = 0.0
    AND default_time_to_live = 3024000
    AND gc_grace_seconds = 7776000
    AND max_index_interval = 2048
    AND memtable_flush_period_in_ms = 3600000
    AND min_index_interval = 128
    AND read_repair_chance = 0.0
    AND speculative_retry = '99PERCENTILE';
```

CLI

Create a new table with a default TTL value using the AWS CLI

1. You can use the following command to create a new table with the default TTL value set to one year.

```
aws keyspaces create-table --keyspace-name 'myKeyspace' --table-name 'myTable' \
            --schema-definition 'allColumns=[{name=id,type=int},
{name=name,type=text},{name=date,type=timestamp}],partitionKeys=[{name=id}]' \
            --default-time-to-live '31536000'
```

2. To confirm the TTL status of the table, you can use the following command.

```
aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
```

   The output of the command looks like in the following example

```
{
    "keyspaceName": "myKeyspace",
```

```
    "tableName": "myTable",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
myKeyspace/table/myTable",
    "creationTimestamp": "2024-09-02T10:52:22.190000+00:00",
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "id",
                "type": "int"
            },
            {
                "name": "date",
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-09-02T10:52:22.190000+00:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 31536000,
    "comment": {
        "message": ""
```

```
    },
    "replicaSpecifications": []
}
```

Update the default Time to Live (TTL) value of a table

You can update an existing table with a new default TTL value. TTL values are set in seconds, and the maximum configurable value is 630,720,000 seconds, which is the equivalent of 20 years.

When you enable TTL on a table, Amazon Keyspaces begins to store additional TTL-related metadata for each row. In addition, TTL uses expiration timestamps to track when rows or columns expire. The timestamps are stored as row metadata and contribute to the storage cost for the row.

After TTL has been enabled for a table, you can overwrite the table's default TTL setting for specific rows or columns with CQL DML statements. For more information, see the section called “Use INSERT to set custom TTL for new rows” and the section called “Use UPDATE to set custom TTL for rows and columns”.

After the TTL feature is enabled, you can't disable it for a table. Setting the table’s `default_time_to_live` to 0 disables default expiration times for new data, but it doesn't deactivate the TTL feature or revert the table back to the original Amazon Keyspaces storage metadata or write behavior.

Follow these steps to update default Time to Live settings for existing tables using the console, CQL, or the AWS CLI.

Console

Update the default TTL value of a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose the table that you want to update, and then choose the **Additional settings** tab.
3. Continue to **Time to Live (TTL)** and choose **Edit**.
4. For the **Default TTL period**, enter the expiration time and choose the unit of time, for example seconds, days, or years. Amazon Keyspaces will store the value in seconds. This doesn't change the TTL value of existing rows.
5. When the TTL settings are defined, choose **Save changes**.

Cassandra Query Language (CQL)

Update the default TTL value of a table using CQL

1. You can use `ALTER TABLE` to edit default Time to Live (TTL) settings of a table. To update the default TTL settings of the table to 2,592,000 seconds, which represents 30 days, you can use the following statement.

```
ALTER TABLE my_table WITH default_time_to_live = 2592000;
```

2. To confirm the TTL settings for the updated table, use the `cqlsh DESCRIBE` statement as shown in the following example. The output shows the default TTL setting for the table as `default_time_to_live`.

```
DESC TABLE my_table;
```

The output of the statement should look similar to this example.

```
CREATE TABLE my_keyspace.my_table (
    id int PRIMARY KEY,
    date timestamp,
    name text
) WITH bloom_filter_fp_chance = 0.01
    AND caching = {'class': 'com.amazonaws.cassandra.DefaultCaching'}
    AND comment = ''
    AND compaction = {'class': 'com.amazonaws.cassandra.DefaultCompaction'}
    AND compression = {'class': 'com.amazonaws.cassandra.DefaultCompression'}
    AND crc_check_chance = 1.0
    AND dclocal_read_repair_chance = 0.0
    AND default_time_to_live = 2592000
    AND gc_grace_seconds = 7776000
    AND max_index_interval = 2048
    AND memtable_flush_period_in_ms = 3600000
    AND min_index_interval = 128
    AND read_repair_chance = 0.0
    AND speculative_retry = '99PERCENTILE';
```

CLI

Update the default TTL value of a table using the AWS CLI

1. You can use `update-table` to edit the default TTL value a table. To update the default TTL settings of the table to 2,592,000 seconds, which represents 30 days, you can use the following statement.

```
aws keyspaces update-table --keyspace-name 'myKeyspace' --table-name 'myTable'
 --default-time-to-live '2592000'
```

2. To confirm the updated default TTL value, you can use the following statement.

```
aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
```

The output of the statement should look like in the following example.

```
{
    "keyspaceName": "myKeyspace",
    "tableName": "myTable",
    "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
myKeyspace/table/myTable",
    "creationTimestamp": "2024-09-02T10:52:22.190000+00:00",
    "status": "ACTIVE",
    "schemaDefinition": {
        "allColumns": [
            {
                "name": "id",
                "type": "int"
            },
            {
                "name": "date",
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
```

```
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-09-02T10:52:22.190000+00:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 2592000,
    "comment": {
        "message": ""
    },
    "replicaSpecifications": []
}
```

Create table with custom Time to Live (TTL) settings enabled

To create a new table with Time to Live custom settings that can be applied to rows and columns without enabling TTL default settings for the entire table, you can use the following commands.

> **Note**
>
> If a table is created with `ttl` custom settings enabled, you can't disable the setting later.

Cassandra Query Language (CQL)

Create a new table with custom TTL setting using CQL

- ```
  CREATE TABLE my_keyspace.my_table (id int primary key) WITH
   CUSTOM_PROPERTIES={'ttl':{'status': 'enabled'}};
  ```

CLI

Create a new table with custom TTL setting using the AWS CLI

1. You can use the following command to create a new table with TTL enabled.

   ```
   aws keyspaces create-table --keyspace-name 'myKeyspace' --table-name 'myTable' \
                                  --schema-definition
    'allColumns=[{name=id,type=int},{name=name,type=text},
    {name=date,type=timestamp}],partitionKeys=[{name=id}]' \
                                  --ttl 'status=ENABLED'
   ```

2. To confirm that TTL is enabled for the table, you can use the following statement.

   ```
   aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
   ```

   The output of the statement should look like in the following example.

   ```
   {
       "keyspaceName": "myKeyspace",
       "tableName": "myTable",
       "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
   myKeyspace/table/myTable",
       "creationTimestamp": "2024-09-02T10:52:22.190000+00:00",
       "status": "ACTIVE",
       "schemaDefinition": {
           "allColumns": [
            {
                   "name": "id",
                   "type": "int"
               },
               {
                   "name": "date",
                   "type": "timestamp"
   ```
   ```

```
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-09-02T11:18:55.796000+00:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    },
    "replicaSpecifications": []
}
```

Update table with custom Time to Live (TTL)

To enable Time to Live custom settings for a table so that TTL values can be applied to individual rows and columns without setting a TTL default value for the entire table, you can use the following commands.

Note

After `ttl` is enabled, you can't disable it for the table.

Cassandra Query Language (CQL)

Enable custom TTL settings for a table using CQL

- ```
  ALTER TABLE my_table WITH CUSTOM_PROPERTIES={'ttl':{'status': 'enabled'}};
  ```

CLI

Enable custom TTL settings for a table using the AWS CLI

1. You can use the following command to update the custom TTL setting of a table.

   ```
   aws keyspaces update-table --keyspace-name 'myKeyspace' --table-name 'myTable'
    --ttl 'status=ENABLED'
   ```

2. To confirm that TTL is now enabled for the table, you can use the following statement.

   ```
   aws keyspaces get-table --keyspace-name 'myKeyspace' --table-name 'myTable'
   ```

   The output of the statement should look like in the following example.

   ```
   {
       "keyspaceName": "myKeyspace",
       "tableName": "myTable",
       "resourceArn": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
   myKeyspace/table/myTable",
       "creationTimestamp": "2024-09-02T11:32:27.349000+00:00",
       "status": "ACTIVE",
       "schemaDefinition": {
           "allColumns": [
               {
                   "name": "id",
                   "type": "int"
               },
               {
   ```
   ```

```
                "name": "date",
                "type": "timestamp"
            },
            {
                "name": "name",
                "type": "text"
            }
        ],
        "partitionKeys": [
            {
                "name": "id"
            }
        ],
        "clusteringKeys": [],
        "staticColumns": []
    },
    "capacitySpecification": {
        "throughputMode": "PAY_PER_REQUEST",
        "lastUpdateToPayPerRequestTimestamp": "2024-09-02T11:32:27.349000+00:00"
    },
    "encryptionSpecification": {
        "type": "AWS_OWNED_KMS_KEY"
    },
    "pointInTimeRecovery": {
        "status": "DISABLED"
    },
    "ttl": {
        "status": "ENABLED"
    },
    "defaultTimeToLive": 0,
    "comment": {
        "message": ""
    },
    "replicaSpecifications": []
}
```

Use the INSERT statement to set custom Time to Live (TTL) values for new rows

> **Note**
>
> Before you can set custom TTL values for rows using the INSERT statement, you must first enable custom TTL on the table. For more information, see the section called “Update table custom TTL”.

To overwrite a table's default TTL value by setting expiration dates for individual rows, you can use the INSERT statement:

- INSERT – Insert a new row of data with a TTL value set.

Setting TTL values for new rows using the INSERT statement takes precedence over the default TTL setting of the table.

The following CQL statement inserts a row of data into the table and changes the default TTL setting to 259,200 seconds (which is equivalent to 3 days).

```
INSERT INTO my_table (userid, time, subject, body, user)
        VALUES (B79CB3BA-745E-5D9A-8903-4A02327A7E09, 96a29100-5e25-11ec-90d7-
b5d91eceda0a, 'Message', 'Hello','205.212.123.123')
        USING TTL 259200;
```

To confirm the TTL settings for the inserted row, use the following statement.

```
SELECT TTL (subject) from my_table;
```

Use the UPDATE statement to edit custom Time to Live (TTL) settings for rows and columns

> **Note**
>
> Before you can set custom TTL values for rows and columns, you must enable TTL on the table first. For more information, see the section called “Update table custom TTL”.

You can use the UPDATE statement to overwrite a table's default TTL value by setting the expiration date for individual rows and columns:

- Rows – You can update an existing row of data with a custom TTL value.
- Columns – You can update a subset of columns within existing rows with a custom TTL value.

Setting TTL values for rows and columns takes precedence over the default TTL setting for the table.

To change the TTL settings of the 'subject' column inserted earlier from 259,200 seconds (3 days) to 86,400 seconds (one day), use the following statement.

```
UPDATE my_table USING TTL 86400 set subject = 'Updated Message' WHERE userid =
 B79CB3BA-745E-5D9A-8903-4A02327A7E09 and time = 96a29100-5e25-11ec-90d7-b5d91eceda0a;
```

You can run a simple select query to see the updated record before the expiration time.

```
SELECT * from my_table;
```

The query shows the following output.

```
userid                                | time                                 | body  |
 subject         | user
--------------------------------------+--------------------------------------+-------
+-----------------+-----------------
b79cb3ba-745e-5d9a-8903-4a02327a7e09  | 96a29100-5e25-11ec-90d7-b5d91eceda0a | Hello |
 Updated Message | 205.212.123.123
50554d6e-29bb-11e5-b345-feff819cdc9f  | cf03fb21-59b5-11ec-b371-dff626ab9620 | Hello |
        Message | 205.212.123.123
```

To confirm that the expiration was successful, run the same query again after the configured expiration time.

```
SELECT * from my_table;
```

The query shows the following output after the 'subject' column has expired.

```
userid                                | time                                 | body  |
 subject | user
```

```
--------------------------------------+--------------------------------------+-------
+---------+----------------
b79cb3ba-745e-5d9a-8903-4a02327a7e09  | 96a29100-5e25-11ec-90d7-b5d91eceda0a | Hello |
   null | 205.212.123.123
50554d6e-29bb-11e5-b345-feff819cdc9f  | cf03fb21-59b5-11ec-b371-dff626ab9620 | Hello |
 Message | 205.212.123.123
```

Using this service with an AWS SDK

AWS software development kits (SDKs) are available for many popular programming languages. Each SDK provides an API, code examples, and documentation that make it easier for developers to build applications in their preferred language.

SDK documentation	Code examples
AWS SDK for C++	AWS SDK for C++ code examples
AWS CLI	AWS CLI code examples
AWS SDK for Go	AWS SDK for Go code examples
AWS SDK for Java	AWS SDK for Java code examples
AWS SDK for JavaScript	AWS SDK for JavaScript code examples
AWS SDK for Kotlin	AWS SDK for Kotlin code examples
AWS SDK for .NET	AWS SDK for .NET code examples
AWS SDK for PHP	AWS SDK for PHP code examples
AWS Tools for PowerShell	AWS Tools for PowerShell code examples
AWS SDK for Python v4	AWS SDK for Python v4 code examples
AWS SDK for Python (Boto3)	AWS SDK for Python (Boto3) code examples
AWS SDK for Ruby	AWS SDK for Ruby code examples
AWS SDK for Rust	AWS SDK for Rust code examples

SDK documentation	Code examples
AWS SDK for SAP ABAP	AWS SDK for SAP ABAP code examples
AWS SDK for Swift	AWS SDK for Swift code examples

Example availability

Can't find what you need? Request a code example by using the **Provide feedback** link at the bottom of this page.

Working with tags and labels for Amazon Keyspaces resources

You can label Amazon Keyspaces (for Apache Cassandra) resources using *tags*. Tags let you categorize your resources in different ways—for example, by purpose, owner, environment, or other criteria. Tags can help you do the following:

- Quickly identify a resource based on the tags that you assigned to it.
- See AWS bills broken down by tags.
- Control access to Amazon Keyspaces resources based on tags. For IAM policy examples using tags, see the section called “Authorization based on Amazon Keyspaces tags”.

Tagging is supported by AWS services like Amazon Elastic Compute Cloud (Amazon EC2), Amazon Simple Storage Service (Amazon S3), Amazon Keyspaces, and more. Efficient tagging can provide cost insights by enabling you to create reports across services that carry a specific tag.

To get started with tagging, do the following:

1. Understand Restrictions for using tags to label resources in Amazon Keyspaces.
2. Create tags by using Tag keyspaces, tables, and streams in Amazon Keyspaces.
3. Use Create cost allocation reports using tags for Amazon Keyspaces to track your AWS costs per active tag.

Finally, it is good practice to follow optimal tagging strategies. For information, see AWS tagging strategies.

Restrictions for using tags to label resources in Amazon Keyspaces

Each tag consists of a key and a value, both of which you define. The following restrictions apply:

- Each Amazon Keyspaces keyspace, table, or stream can have only one tag with the same key. If you try to add an existing tag (same key), the existing tag value is updated to the new value.
- Tags applied to a keyspace don't automatically apply to tables within that keyspace. To apply the same tag to a keyspace and all its tables, each resource must be individually tagged.
- Tags applied to a table don't automatically apply to the stream of that table. To apply the same tags to a table and the stream during table creation, you can use the `PropagateTagsOnEnable` flag when you create the table. Using this flag, Amazon Keyspaces applies the tags of the table to the stream during stream creation. When the stream is active, changes to the table tags don't apply to the stream.
- When you create a multi-Region keyspace or table, any tags that you define during the creation process are automatically applied to all keyspaces and tables in all Regions. When you change existing tags using `ALTER KEYSPACE` or `ALTER TABLE`, the update is only applied to the keyspace or table in the Region where you're making the change.
- A value acts as a descriptor within a tag category (key). In Amazon Keyspaces the value cannot be empty or null.
- Tag keys and values are case sensitive.
- The maximum key length is 128 Unicode characters.
- The maximum value length is 256 Unicode characters.
- The allowed characters are letters, white space, and numbers, plus the following special characters: `+ - = . _ : /`
- The maximum number of tags per resource is 50.
- AWS-assigned tag names and values are automatically assigned the `aws:` prefix, which you can't assign. AWS-assigned tag names don't count toward the tag limit of 50. User-assigned tag names have the prefix `user:` in the cost allocation report.
- You can't backdate the application of a tag.

Tag keyspaces, tables, and streams in Amazon Keyspaces

You can add, list, edit, or delete tags for keyspaces, tables, and streams using the Amazon Keyspaces console, the AWS CLI, or Cassandra Query Language (CQL). You can then activate these

user-defined tags so that they appear on the AWS Billing and Cost Management console for cost allocation tracking. For more information, see Create cost allocation reports using tags for Amazon Keyspaces.

For bulk editing, you can also use Tag Editor on the console. For more information, see Working with Tag Editor in the *AWS Resource Groups User Guide*.

For information about tag structure, see Restrictions for using tags to label resources in Amazon Keyspaces.

Topics

- Add tags when creating a new keyspace
- Add tags to a keyspace
- Delete tags from a keyspace
- View the tags of a keyspace
- Add tags when creating a new table
- Add tags to a table
- Delete tags from a table
- View the tags of a table
- Add tags to a new stream when creating a table
- Add tags to a new stream for an existing table
- Add new tags to a stream
- Delete tags from a stream
- View the tags of a stream

Add tags when creating a new keyspace

You can use the Amazon Keyspaces console, CQL or the AWS CLI to add tags when you create a new keyspace.

Console

Set a tag when creating a new keyspace using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.

2. In the navigation pane, choose **Keyspaces**, and then choose **Create keyspace**.
3. On the **Create keyspace** page, provide a name for the keyspace.
4. Under **Tags** choose **Add new tag** and enter a key and a value.
5. Choose **Create keyspace**.

Cassandra Query Language (CQL)

Set a tag when creating a new keyspace using CQL

- The following example creates a new keyspace with tags.

```
CREATE KEYSPACE mykeyspace WITH TAGS = {'key1':'val1', 'key2':'val2'};
```

CLI

Set a tag when creating a new keyspace using the AWS CLI

- The following statement creates a new keyspace with tags.

```
aws keyspaces create-keyspace --keyspace-name 'myKeyspace' --tags
 'key=key1,value=val1' 'key=key2,value=val2'
```

Add tags to a keyspace

The following examples show how to add tags to a keyspace in Amazon Keyspaces.

Console

Add a tag to an existing keyspace using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose a keyspace from the list. Then choose the **Tags** tab where you can view the tags of the keyspace.
4. Choose **Manage tags** to add, edit, or delete tags.

5. Choose **Save changes**.

Cassandra Query Language (CQL)

Add a tag to an existing keyspace using CQL

- ```
  ALTER KEYSPACE mykeyspace ADD TAGS {'key1':'val1', 'key2':'val2'};
  ```

CLI

Add a tag to an existing keyspace using the AWS CLI

- The following example shows how to add new tags to an existing keyspace.

  ```
  aws keyspaces tag-resource --resource-arn 'arn:aws:cassandra:us-
  east-1:111122223333:/keyspace/myKeyspace/' --tags 'key=key3,value=val3'
   'key=key4,value=val4'
  ```

Delete tags from a keyspace

Console

Delete a tag from an existing keyspace using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose a keyspace from the list. Then choose the **Tags** tab where you can view the tags of the keyspace.
4. Choose **Manage tags** and delete the tags you don't need anymore.
5. Choose **Save changes**.
  ```

Cassandra Query Language (CQL)

Delete a tag from an existing keyspace using CQL

- ```
  ALTER KEYSPACE mykeyspace DROP TAGS {'key1':'val1', 'key2':'val2'};
  ```

CLI

Delete a tag from an existing keyspace using the AWS CLI

- The following statement removes the specified tags from a keyspace.

  ```
  aws keyspaces untag-resource --resource-arn 'arn:aws:cassandra:us-
  east-1:111122223333:/keyspace/myKeyspace/' --tags 'key=key3,value=val3'
   'key=key4,value=val4'
  ```

View the tags of a keyspace

The following examples show how to read tags using the console, CQL or the AWS CLI.

Console

View the tags of a keyspace using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Keyspaces**.
3. Choose a keyspace from the list. Then choose the **Tags** tab where you can view the tags of the keyspace.

Cassandra Query Language (CQL)

View the tags of a keyspace using CQL

To read the tags attached to a keyspace, use the following CQL statement.

```
SELECT * FROM system_schema_mcs.tags WHERE valid_where_clause;
```
```

The WHERE clause is required, and must use one of the following formats:

- `keyspace_name = 'mykeyspace' AND resource_type = 'keyspace'`
- `resource_id = arn`

- The following statement shows whether a keyspace has tags.

```
SELECT * FROM system_schema_mcs.tags WHERE keyspace_name = 'mykeyspace' AND
 resource_type = 'keyspace';
```

The output of the query looks like the following.

```
resource_id                                                          | keyspace_name
 | resource_name | resource_type | tags
-------------------------------------------------------------------
+---------------+---------------+---------------+------
arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/      | mykeyspace
    | mykeyspace    | keyspace      | {'key1': 'val1', 'key2': 'val2'}
```

CLI

View the tags of a keyspace using the AWS CLI

- This example shows how to list the tags of the specified resource.

```
aws keyspaces list-tags-for-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/myKeyspace/'
```

The output of the last command looks like this.

```
{
    "tags": [
        {
            "key": "key1",
            "value": "val1"
        },
        {
            "key": "key2",
```

```
            "value": "val2"
        },
        {
            "key": "key3",
            "value": "val3"
        },
        {
            "key": "key4",
            "value": "val4"
        }
    ]
}
```

Add tags when creating a new table

You can use the Amazon Keyspaces console, CQL or the AWS CLI to add tags to new tables when you create them.

Console

Add a tag when creating a new table using the (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the table.
4. In the **Schema** section, create the schema for your table.
5. In the **Table settings** section, choose **Customize settings**.
6. Continue to the **Table tags – *optional*** section, and choose **Add new tag** to create new tags.
7. Choose **Create table**.

Cassandra Query Language (CQL)

Add tags when creating a new table using CQL

- The following example creates a new table with tags.

```
CREATE TABLE mytable(...) WITH TAGS = {'key1':'val1', 'key2':'val2'};
```

CLI

Add tags when creating a new table using the AWS CLI

- The following example shows how to create a new table with tags. The command creates a table *myTable* in an already existing keyspace *myKeyspace*. Note that the command has been broken up into different lines to help with readability.

```
aws keyspaces create-table --keyspace-name 'myKeyspace' --table-name 'myTable'
            --schema-definition 'allColumns=[{name=id,type=int},
{name=name,type=text},{name=date,type=timestamp}],partitionKeys=[{name=id}]'
            --tags 'key=key1,value=val1' 'key=key2,value=val2'
```

Add tags to a table

You can add tags to an existing table in Amazon Keyspaces using the console, CQL or the AWS CLI.

Console

Add tags to a table using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose a table from the list and choose the **Tags** tab.
4. Choose **Manage tags** to add tags to the table.
5. Choose **Save changes**.

Cassandra Query Language (CQL)

Add tags to a table using CQL

- The following statement shows how to add tags to an existing table.

```
ALTER TABLE mykeyspace.mytable ADD TAGS {'key1':'val1', 'key2':'val2'};
```

CLI

Add tags to a table using the AWS CLI

- The following example shows how to add new tags to an existing table.

```
aws keyspaces tag-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/myKeyspace/table/myTable' --tags
 'key=key3,value=val3' 'key=key4,value=val4'
```

Delete tags from a table

Console

Delete tags from a table using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose a table from the list and choose the **Tags** tab.
4. Choose **Manage tags** to delete tags from the table.
5. Choose **Save changes**.

Cassandra Query Language (CQL)

Delete tags from a table using CQL

- The following statement shows how to delete tags from an existing table.

```
ALTER TABLE mytable DROP TAGS {'key3':'val3', 'key4':'val4'};
```

CLI

Add tags to a table using the AWS CLI

- The following statement removes the specified tags from a keyspace.

```
aws keyspaces untag-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/myKeyspace/table/myTable' --tags
 'key=key3,value=val3' 'key=key4,value=val4'
```

View the tags of a table

The following examples show how to view the tags of a table in Amazon Keyspaces using the console, CQL, or the AWS CLI.

Console

View the tags of a table using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose a table from the list and choose the **Tags** tab.

Cassandra Query Language (CQL)

View the tags of a table using CQL

To read the tags attached to a table, use the following CQL statement.

```
SELECT * FROM system_schema_mcs.tags WHERE valid_where_clause;
```

The WHERE clause is required, and must use one of the following formats:

- `keyspace_name = 'mykeyspace' AND resource_name = 'mytable'`
- `resource_id = arn`

- The following query returns the tags of the specified table.

```
SELECT * FROM system_schema_mcs.tags WHERE keyspace_name = 'mykeyspace' AND
 resource_name = 'mytable';
```

The output of that query looks like the following.

```
resource_id                                                                  |
 keyspace_name | resource_name | resource_type | tags
------------------------------------------------------------------------------
+---------------+---------------+---------------+------
arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/mytable|
 mykeyspace    | mytable       | table         | {'key1': 'val1', 'key2':
 'val2'}
```

CLI

View the tags of a table using the AWS CLI

- This example shows how to list the tags of the specified resource.

```
aws keyspaces list-tags-for-resource --resource-arn
 'arn:aws:arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/
table/my_table/stream/2025-05-11T21:21:33.291cassandra:us-east-1:111122223333:/
keyspace/myKeyspace/table/myTable'
```

The output of the last command looks like this.

```
{
    "tags": [
        {
            "key": "key1",
            "value": "val1"
        },
        {
            "key": "key2",
            "value": "val2"
        },
        {
            "key": "key3",
```

```
            "value": "val3"
        },
        {
            "key": "key4",
            "value": "val4"
        }
    ]
}
```

Add tags to a new stream when creating a table

You can add tags to streams when you create a new table with a stream using CQL or the AWS CLI to tag a stream.

> **Note**
>
> Amazon Keyspaces CDC requires the presence of a service-linked role (`AWSServiceRoleForAmazonKeyspacesCDC`) that publishes metric data from Amazon Keyspaces CDC streams into the `"cloudwatch:namespace": "AWS/Cassandra"` in your CloudWatch account on your behalf. This role is created automatically for you. For more information, see the section called “CDC streams”.

Cassandra Query Language (CQL)

Add tags to a stream when creating a new table using CQL

1. To create a new table with a stream and apply the table tags automatically to the stream, you can use the `'propagate_tags': 'TABLE'` flag. The following statement is an example of this.

```
CREATE TABLE mytable (pk int, ck text, PRIMARY KEY(pk))
WITH TAGS={'key1':'val1', 'key2':'val2'}
AND cdc = TRUE
AND CUSTOM_PROPERTIES={
    'cdc_specification': {
        'view_type': 'NEW_IMAGE',
        'propagate_tags': 'TABLE'
    }
};
```

2. To apply new tags to the stream, you can use the following example.

```
CREATE TABLE mytable (pk int, ck text, PRIMARY KEY(pk))
WITH TAGS={'key1':'val1', 'key2':'val2'}
AND cdc = TRUE
AND CUSTOM_PROPERTIES={
    'cdc_specification': {
        'view_type': 'NEW_IMAGE',
        'tags': { 'key': 'string', 'value': 'string' },
    }
};
```

CLI

Add tags to a stream when creating a new table using the AWS CLI

1. To create a table with a stream and apply the table tags automatically to the stream, you can use the `propagateTags=Table` flag. The following code is an example of this.

```
aws keyspaces create-table \
--keyspace-name 'my_keyspace' \
--table-name 'my_table' \
--schema-definition 'allColumns=[{name=pk,type=int},
{name=ck,type=text}],clusteringKeys=[{name=ck,orderBy=ASC}],partitionKeys=[{name=pk}]'
 \
--tags key=tag_key,value=tag_value
--cdc-specification propagateTags=TABLE,status=ENABLED,viewType=NEW_IMAGE
```

2. To apply different tags to the stream, you can use the following example.

```
aws keyspaces create-table \
--keyspace-name 'my_keyspace' \
--table-name 'my_table' \
--schema-definition 'allColumns=[{name=pk,type=int},
{name=ck,type=text}],clusteringKeys=[{name=ck,orderBy=ASC}],partitionKeys=[{name=pk}]'
 \
--tags key=tag_key,value=tag_value
--cdc-specification 'status=ENABLED,viewType=NEW_IMAGE,tags=[{key=tag_key,
 value=tag_value}]'
```

Add tags to a new stream for an existing table

You can add tags when you create a new stream for an existing table. You can either use the `PropagateTags` flag to apply the table tags to the stream or specify new tags for the stream. You can use CQL or the AWS CLI to tag a new stream.

> **Note**
>
> Amazon Keyspaces CDC requires the presence of a service-linked role (`AWSServiceRoleForAmazonKeyspacesCDC`) that publishes metric data from Amazon Keyspaces CDC streams into the `"cloudwatch:namespace": "AWS/Cassandra"` in your CloudWatch account on your behalf. This role is created automatically for you. For more information, see the section called “CDC streams”.

Console

Add tags when creating a new stream using the (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose the table you want to add a stream for.
3. Choose the **Streams** tab.
4. In the **Stream details** section, choose **Edit**.
5. Select **Turn on streams** .
6. Select the **View type** and continue to **Tags** to create tags for the stream.
7. You can select one of the following options:
   - **No tags** – Use this option if you don't want to create any tags for the stream.
   - **Copy tags from table** – Use this option if you want to copy the tags from the table to the stream. After copying the tags, you can edit them for the stream. Note that this option is only available if the table has tags.
   - **Add new tags** – You can add up to 50 tags for the stream by choosing **Add new tag**.
8. Choose **Save changes**.

Cassandra Query Language (CQL)

Add tags when creating a new stream

1. To create a new stream for an existing table and apply the table's tags to the stream, you can use the `'propagate_tags': 'TABLE'` flag. The following statements is an example of this.

```
ALTER TABLE mytable WITH cdc = TRUE AND CUSTOM_PROPERTIES={ 'cdc_specification':
 { 'view_type': 'NEW_IMAGE', 'propagate_tags': 'TABLE' } };
```

2. To create a new stream for an existing table and specify new tags, you can use the following example.

```
ALTER TABLE mytable WITH cdc = TRUE AND CUSTOM_PROPERTIES={ 'cdc_specification':
 { 'view_type': 'NEW_IMAGE', 'tags': { 'key': 'string', 'value': 'string' }} };
```

CLI

Add tags when creating a new stream using the AWS CLI

1. To create a new stream with tags, you can use the `propagateTags=TABLE` flag to apply the table's tags automatically to the stream. The following code is an example of this.

```
aws keyspaces update-table \
--keyspace-name 'my_keyspace' \
--table-name 'my_table' \
--cdc-specification propagateTags=TABLE,status=ENABLED,viewType=NEW_IMAGE
```

2. To create a new stream for an existing table and specify new tags, you can use the following example.

```
aws keyspaces update-table \
--keyspace-name 'my_keyspace' \
--table-name 'my_table' \
--cdc-specification 'status=ENABLED,viewType=NEW_IMAGE,tags=[{key=tag_key,
 value=tag_value}]'
```

Add new tags to a stream

You can add new tags to an existing stream in Amazon Keyspaces using the CQL or the AWS CLI. You can only add tags to the latest stream.

Console

Add tags to an existing stream (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose the table with the stream that you want to tag.
3. Choose the **Streams** tab.
4. In the **Tags** section, choose **Manage tags**.
5. Choose **Add new tag** to add a new tag. You can create up to 50 tags by repeating this step.
6. Choose **Save changes**.

Cassandra Query Language (CQL)

Add tags to a stream using CQL

- The following statement shows how to add tags to an existing stream.

```
ALTER TABLE mykeyspace.mytable ADD TAGS_FOR_CDC {'key1':'val1', 'key2':'val2'};
```

CLI

Add tags to a stream using the AWS CLI

- The following example shows how to add new tags to an existing stream.

```
aws keyspaces tag-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/my_keyspace/table/my_table/
stream/2025-05-11T21:21:33.291' --tags 'key=key3,value=val3'
 'key=key4,value=val4'
```

Delete tags from a stream

To delete tags from a stream, you can use CQL or the AWS CLI. You can only delete the tags for the latest stream.

Console

Delete tags from a table using the Amazon Keyspaces console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose a table from the list and choose the **Streams** tab.
4. In the **Tags** section choose **Manage tags** to delete tags from the table.
5. After the tag you want to delete, choose **Remove**.
6. Choose **Save changes**.

Cassandra Query Language (CQL)

Delete tags from a stream using CQL

- The following statement shows how to delete tags from an existing stream.

```
ALTER TABLE mytable DROP TAGS_FOR_CDC {'key3':'val3', 'key4':'val4'};
```

CLI

Delete tags from a stream using the AWS CLI

- The following statement removes the specified tags from a stream.

```
aws keyspaces untag-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/my_keyspace/table/my_table/
stream/2025-05-11T21:21:33.291' --tags 'key=key3,value=val3'
 'key=key4,value=val4'
```

View the tags of a stream

The following examples show how to view the tags of a stream in Amazon Keyspaces using CQL or the AWS CLI.

Console

View the tags of a stream using the console

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose a table from the list and choose the **Streams** tab.
4. You can view the tags of the stream in the **Tags** section.

Cassandra Query Language (CQL)

View the tags of a stream using CQL

To read the tags attached to a stream, you must specify the resource ARN of the stream in the `WHERE` clause. The following CQL syntax is an example of this.

```
SELECT * FROM system_schema_mcs.tags WHERE resource_id = stream_arn;
```

- The following query returns the tags for the specified stream.

  ```
  SELECT tags FROM system_schema_mcs.tags WHERE resource_id =
   'arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/table/my_table/
  stream/2025-05-06T17:17:39.800';
  ```

  The output of that query looks like the following.

  ```
   resource_id
                                       | keyspace_name | resource_name           |
   resource_type | tags
   ------------------------------------------------------------------------------------------
  +--------------+------------------------+--------------
  +----------------------
  ```

```
 arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/table/my_table/
stream/2025-04-02T23:00:07.052     |      singleks | 2025-04-02T23:00:07.052 |
      stream | {'tagkey': 'tagval'}
```

CLI

View the tags of a stream using the AWS CLI

- This example shows how to list the tags for all streams under the specified keyspace.

```
aws keyspaces list-tags-for-resource --resource-arn 'arn:aws:cassandra:us-
east-1:111122223333:/keyspace/my_keyspace/table/my_table/
stream/2025-05-11T21:21:33.291'
```

The output of the last command looks like this.

```
{
    "tags": [
        {
            "key": "key1",
            "value": "val1"
        },
        {
            "key": "key2",
            "value": "val2"
        },
        {
            "key": "key3",
            "value": "val3"
        },
        {
            "key": "key4",
            "value": "val4"
        }
    ]
}
```

Create cost allocation reports using tags for Amazon Keyspaces

AWS uses tags to organize resource costs on your cost allocation report. AWS provides two types of cost allocation tags:

- An AWS-generated tag. AWS defines, creates, and applies this tag for you.
- User-defined tags. You define, create, and apply these tags.

You must activate both types of tags separately before they can appear in Cost Explorer or on a cost allocation report.

To activate AWS-generated tags:

1. Sign in to the AWS Management Console and open the Billing and Cost Management console at https://console.aws.amazon.com/billing/home#/.
2. In the navigation pane, choose **Cost Allocation Tags**.
3. Under **AWS-Generated Cost Allocation Tags**, choose **Activate**.

To activate user-defined tags:

1. Sign in to the AWS Management Console and open the Billing and Cost Management console at https://console.aws.amazon.com/billing/home#/.
2. In the navigation pane, choose **Cost Allocation Tags**.
3. Under **User-Defined Cost Allocation Tags**, choose **Activate**.

After you create and activate tags, AWS generates a cost allocation report with your usage and costs grouped by your active tags. The cost allocation report includes all of your AWS costs for each billing period. The report includes both tagged and untagged resources, so that you can clearly organize the charges for resources.

> **Note**
>
> Currently, any data transferred out from Amazon Keyspaces won't be broken down by tags on cost allocation reports.

For more information, see Using cost allocation tags.

Create Amazon Keyspaces resources with AWS CloudFormation

Amazon Keyspaces is integrated with AWS CloudFormation, a service that helps you model and set up your AWS keyspaces and tables so that you can spend less time creating and managing your resources and infrastructure. You create a template that describes the keyspaces and tables that you want, and CloudFormation takes care of provisioning and configuring those resources for you.

When you use CloudFormation, you can reuse your template to set up your Amazon Keyspaces resources consistently and repeatedly. Just describe your resources once, and then provision the same resources over and over in multiple AWS accounts and Regions.

Amazon Keyspaces and CloudFormation templates

To provision and configure resources for Amazon Keyspaces, you must understand CloudFormation templates. Templates are formatted text files in JSON or YAML. These templates describe the resources that you want to provision in your CloudFormation stacks. If you're unfamiliar with JSON or YAML, you can use CloudFormation Designer to help you get started with CloudFormation templates. For more information, see What is CloudFormation designer? in the *AWS CloudFormation User Guide*.

Amazon Keyspaces supports creating keyspaces and tables in CloudFormation. For the tables you create using CloudFormation templates, you can specify the schema, read/write mode, provisioned throughput settings, and other supported features. For more information, including examples of JSON and YAML templates for keyspaces and tables, see Amazon Keyspaces (for Apache Cassandra) resource type reference in the *AWS CloudFormation Template Reference*.

Learn more about CloudFormation

To learn more about CloudFormation, see the following resources:

- AWS CloudFormation
- AWS CloudFormation User Guide
- AWS CloudFormation command line interface User Guide

Using NoSQL Workbench with Amazon Keyspaces (for Apache Cassandra)

NoSQL Workbench is a client-side application that helps you design and visualize nonrelational data models for Amazon Keyspaces more easily. NoSQL Workbench clients are available for Windows, macOS, and Linux.

Designing data models and creating resources automatically

NoSQL Workbench provides you a point-and-click interface to design and create Amazon Keyspaces data models. You can easily create new data models from scratch by defining keyspaces, tables, and columns. You can also import existing data models and make modifications (such as adding, editing, or removing columns) to adapt the data models for new applications. NoSQL Workbench then enables you to commit the data models to Amazon Keyspaces or Apache Cassandra, and create the keyspaces and tables automatically. To learn how to build data models, see the section called “Create a data model” and the section called “Edit a data model”.

Visualizing data models

Using NoSQL Workbench, you can visualize your data models to help ensure that the data models can support your application’s queries and access patterns. You can also save and export your data models in a variety of formats for collaboration, documentation, and presentations. For more information, see the section called “Visualize a data model”.

Topics

- Download NoSQL Workbench
- Getting started with NoSQL Workbench
- Visualize data models with NoSQL Workbench
- Create a new data model with NoSQL Workbench
- Edit existing data models with NoSQL Workbench
- How to commit data models to Amazon Keyspaces and Apache Cassandra
- Sample data models in NoSQL Workbench
- Release history for NoSQL Workbench

Download NoSQL Workbench

Follow these instructions to download and install NoSQL Workbench.

To download and install NoSQL Workbench

1. Use one of the following links to download NoSQL Workbench for free.

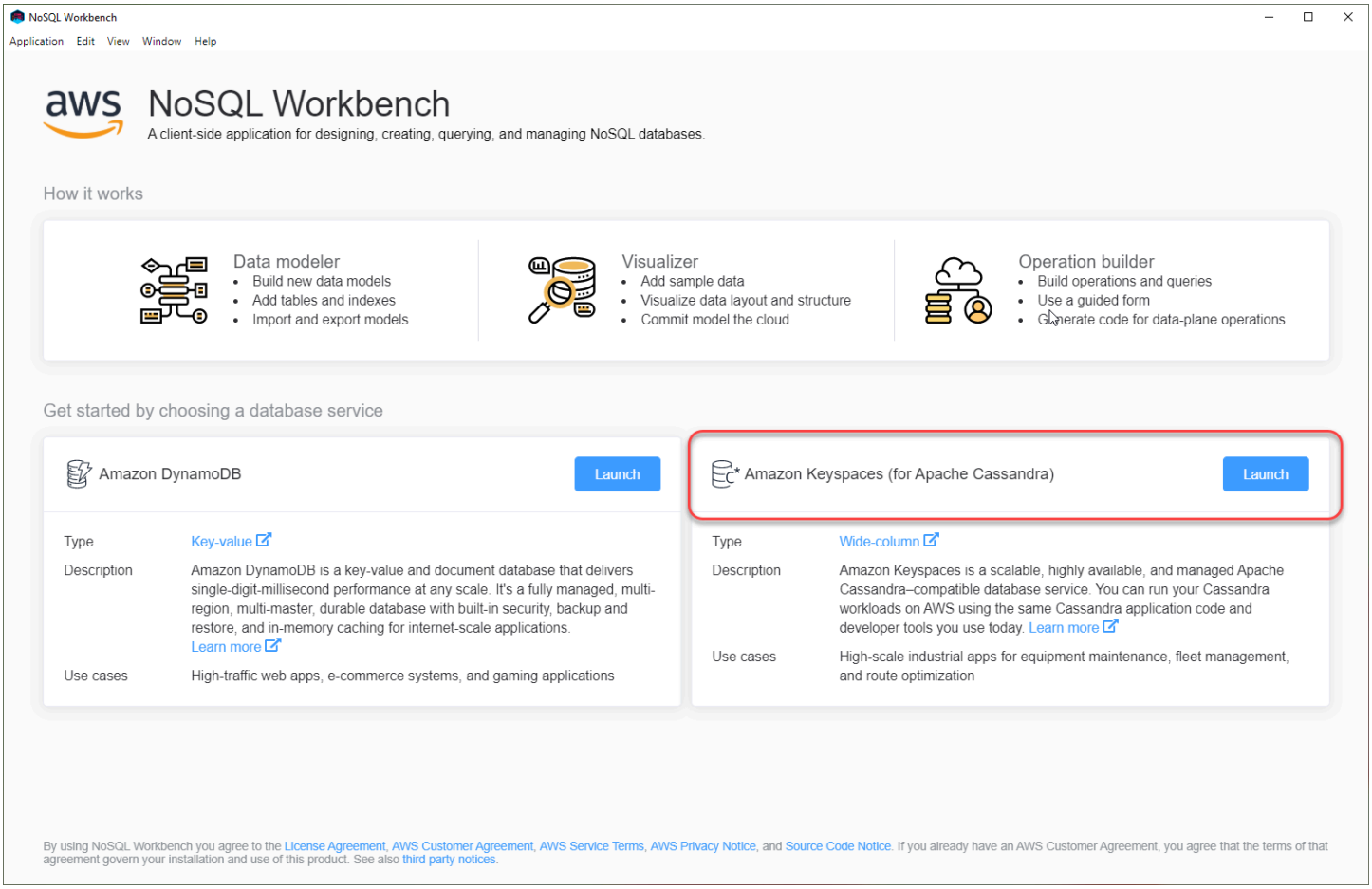
Operating System	Download Link
macOS	Download for macOS
Linux*	Download for Linux
Windows	Download for Windows

   * NoSQL Workbench supports Ubuntu 12.04, Fedora 21, and Debian 8 or any newer versions of these Linux distributions.

2. After the download completes, start the application and follow the onscreen instructions to complete the installation.

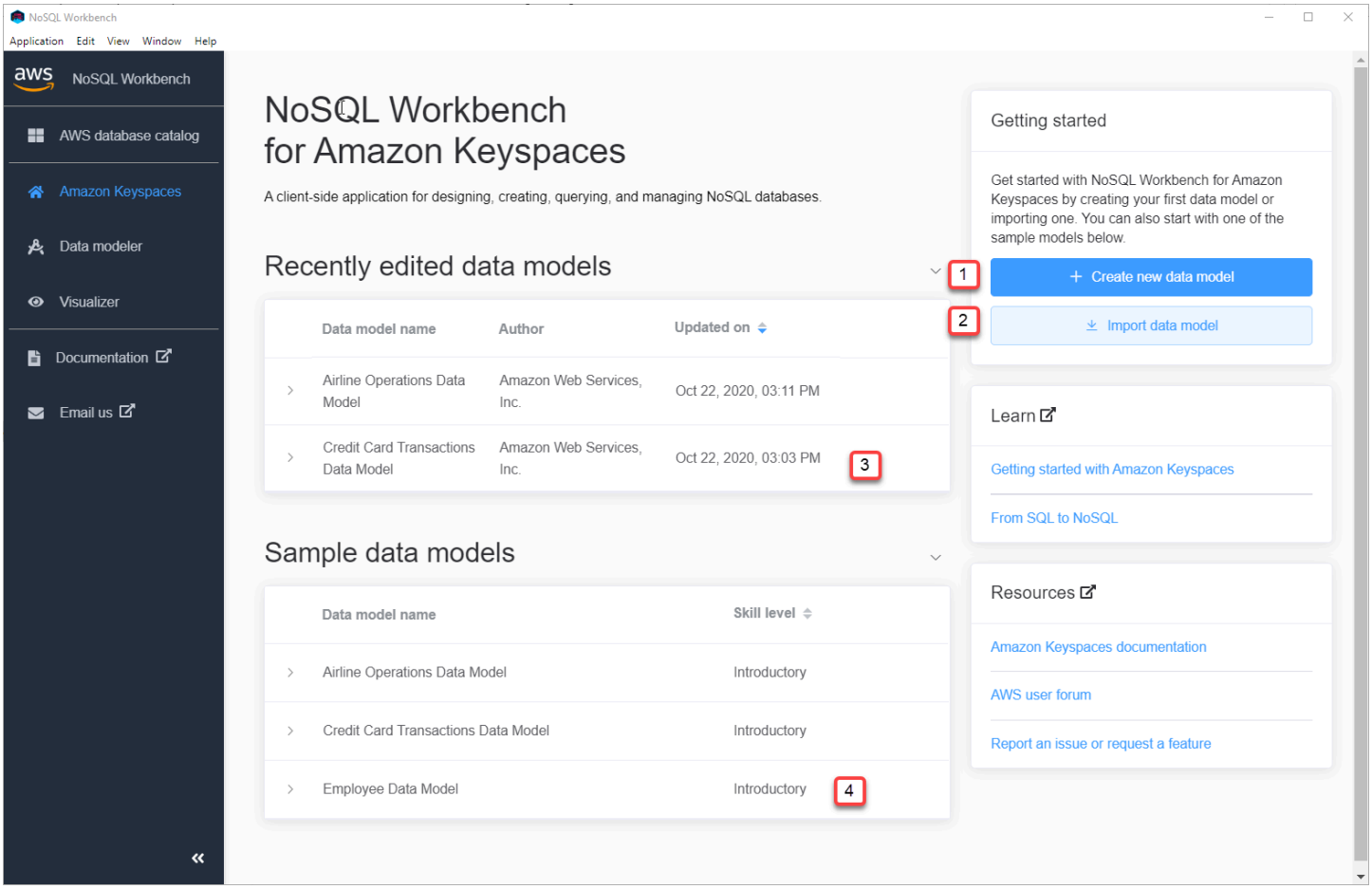
Getting started with NoSQL Workbench

To get started with NoSQL Workbench, on the Database Catalog page in NoSQL Workbench, choose Amazon Keyspaces, and then choose **Launch**.



This opens the NoSQL Workbench home page for Amazon Keyspaces where you have the following options to get started:

1. Create a new data model.
2. Import an existing data model in JSON format.
3. Open a recently edited data model.
4. Open one of the available sample models.



Each of the options opens the NoSQL Workbench data modeler. To continue creating a new data model, see the section called "Create a data model". To edit an existing data model, see the section called "Edit a data model".

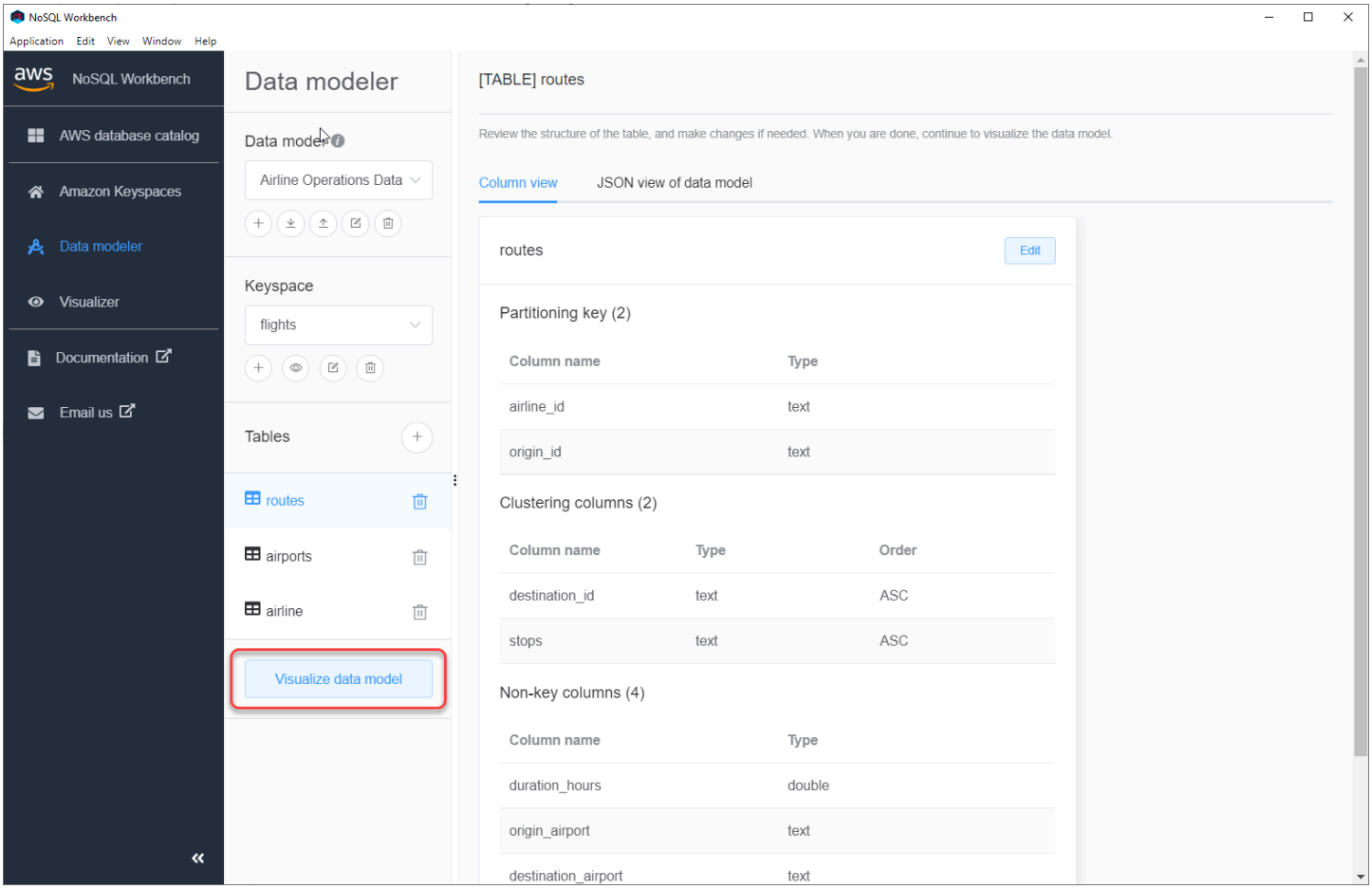
Visualize data models with NoSQL Workbench

Using NoSQL Workbench, you can visualize your data models to help ensure that the data models can support your application's queries and access patterns. You also can save and export your data models in a variety of formats for collaboration, documentation, and presentations.

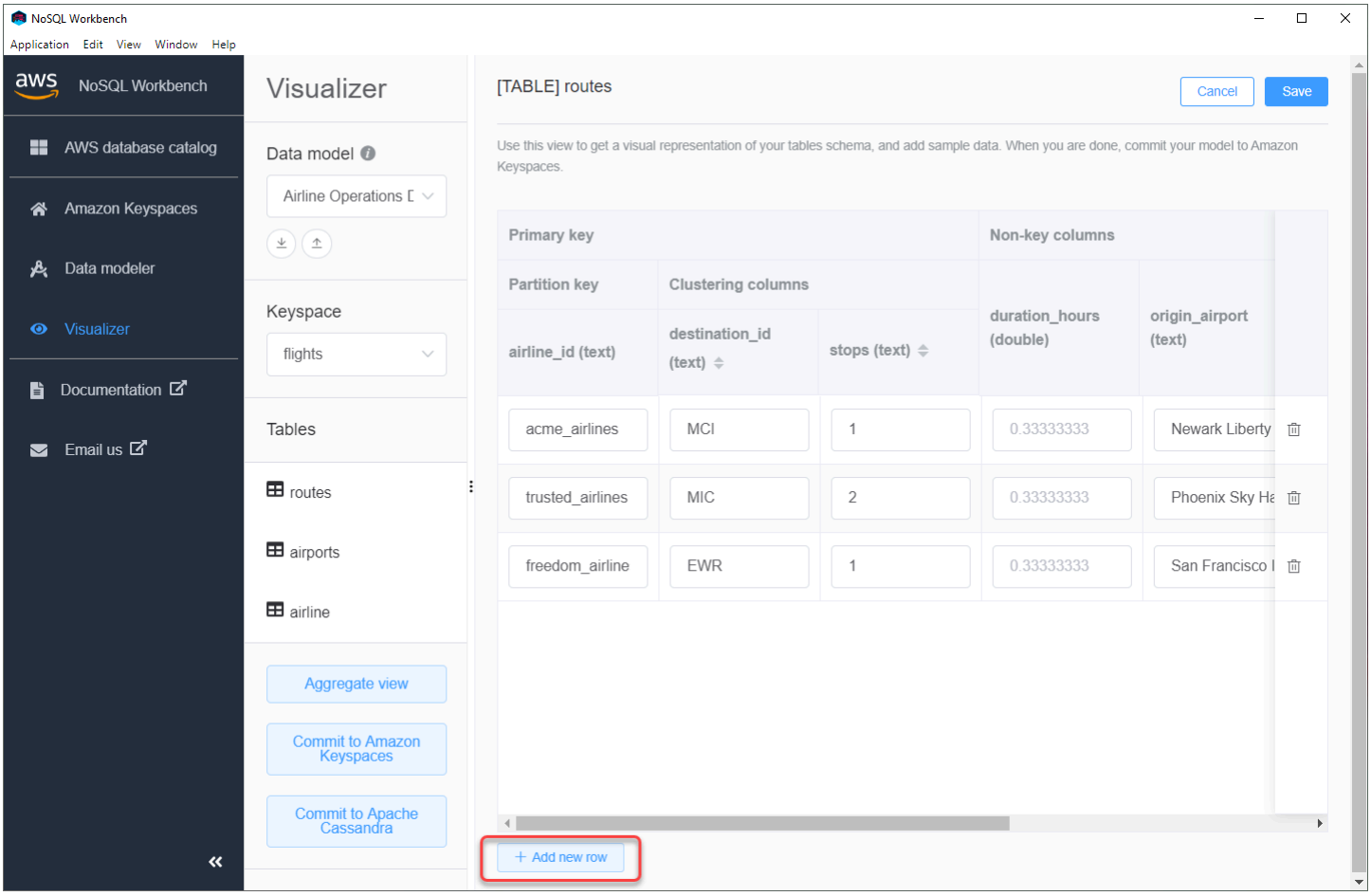
After you have created a new data model or edited an existing data model, you can visualize the model.

Visualizing data models with NoSQL Workbench

When you have completed the data model in the data modeler, choose **Visualize data model**.

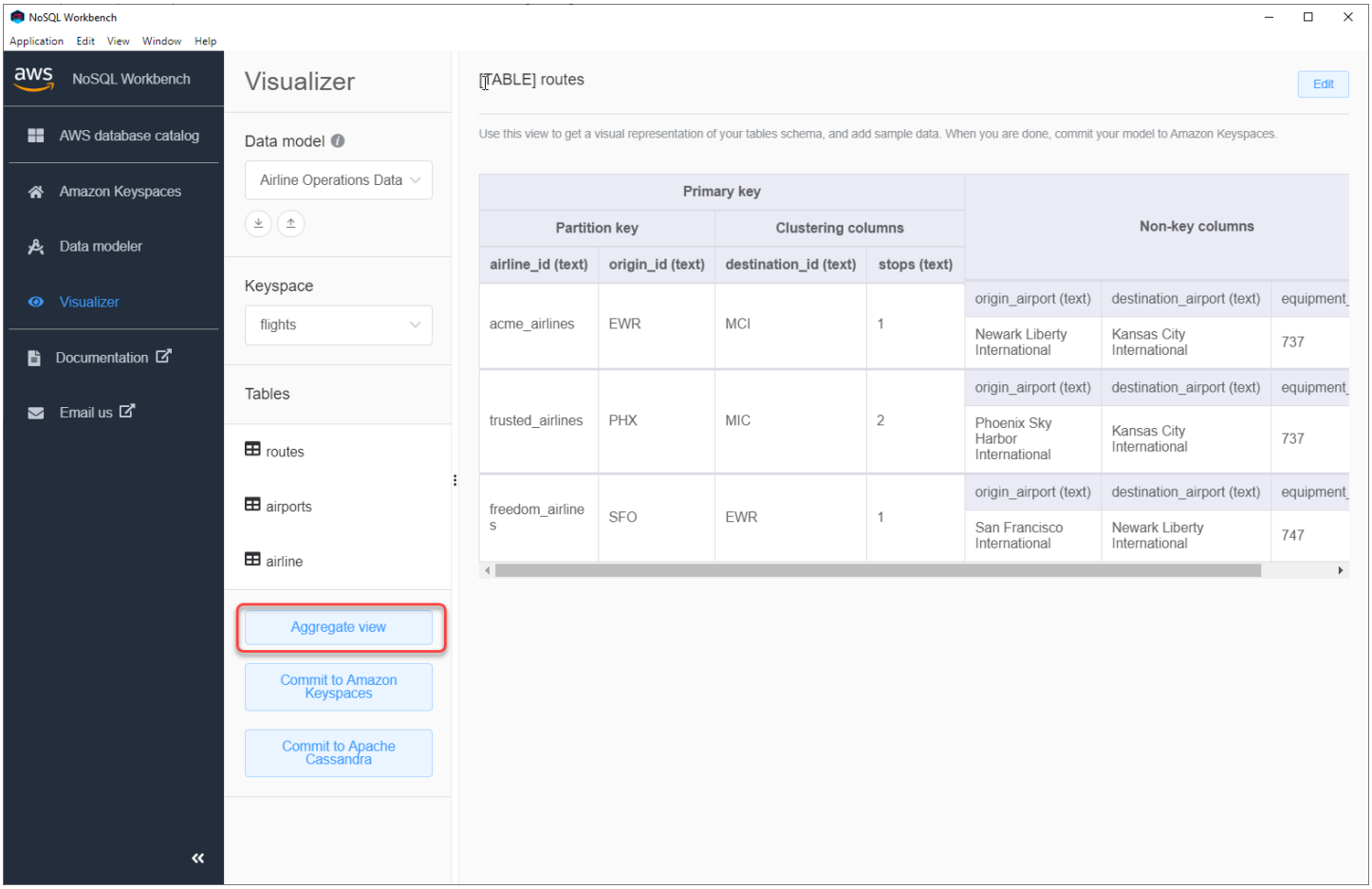


This takes you to the data visualizer in NoSQL Workbench. The data visualizer provides a visual representation of the table's schema and lets you add sample data. To add sample data to a table, choose a table from the model, and then choose **Edit**. To add a new row of data, choose **Add new row** at the bottom of the screen. Choose **Save** when you're done.



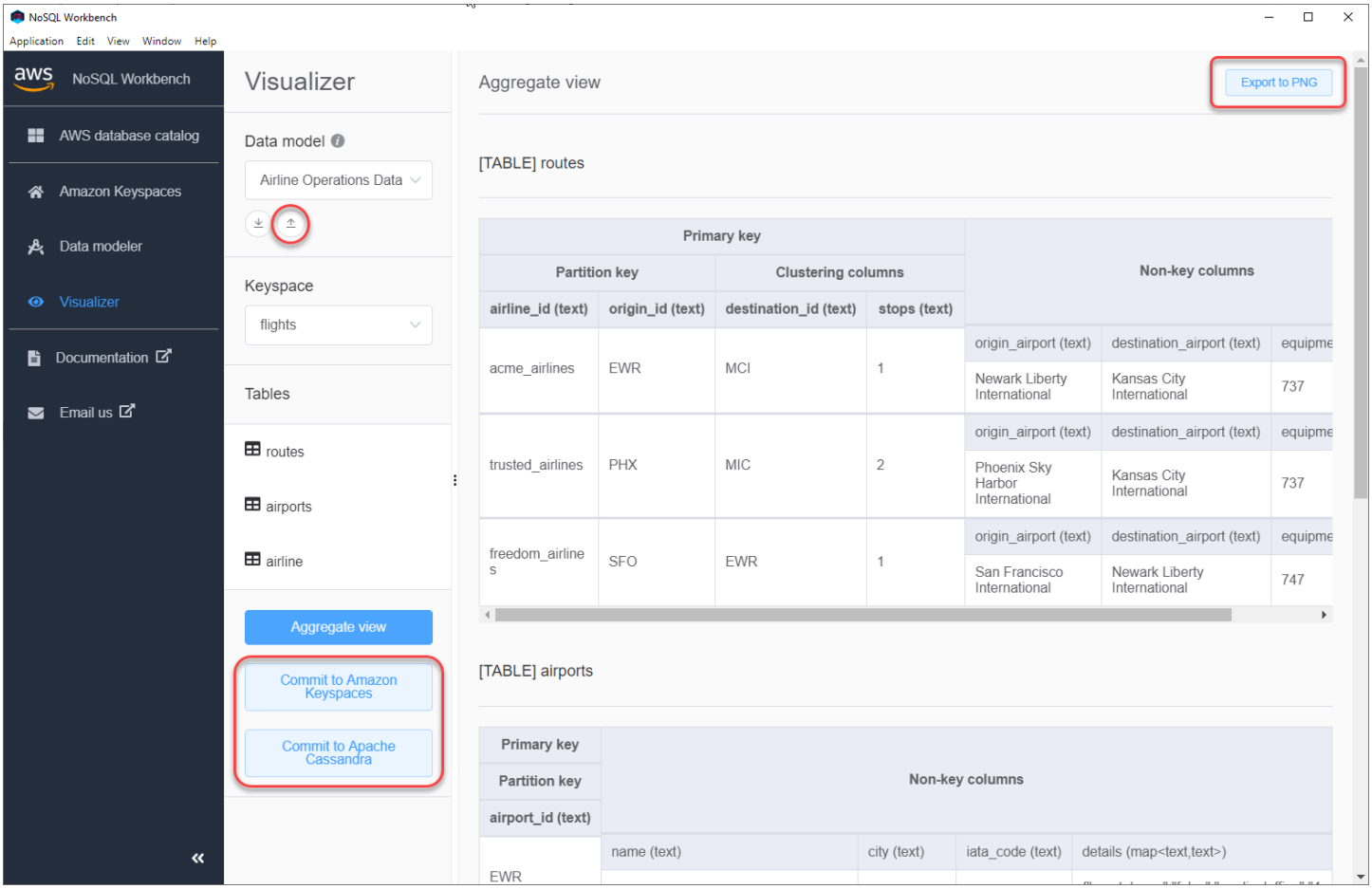
Aggregate view

After you have confirmed the table's schema, you can aggregate data model visualizations.



After you have aggregated the view of the data model, you can export the view to a PNG file. To export the data model to a JSON file, choose the upload sign under the data model name.

> **Note**
>
> You can export the data model in JSON format at any time in the design process.



You have the following options to commit the changes:

- Commit to Amazon Keyspaces
- Commit to an Apache Cassandra cluster

To learn more about how to commit changes, see the section called “Commit a data model”.

Create a new data model with NoSQL Workbench

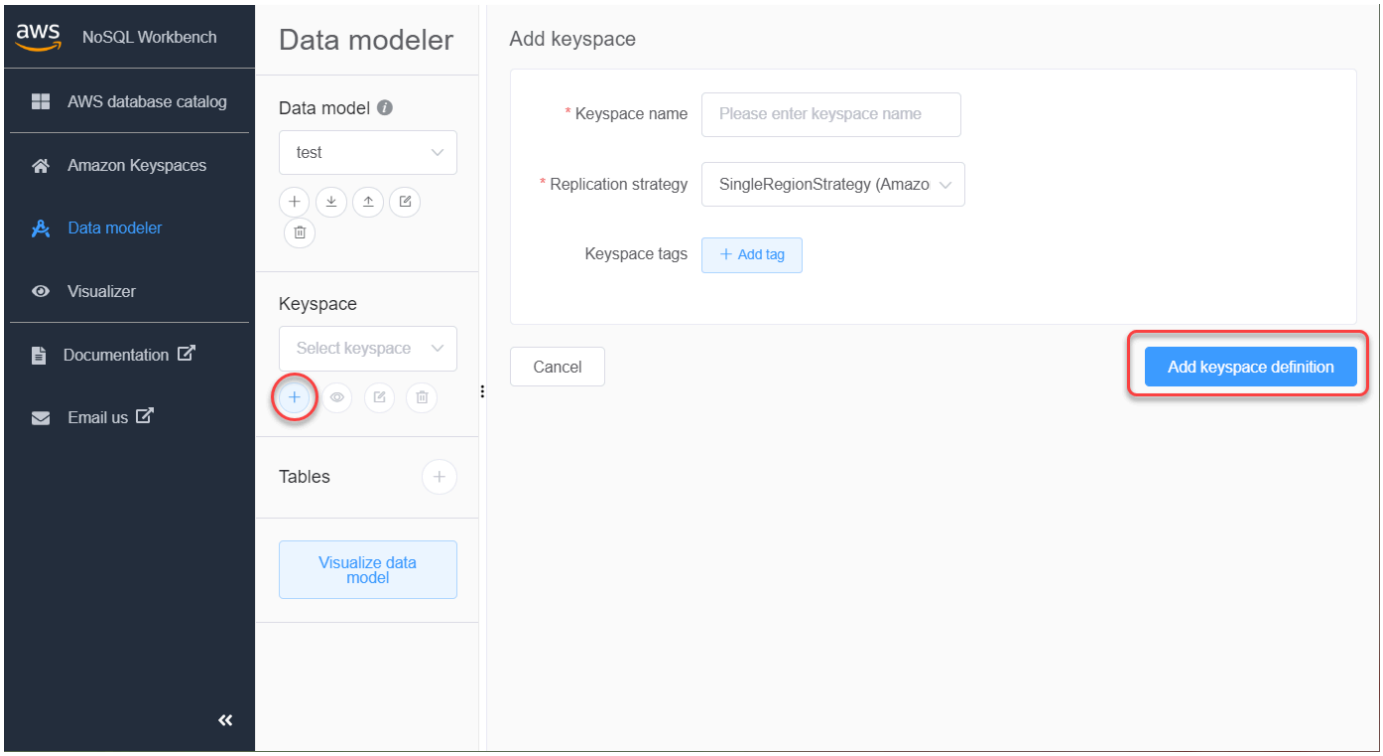
You can use the NoSQL Workbench data modeler to design new data models based on your application's data access patterns. To create a new data model for Amazon Keyspaces, you can use the NoSQL Workbench data modeler to create keyspaces, tables, and columns. Follow these steps to create a new data model.

1. To create a new keyspace, choose the plus sign under **Keyspace**.

   In this step, choose the following properties and settings.

- **Keyspace name** – Enter the name of the new keyspace.
- **Replication strategy** – Choose the replication strategy for the keyspace. Amazon Keyspaces uses the **SingleRegionStrategy** to replicate data three times automatically in multiple AWS Availability Zones. If you're planning to commit the data model to an Apache Cassandra cluster, you can choose **SimpleStrategy** or **NetworkTopologyStrategy**.
- **Keyspaces tags** – Resource tags are optional and let you categorize your resources in different ways—for example, by purpose, owner, environment, or other criteria. To learn more about tags for Amazon Keyspaces resources, see the section called “Working with tags”.

2. Choose **Add keyspace definition** to create the keyspace.

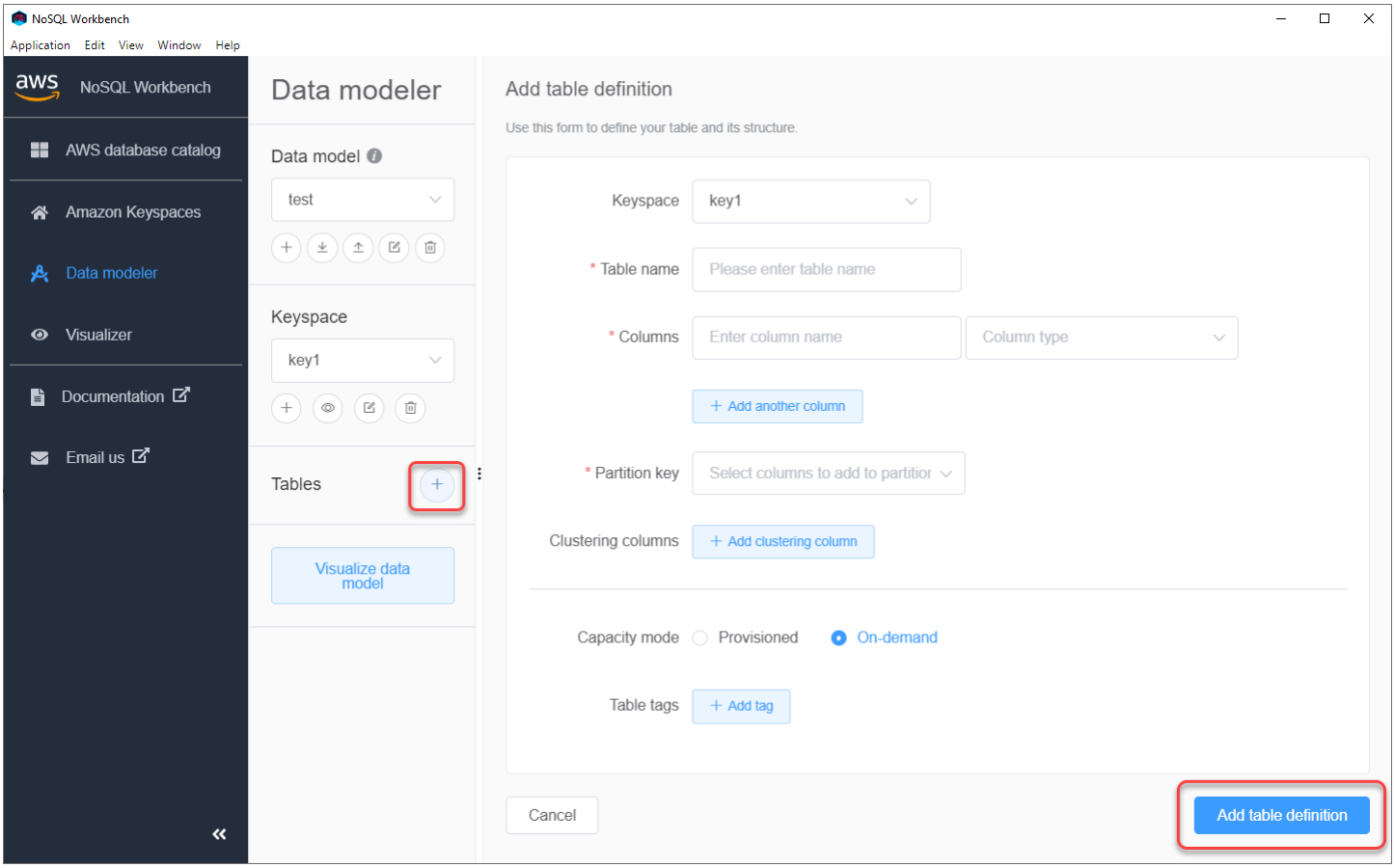


3. To create a new table, choose the plus sign next to **Tables**. In this step, you define the following properties and settings.

- **Table name** – The name of the new table.
- **Columns** – Add a column name and choose the data type. Repeat these steps for every column in your schema.
- **Partition key** – Choose columns for the partition key.
- **Clustering columns** – Choose clustering columns (optional).

- **Capacity mode** – Choose the read/write capacity mode for the table. You can choose provisioned or on-demand capacity. To learn more about capacity modes, see the section called "Configure read/write capacity modes".
- **Table tags** – Resource tags are optional and let you categorize your resources in different ways—for example, by purpose, owner, environment, or other criteria. To learn more about tags for Amazon Keyspaces resources, see the section called "Working with tags".

4. Choose **Add table definition** to create the new table.
5. Repeat these steps to create additional tables.
6. Continue to the section called "Visualizing a Data Model" to visualize the data model that you created.



Edit existing data models with NoSQL Workbench

You can use the data modeler to import and modify existing data models created using NoSQL Workbench. The data modeler also includes a few sample data models to help you get started with

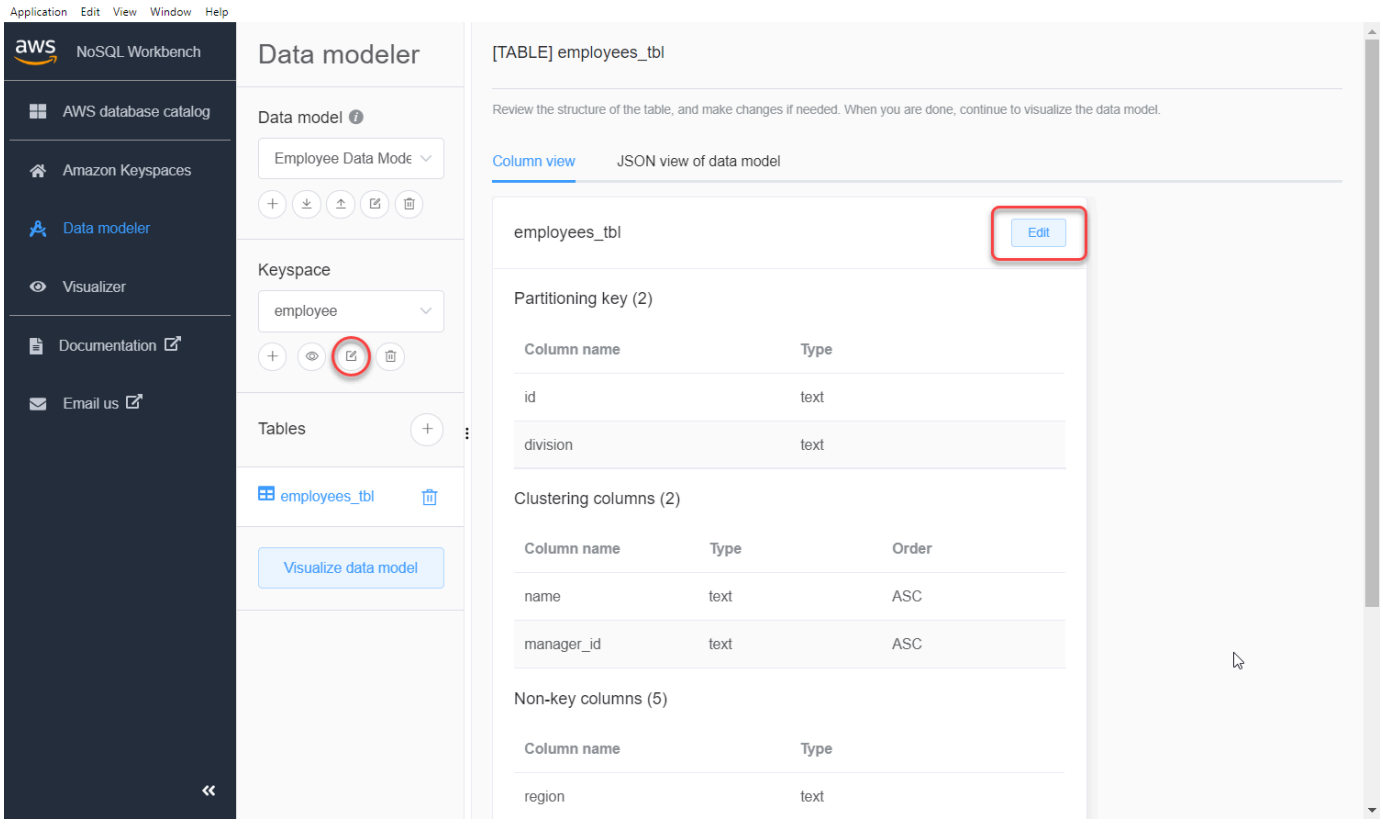
data modeling. The data models you can edit with NoSQL Workbench can be data models that are imported from a file, the provided sample data models, or data models that you created previously.

1. To edit a keyspace, choose the edit symbol under **Keyspace**.

   In this step, you can edit the following properties and settings.

   - **Keyspace name** – Enter the name of the new keyspace.
   - **Replication strategy** – Choose the replication strategy for the keyspace. Amazon Keyspaces uses the **SingleRegionStrategy** to replicate data three times automatically in multiple AWS Availability Zones. If you're planning to commit the data model to an Apache Cassandra cluster, you can choose **SimpleStrategy** or **NetworkTopologyStrategy**.
   - **Keyspaces tags** – Resource tags are optional and let you categorize your resources in different ways—for example, by purpose, owner, environment, or other criteria. To learn more about tags for Amazon Keyspaces resources, see the section called “Working with tags”.

2. Choose **Save edits** to update the keyspace.



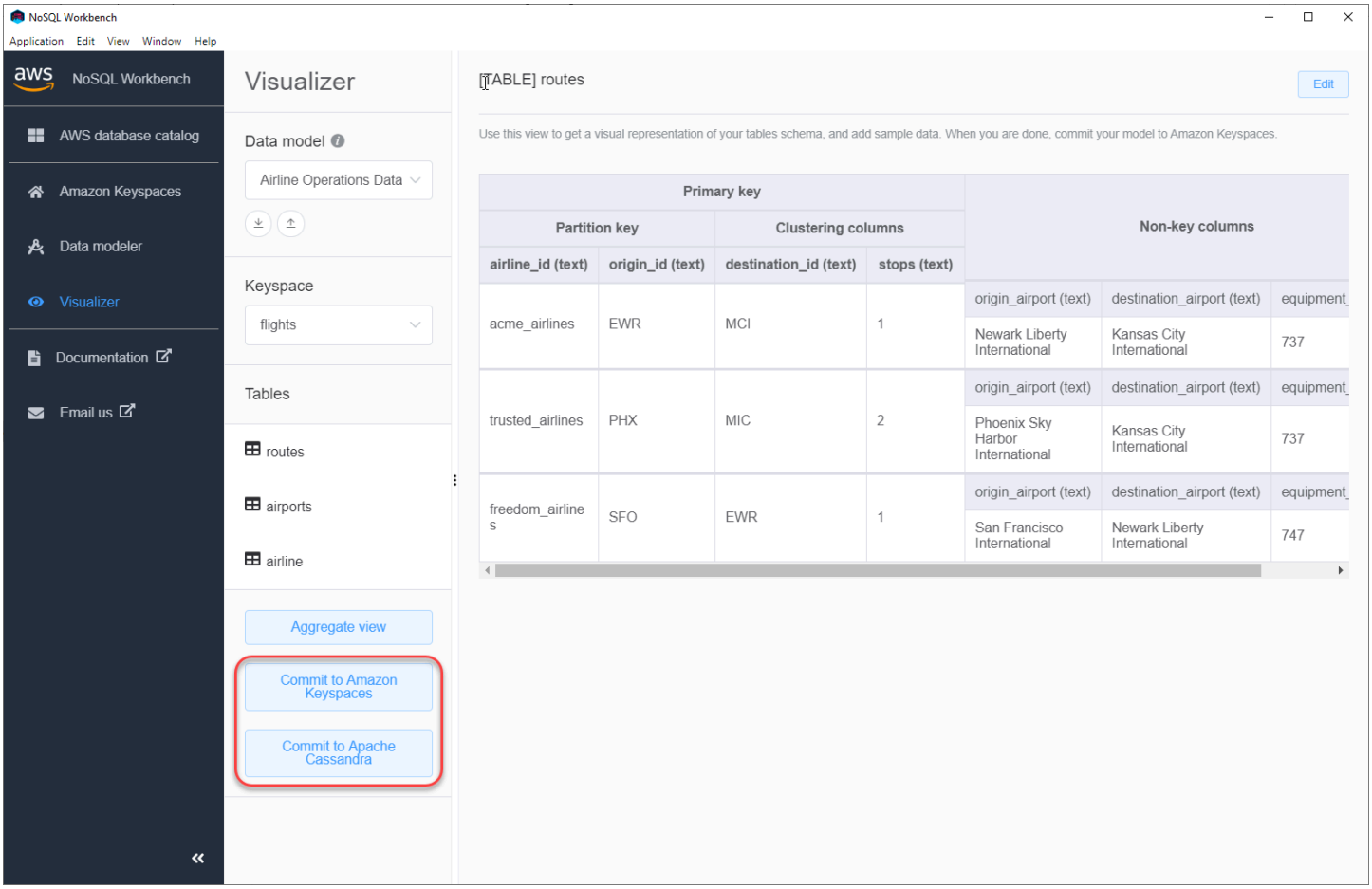
3. To edit a table, choose **Edit** next to the table name. In this step, you can update the following properties and settings.

- **Table name** – The name of the new table.
- **Columns** – Add a column name and choose the data type. Repeat these steps for every column in your schema.
- **Partition key** – Choose columns for the partition key.
- **Clustering columns** – Choose clustering columns (optional).
- **Capacity mode** – Choose the read/write capacity mode for the table. You can choose provisioned or on-demand capacity. To learn more about capacity modes, see the section called “Configure read/write capacity modes”.
- **Table tags** – Resource tags are optional and let you categorize your resources in different ways—for example, by purpose, owner, environment, or other criteria. To learn more about tags for Amazon Keyspaces resources, see the section called “Working with tags”.

4. Choose **Save edits** to update the table.
5. Continue to the section called “Visualizing a Data Model” to visualize the data model that you updated.

How to commit data models to Amazon Keyspaces and Apache Cassandra

This section shows you how to commit completed data models to Amazon Keyspaces and Apache Cassandra clusters. This process automatically creates the server-side resources for keyspaces and tables based on the settings that you defined in the data model.



Topics

- Before you begin
- Connect to Amazon Keyspaces with service-specific credentials
- Connect to Amazon Keyspaces with AWS Identity and Access Management (IAM) credentials
- Use a saved connection
- Commit to Apache Cassandra

Before you begin

Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients. To connect to Amazon Keyspaces using TLS, you need to complete the following task before you can start.

- Download the following digital certificates and save the files locally or in your home directory.
  1. AmazonRootCA1

2. AmazonRootCA2
3. AmazonRootCA3
4. AmazonRootCA4
5. Starfield Class 2 Root (optional – for backward compatibility)

To download the certificates, you can use the following commands.

```
curl -O https://www.amazontrust.com/repository/AmazonRootCA1.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA2.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA3.pem
curl -O https://www.amazontrust.com/repository/AmazonRootCA4.pem
curl -O https://certs.secureserver.net/repository/sf-class2-root.crt
```

Note

Amazon Keyspaces previously used TLS certificates anchored to the Starfield Class 2 CA. AWS is migrating all AWS Regions to certificates issued under Amazon Trust Services (Amazon Root CAs 1–4). During this transition, configure clients to trust both Amazon Root CAs 1–4 and the Starfield root to ensure compatibility across all Regions.

Combine all downloaded certificates into a single pem file with the name *keyspaces-bundle.pem* in our examples. You can do this by running the following command. Take note of the path to the file, you need this later.

```
cat AmazonRootCA1.pem \
 AmazonRootCA2.pem \
 AmazonRootCA3.pem \
 AmazonRootCA4.pem \
 sf-class2-root.crt \
 > keyspaces-bundle.pem
```

After you have saved the certificate file, you can connect to Amazon Keyspaces. One option is to connect by using service-specific credentials. Service-specific credentials are a user name and password that are associated with a specific IAM user and can only be used with the specified service. The second option is to connect with IAM credentials that are using the AWS Signature

Version 4 process (SigV4). To learn more about these two options, see the section called "Create programmatic access credentials".

To connect with service-specific credentials, see the section called "Connect with service-specific credentials".

To connect with IAM credentials, see the section called "Connect with IAM credentials".

Connect to Amazon Keyspaces with service-specific credentials

This section shows how to use service-specific credentials to commit the data model you created or edited with NoSQL Workbench.

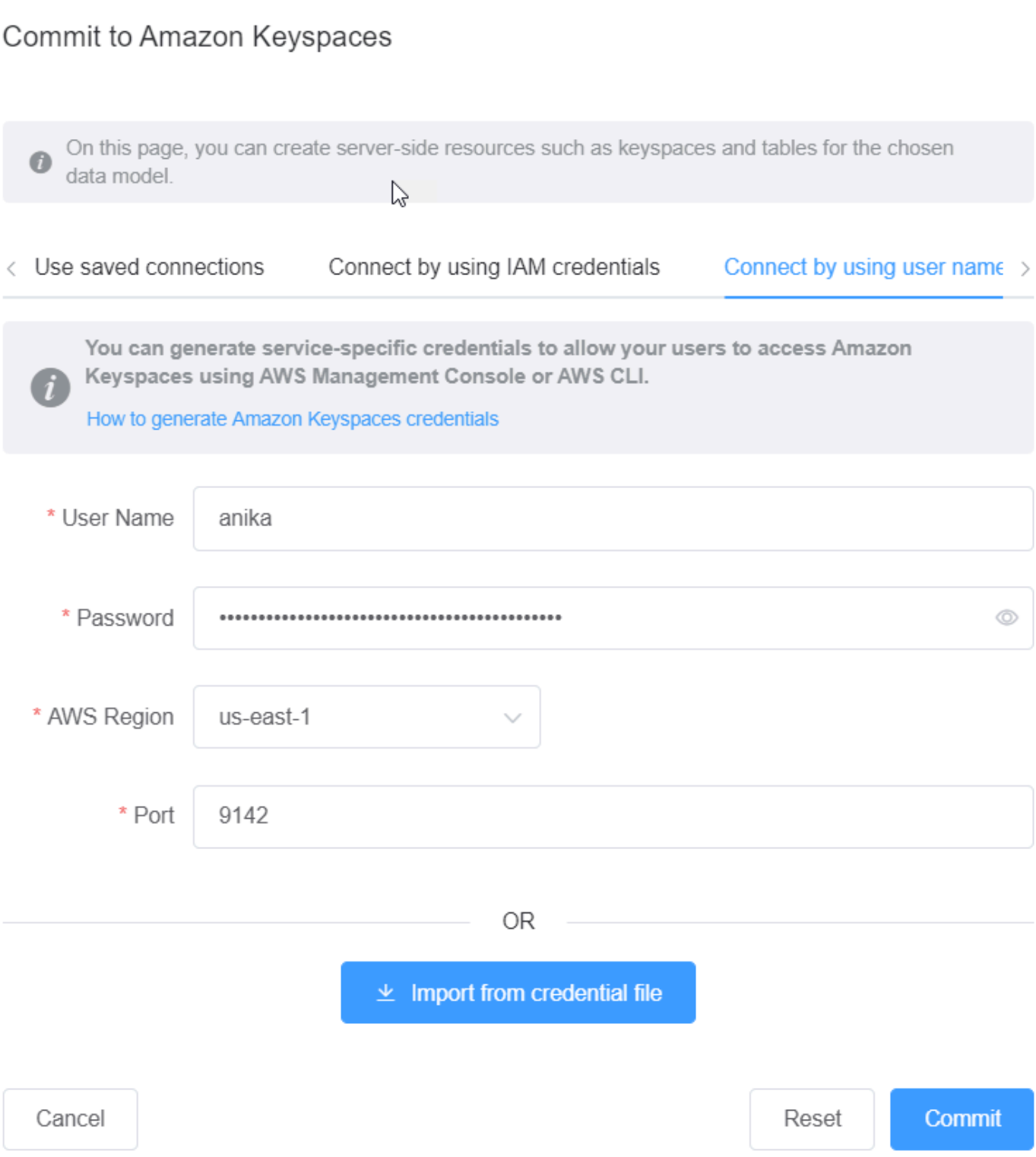
1. To create a new connection using service-specific credentials, choose the **Connect by using user name and password** tab.

   - Before you begin, you must create service-specific credentials using the process documented at the section called "Create service-specific credentials".

   After you have obtained the service-specific credentials, you can continue to set up the connection. Continue with one of the following:

   - **User name** – Enter the user name.
   - **Password** – Enter the password.
   - **AWS Region** – For available Regions, see the section called "Service endpoints".
   - **Port** – Amazon Keyspaces uses port 9142.

   Alternatively, you can import saved credentials from a file.
2. Choose **Commit** to update Amazon Keyspaces with the data model.


Commit to Amazon Keyspaces
On this page, you can create server-side resources such as keyspaces and tables for the chosen data model.
Use saved connections
Connect by using IAM credentials
Connect by using user name
You can generate service-specific credentials to allow your users to access Amazon Keyspaces using AWS Management Console or AWS CLI.
How to generate Amazon Keyspaces credentials
* User Name
anika
* Password
* AWS Region
us-east-1
* Port
9142
OR
Import from credential file
Cancel
Reset
Commit

Connect to Amazon Keyspaces with AWS Identity and Access Management (IAM) credentials

This section shows how to use IAM credentials to commit the data model created or edited with NoSQL Workbench.

1. To create a new connection using IAM credentials, choose the **Connect by using IAM credentials** tab.

   - Before you begin, you must create IAM credentials using one of the following methods.

     - For console access, use your IAM user name and password to sign in to the AWS Management Console from the IAM sign-in page. For information about AWS security credentials, including programmatic access and alternatives to long-term credentials, see AWS security credentials in the *IAM User Guide*. For details about signing in to your AWS account, see How to sign in to AWS in the *AWS Sign-In User Guide*.
     - For CLI access, you need an access key ID and a secret access key. Use temporary credentials instead of long-term access keys when possible. Temporary credentials include an access key ID, a secret access key, and a security token that indicates when the credentials expire. For more information, see Using temporary credentials with AWS resources in the *IAM User Guide*.
     - For API access, you need an access key ID and secret access key. Use IAM user access keys instead of AWS account root user access keys. For more information about creating access keys, see Manage access keys for IAM users in the *IAM User Guide*.

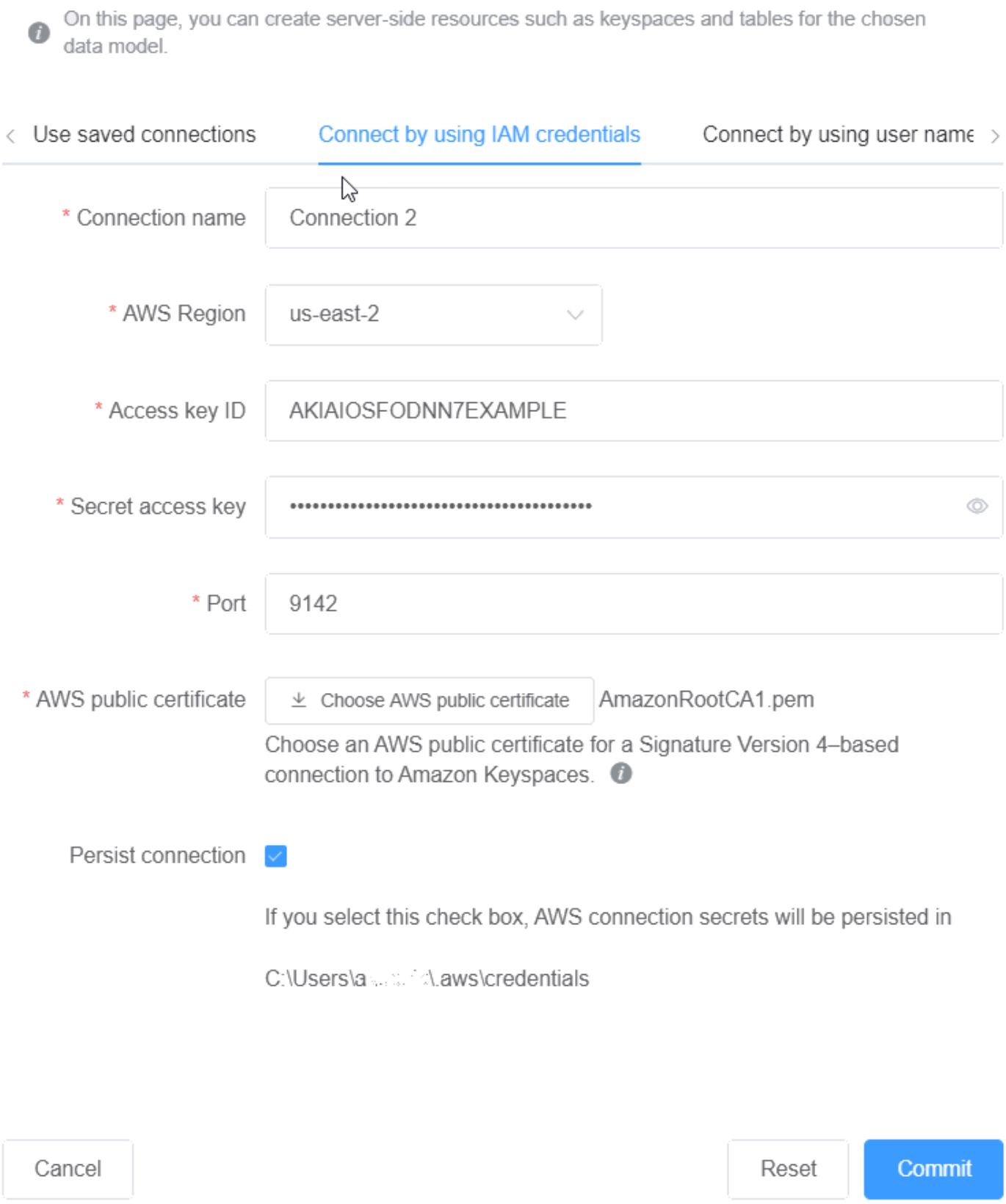
     For more information, see Managing access keys for IAM users.

   After you have obtained the IAM credentials, you can continue to set up the connection.

   - **Connection name** – The name of the connection.
   - **AWS Region** – For available Regions, see the section called “Service endpoints”.
   - **Access key ID** – Enter the access key ID.
   - **Secret access key** – Enter the secret access key.
   - **Port** – Amazon Keyspaces uses port 9142.
   - **AWS public certificate** – Point to the AWS certificate that was downloaded in the first step.

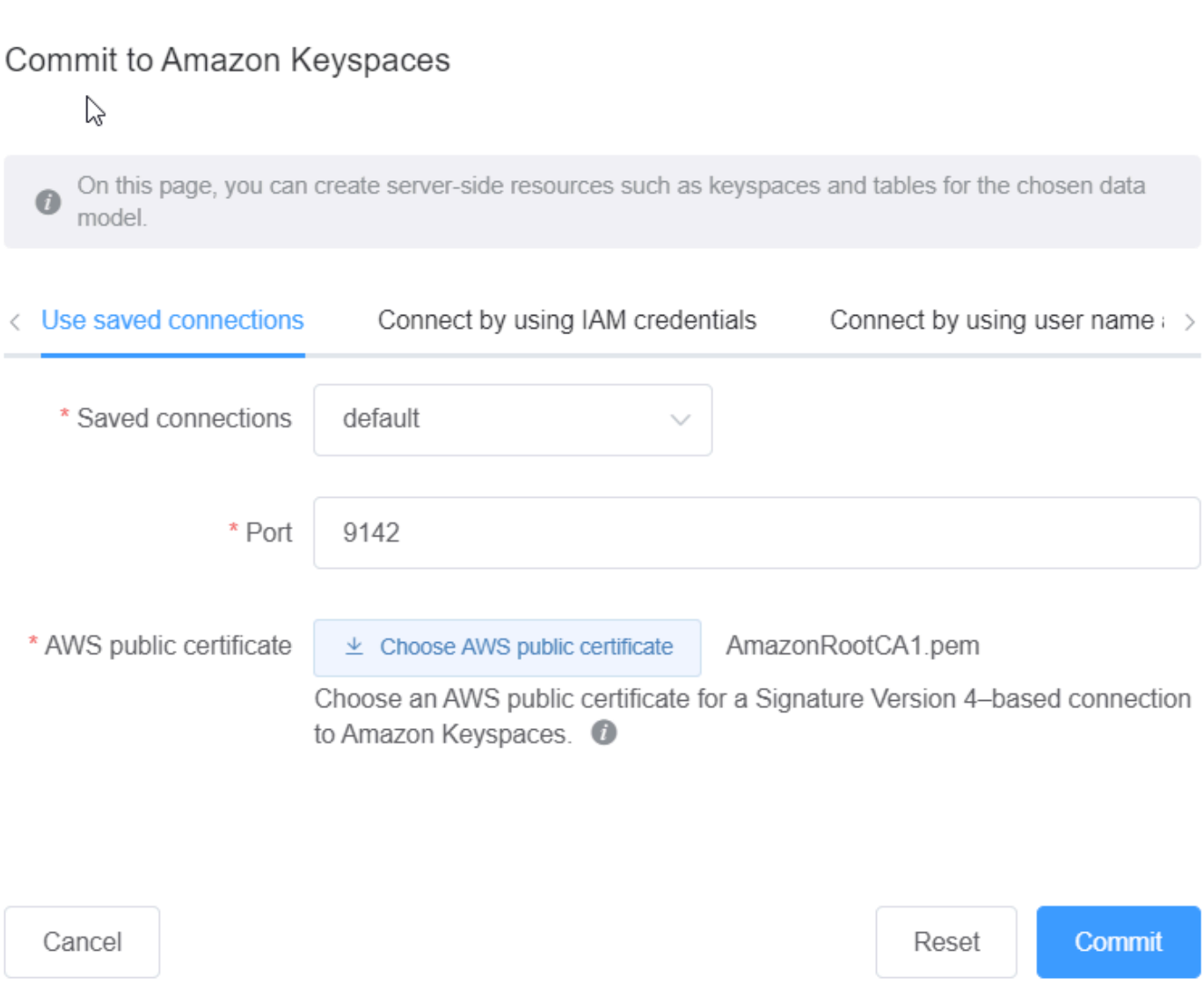
- **Persist connection** – Select this check box if you want to save the AWS connection secrets locally.

2. Choose **Commit** to update Amazon Keyspaces with the data model.


On this page, you can create server-side resources such as keyspaces and tables for the chosen data model.
Use saved connections
Connect by using IAM credentials
Connect by using user name
* Connection name
Connection 2
* AWS Region
us-east-2
* Access key ID
AKIAIOSFODNN7EXAMPLE
* Secret access key
* Port
9142
* AWS public certificate
Choose AWS public certificate
AmazonRootCA1.pem
Choose an AWS public certificate for a Signature Version 4–based connection to Amazon Keyspaces.
Persist connection
If you select this check box, AWS connection secrets will be persisted in
C:\Users\a .aws\credentials
Cancel
Reset
Commit

Use a saved connection

If you have previously set up a connection to Amazon Keyspaces, you can use that as the default connection to commit data model changes. Choose the **Use saved connections** tab and continue to commit the updates.

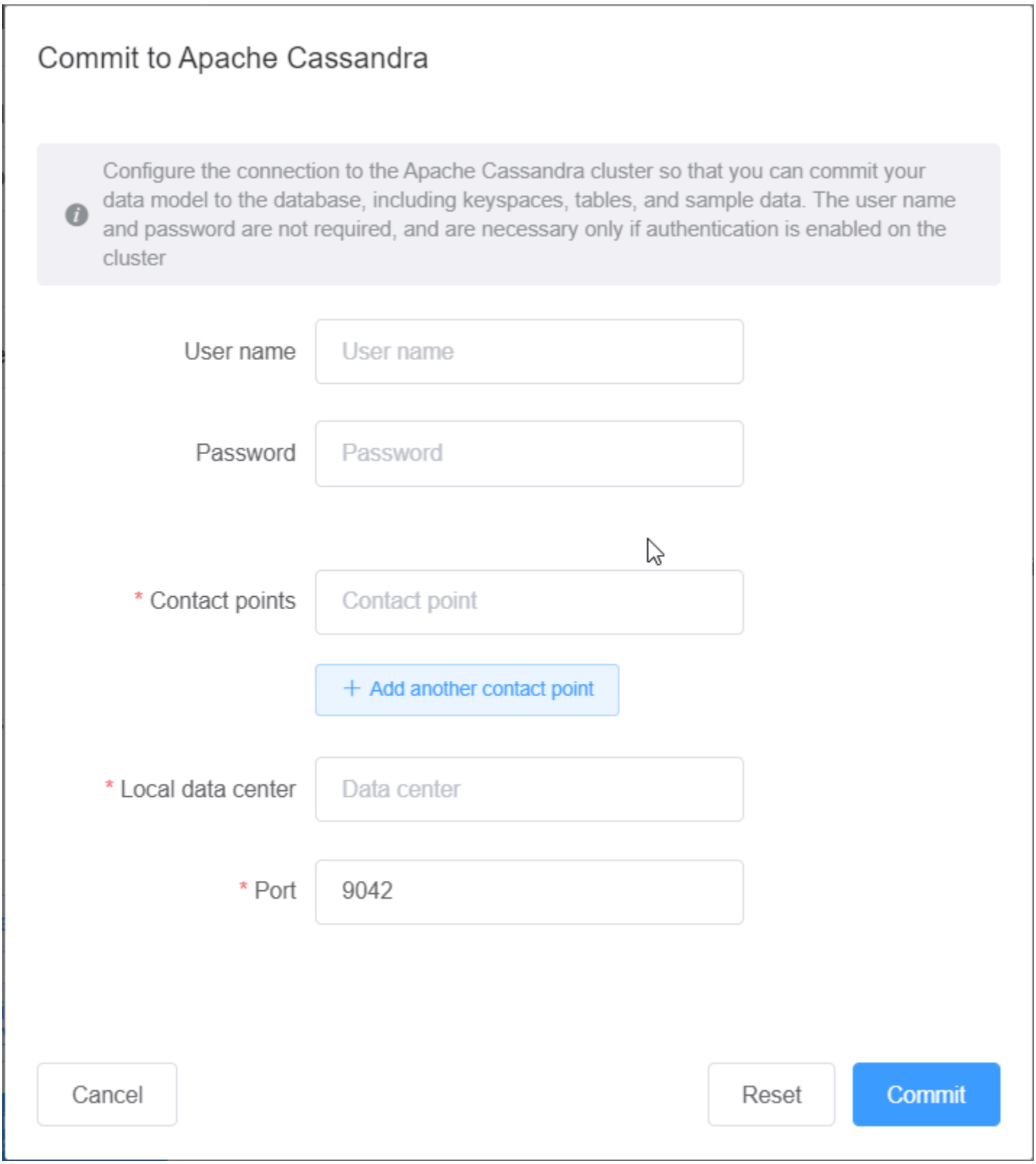


Commit to Apache Cassandra

This section walks you through making the connections to an Apache Cassandra cluster to commit the data model created or edited with NoSQL Workbench.

> **Note**
>
> Only data models that have been created with `SimpleStrategy` or `NetworkTopologyStrategy` can be committed to Apache Cassandra clusters. To change the replication strategy, edit the keyspace in the data modeler.

1.
   - **User name** – Enter the user name if authentication is enabled on the cluster.
   - **Password** – Enter the password if authentication is enabled on the cluster.
   - **Contact points** – Enter the contact points.
   - **Local data center** – Enter the name of the local data center.
   - **Port** – The connection uses port 9042.
2. Choose **Commit** to update the Apache Cassandra cluster with the data model.


Commit to Apache Cassandra
Configure the connection to the Apache Cassandra cluster so that you can commit your data model to the database, including keyspaces, tables, and sample data. The user name and password are not required, and are necessary only if authentication is enabled on the cluster
User name
User name
Password
Password
* Contact points
Contact point
+ Add another contact point
* Local data center
Data center
* Port
9042
Cancel
Reset
Commit

Sample data models in NoSQL Workbench

The home page for the modeler and visualizer displays a number of sample models that ship with NoSQL Workbench. This section describes these models and their potential uses.

Topics

- Employee data model
- Credit card transactions data model
- Airline operations data model

Employee data model

This data model represents an Amazon Keyspaces schema for an employee database application.

Applications that access employee information for a given company can use this data model.

The access patterns supported by this data model are:

- Retrieval of an employee record with a given ID.
- Retrieval of an employee record with a given ID and division.
- Retrieval of an employee record with a given ID and name.

Credit card transactions data model

This data model represents an Amazon Keyspaces schema for credit card transactions at retail stores.

The storage of credit card transactions not only helps stores with bookkeeping, but also helps store managers analyze purchase trends, which can help them with forecasting and planning.

The access patterns supported by this data model are:

- Retrieval of transactions by credit card number, month and year, and date.
- Retrieval of transactions by credit card number, category, and date.
- Retrieval of transactions by category, location, and credit card number.
- Retrieval of transactions by credit card number and dispute status.

Airline operations data model

This data model shows data about plane flights, including airports, airlines, and flight routes.

Key components of Amazon Keyspaces modeling that are demonstrated are key-value pairs, wide-column data stores, composite keys, and complex data types such as maps to demonstrate common NoSQL data-access patterns.

The access patterns supported by this data model are:

- Retrieval of routes originating from a given airline at a given airport.
- Retrieval of routes with a given destination airport.
- Retrieval of airports with direct flights.
- Retrieval of airport details and airline details.

Release history for NoSQL Workbench

The following table describes the important changes in each release of the *NoSQL Workbench* client-side application.

Change	Description	Date
NoSQL Workbench for Amazon Keyspaces – GA.	NoSQL Workbench for Amazon Keyspaces is generally available.	October 28, 2020
NoSQL Workbench preview released.	NoSQL Workbench is a client-side application that helps you design and visualize nonrelational data models for Amazon Keyspaces more easily. NoSQL Workbench clients are available for Windows, macOS, and Linux. For more information, see NoSQL Workbench for Amazon Keyspaces.	October 5, 2020

Code examples for Amazon Keyspaces using AWS SDKs

The following code examples show how to use Amazon Keyspaces with an AWS software development kit (SDK).

Basics are code examples that show you how to perform the essential operations within a service.

Actions are code excerpts from larger programs and must be run in context. While actions show you how to call individual service functions, you can see actions in context in their related scenarios.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Code examples

- Basic examples for Amazon Keyspaces using AWS SDKs
  - Hello Amazon Keyspaces
  - Learn the basics of Amazon Keyspaces with an AWS SDK
  - Actions for Amazon Keyspaces using AWS SDKs
    - Use CreateKeyspace with an AWS SDK
    - Use CreateTable with an AWS SDK
    - Use DeleteKeyspace with an AWS SDK
    - Use DeleteTable with an AWS SDK
    - Use GetKeyspace with an AWS SDK
    - Use GetTable with an AWS SDK
    - Use ListKeyspaces with an AWS SDK
    - Use ListTables with an AWS SDK
    - Use RestoreTable with an AWS SDK
    - Use UpdateTable with an AWS SDK

Basic examples for Amazon Keyspaces using AWS SDKs

The following code examples show how to use the basics of Amazon Keyspaces (for Apache Cassandra) with AWS SDKs.

Examples

- Hello Amazon Keyspaces
- Learn the basics of Amazon Keyspaces with an AWS SDK
- Actions for Amazon Keyspaces using AWS SDKs
  - Use CreateKeyspace with an AWS SDK
  - Use CreateTable with an AWS SDK
  - Use DeleteKeyspace with an AWS SDK
  - Use DeleteTable with an AWS SDK
  - Use GetKeyspace with an AWS SDK
  - Use GetTable with an AWS SDK
  - Use ListKeyspaces with an AWS SDK
  - Use ListTables with an AWS SDK
  - Use RestoreTable with an AWS SDK
  - Use UpdateTable with an AWS SDK

Hello Amazon Keyspaces

The following code examples show how to get started using Amazon Keyspaces.

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
namespace KeyspacesActions;

public class HelloKeyspaces
{
    private static ILogger logger = null!;
```

```
    static async Task Main(string[] args)
    {
        // Set up dependency injection for Amazon Keyspaces (for Apache
 Cassandra).
        using var host = Host.CreateDefaultBuilder(args)
            .ConfigureLogging(logging =>
                logging.AddFilter("System", LogLevel.Debug)
                    .AddFilter<DebugLoggerProvider>("Microsoft",
 LogLevel.Information)
                    .AddFilter<ConsoleLoggerProvider>("Microsoft",
 LogLevel.Trace))
            .ConfigureServices((_, services) =>
                services.AddAWSService<IAmazonKeyspaces>()
                .AddTransient<KeyspacesWrapper>()
            )
            .Build();

        logger = LoggerFactory.Create(builder => { builder.AddConsole(); })
            .CreateLogger<HelloKeyspaces>();

        var keyspacesClient =
 host.Services.GetRequiredService<IAmazonKeyspaces>();
        var keyspacesWrapper = new KeyspacesWrapper(keyspacesClient);

        Console.WriteLine("Hello, Amazon Keyspaces! Let's list your keyspaces:");
        await keyspacesWrapper.ListKeyspaces();
    }
}
```

- For API details, see ListKeyspaces in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.keyspaces.KeyspacesClient;
import software.amazon.awssdk.services.keyspaces.model.KeyspaceSummary;
import software.amazon.awssdk.services.keyspaces.model.KeyspacesException;
import software.amazon.awssdk.services.keyspaces.model.ListKeyspacesRequest;
import software.amazon.awssdk.services.keyspaces.model.ListKeyspacesResponse;
import java.util.List;

/**
 * Before running this Java (v2) code example, set up your development
 * environment, including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-
started.html
 */
public class HelloKeyspaces {
    public static void main(String[] args) {
        Region region = Region.US_EAST_1;
        KeyspacesClient keyClient = KeyspacesClient.builder()
                .region(region)
                .build();

        listKeyspaces(keyClient);
    }

    public static void listKeyspaces(KeyspacesClient keyClient) {
        try {
            ListKeyspacesRequest keyspacesRequest =
 ListKeyspacesRequest.builder()
                    .maxResults(10)
                    .build();

            ListKeyspacesResponse response =
 keyClient.listKeyspaces(keyspacesRequest);
            List<KeyspaceSummary> keyspaces = response.keyspaces();
            for (KeyspaceSummary keyspace : keyspaces) {
                System.out.println("The name of the keyspace is " +
 keyspace.keyspaceName());
            }

        } catch (KeyspacesException e) {
```

```
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
}
```

- For API details, see ListKeyspaces in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
/**
Before running this Kotlin code example, set up your development environment,
 including your credentials.

For more information, see the following documentation topic:

https://docs.aws.amazon.com/sdk-for-kotlin/latest/developer-guide/setup.html
*/

suspend fun main() {
    listKeyspaces()
}

suspend fun listKeyspaces() {
    val keyspacesRequest =
        ListKeyspacesRequest {
            maxResults = 10
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.listKeyspaces(keyspacesRequest)
        response.keyspaces?.forEach { keyspace ->
```

```
            println("The name of the keyspace is ${keyspace.keyspaceName}")
        }
    }
}
```

- For API details, see ListKeyspaces in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
import boto3


def hello_keyspaces(keyspaces_client):
    """
    Use the AWS SDK for Python (Boto3) to create an Amazon Keyspaces (for Apache
 Cassandra)
    client and list the keyspaces in your account.
    This example uses the default settings specified in your shared credentials
    and config files.

    :param keyspaces_client: A Boto3 Amazon Keyspaces Client object. This object
 wraps
                             the low-level Amazon Keyspaces service API.
    """
    print("Hello, Amazon Keyspaces! Let's list some of your keyspaces:\n")
    for ks in keyspaces_client.list_keyspaces(maxResults=5).get("keyspaces", []):
        print(ks["keyspaceName"])
        print(f"\t{ks['resourceArn']}")


if __name__ == "__main__":
    hello_keyspaces(boto3.client("keyspaces"))
```

- For API details, see ListKeyspaces in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Learn the basics of Amazon Keyspaces with an AWS SDK

The following code examples show how to:

- Create a keyspace and table. The table schema holds movie data and has point-in-time recovery enabled.
- Connect to the keyspace using a secure TLS connection with SigV4 authentication.
- Query the table. Add, retrieve, and update movie data.
- Update the table. Add a column to track watched movies.
- Restore the table to its previous state and clean up resources.

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
global using System.Security.Cryptography.X509Certificates;
global using Amazon.Keyspaces;
global using Amazon.Keyspaces.Model;
global using KeyspacesActions;
global using KeyspacesScenario;
global using Microsoft.Extensions.Configuration;
global using Microsoft.Extensions.DependencyInjection;
global using Microsoft.Extensions.Hosting;
global using Microsoft.Extensions.Logging;
```

```
global using Microsoft.Extensions.Logging.Console;
global using Microsoft.Extensions.Logging.Debug;
global using Newtonsoft.Json;


namespace KeyspacesBasics;

/// <summary>
/// Amazon Keyspaces (for Apache Cassandra) scenario. Shows some of the basic
/// actions performed with Amazon Keyspaces.
/// </summary>
public class KeyspacesBasics
{
    private static ILogger logger = null!;

    static async Task Main(string[] args)
    {
        // Set up dependency injection for the Amazon service.
        using var host = Host.CreateDefaultBuilder(args)
            .ConfigureLogging(logging =>
                logging.AddFilter("System", LogLevel.Debug)
                    .AddFilter<DebugLoggerProvider>("Microsoft",
 LogLevel.Information)
                    .AddFilter<ConsoleLoggerProvider>("Microsoft",
 LogLevel.Trace))
            .ConfigureServices((_, services) =>
            services.AddAWSService<IAmazonKeyspaces>()
            .AddTransient<KeyspacesWrapper>()
            .AddTransient<CassandraWrapper>()
            )
            .Build();

        logger = LoggerFactory.Create(builder => { builder.AddConsole(); })
            .CreateLogger<KeyspacesBasics>();

        var configuration = new ConfigurationBuilder()
            .SetBasePath(Directory.GetCurrentDirectory())
            .AddJsonFile("settings.json") // Load test settings from .json file.
            .AddJsonFile("settings.local.json",
                true) // Optionally load local settings.
            .Build();

        var keyspacesWrapper =
 host.Services.GetRequiredService<KeyspacesWrapper>();
```

```
        var uiMethods = new UiMethods();

        var keyspaceName = configuration["KeyspaceName"];
        var tableName = configuration["TableName"];

        bool success; // Used to track the results of some operations.

        uiMethods.DisplayOverview();
        uiMethods.PressEnter();

        // Create the keyspace.
        var keyspaceArn = await keyspacesWrapper.CreateKeyspace(keyspaceName);

        // Wait for the keyspace to be available. GetKeyspace results in a
        // resource not found error until it is ready for use.
        try
        {
            var getKeyspaceArn = "";
            Console.Write($"Created {keyspaceName}. Waiting for it to become
available. ");
            do
            {
                getKeyspaceArn = await
keyspacesWrapper.GetKeyspace(keyspaceName);
                Console.Write(". ");
            } while (getKeyspaceArn != keyspaceArn);
        }
        catch (ResourceNotFoundException)
        {
            Console.WriteLine("Waiting for keyspace to be created.");
        }

        Console.WriteLine($"\nThe keyspace {keyspaceName} is ready for use.");

        uiMethods.PressEnter();

        // Create the table.
        // First define the schema.
        var allColumns = new List<ColumnDefinition>
        {
            new ColumnDefinition { Name = "title", Type = "text" },
            new ColumnDefinition { Name = "year", Type = "int" },
            new ColumnDefinition { Name = "release_date", Type = "timestamp" },
            new ColumnDefinition { Name = "plot", Type = "text" },
```

```
        };

        var partitionKeys = new List<PartitionKey>
        {
            new PartitionKey { Name = "year", },
            new PartitionKey { Name = "title" },
        };

        var tableSchema = new SchemaDefinition
        {
            AllColumns = allColumns,
            PartitionKeys = partitionKeys,
        };

        var tableArn = await keyspacesWrapper.CreateTable(keyspaceName,
tableSchema, tableName);

        // Wait for the table to be active.
        try
        {
            var resp = new GetTableResponse();
            Console.Write("Waiting for the new table to be active. ");
            do
            {
                try
                {
                    resp = await keyspacesWrapper.GetTable(keyspaceName,
tableName);
                    Console.Write(".");
                }
                catch (ResourceNotFoundException)
                {
                    Console.Write(".");
                }
            } while (resp.Status != TableStatus.ACTIVE);

            // Display the table's schema.
            Console.WriteLine($"\nTable {tableName} has been created in
{keyspaceName}");
            Console.WriteLine("Let's take a look at the schema.");
            uiMethods.DisplayTitle("All columns");
            resp.SchemaDefinition.AllColumns.ForEach(column =>
            {
                Console.WriteLine($"{column.Name,-40}\t{column.Type,-20}");
```

```
            });

            uiMethods.DisplayTitle("Cluster keys");
            resp.SchemaDefinition.ClusteringKeys.ForEach(clusterKey =>
            {

Console.WriteLine($"{clusterKey.Name,-40}\t{clusterKey.OrderBy,-20}");
            });

            uiMethods.DisplayTitle("Partition keys");
            resp.SchemaDefinition.PartitionKeys.ForEach(partitionKey =>
            {
                Console.WriteLine($"{partitionKey.Name}");
            });

            uiMethods.PressEnter();
        }
        catch (ResourceNotFoundException ex)
        {
            Console.WriteLine($"Error: {ex.Message}");
        }

        // Access Apache Cassandra using the Cassandra drive for C#.
        var cassandraWrapper =
host.Services.GetRequiredService<CassandraWrapper>();
        var movieFilePath = configuration["MovieFile"];

        Console.WriteLine("Let's add some movies to the table we created.");
        var inserted = await cassandraWrapper.InsertIntoMovieTable(keyspaceName,
tableName, movieFilePath);

        uiMethods.PressEnter();

        Console.WriteLine("Added the following movies to the table:");
        var rows = await cassandraWrapper.GetMovies(keyspaceName, tableName);
        uiMethods.DisplayTitle("All Movies");

        foreach (var row in rows)
        {
            var title = row.GetValue<string>("title");
            var year = row.GetValue<int>("year");
            var plot = row.GetValue<string>("plot");
            var release_date = row.GetValue<DateTime>("release_date");
            Console.WriteLine($"{release_date}\t{title}\t{year}\n{plot}");
```

```
            Console.WriteLine(uiMethods.SepBar);
        }

        // Update the table schema
        uiMethods.DisplayTitle("Update table schema");
        Console.WriteLine("Now we will update the table to add a boolean field
called watched.");

        // First save the current time as a UTC Date so the original
        // table can be restored later.
        var timeChanged = DateTime.UtcNow;

        // Now update the schema.
        var resourceArn = await keyspacesWrapper.UpdateTable(keyspaceName,
tableName);
        uiMethods.PressEnter();

        Console.WriteLine("Now let's mark some of the movies as watched.");

        // Pick some files to mark as watched.
        var movieToWatch = rows[2].GetValue<string>("title");
        var watchedMovieYear = rows[2].GetValue<int>("year");
        var changedRows = await cassandraWrapper.MarkMovieAsWatched(keyspaceName,
tableName, movieToWatch, watchedMovieYear);

        movieToWatch = rows[6].GetValue<string>("title");
        watchedMovieYear = rows[6].GetValue<int>("year");
        changedRows = await cassandraWrapper.MarkMovieAsWatched(keyspaceName,
tableName, movieToWatch, watchedMovieYear);

        movieToWatch = rows[9].GetValue<string>("title");
        watchedMovieYear = rows[9].GetValue<int>("year");
        changedRows = await cassandraWrapper.MarkMovieAsWatched(keyspaceName,
tableName, movieToWatch, watchedMovieYear);

        movieToWatch = rows[10].GetValue<string>("title");
        watchedMovieYear = rows[10].GetValue<int>("year");
        changedRows = await cassandraWrapper.MarkMovieAsWatched(keyspaceName,
tableName, movieToWatch, watchedMovieYear);

        movieToWatch = rows[13].GetValue<string>("title");
        watchedMovieYear = rows[13].GetValue<int>("year");
        changedRows = await cassandraWrapper.MarkMovieAsWatched(keyspaceName,
tableName, movieToWatch, watchedMovieYear);
```

```
        uiMethods.DisplayTitle("Watched movies");
        Console.WriteLine("These movies have been marked as watched:");
        rows = await cassandraWrapper.GetWatchedMovies(keyspaceName, tableName);
        foreach (var row in rows)
        {
            var title = row.GetValue<string>("title");
            var year = row.GetValue<int>("year");
            Console.WriteLine($"{title,-40}\t{year,8}");
        }
        uiMethods.PressEnter();

        Console.WriteLine("We can restore the table to its previous state but
that can take up to 20 minutes to complete.");
        string answer;
        do
        {
            Console.WriteLine("Do you want to restore the table? (y/n)");
            answer = Console.ReadLine();
        } while (answer.ToLower() != "y" && answer.ToLower() != "n");

        if (answer == "y")
        {
            var restoredTableName = $"{tableName}_restored";
            var restoredTableArn = await keyspacesWrapper.RestoreTable(
                keyspaceName,
                tableName,
                restoredTableName,
                timeChanged);
            // Loop and call GetTable until the table is gone. Once it has been
            // deleted completely, GetTable will raise a
ResourceNotFoundException.
            bool wasRestored = false;

            try
            {
                do
                {
                    var resp = await keyspacesWrapper.GetTable(keyspaceName,
restoredTableName);
                    wasRestored = (resp.Status == TableStatus.ACTIVE);
                } while (!wasRestored);
            }
            catch (ResourceNotFoundException)
```

```
            {
                // If the restored table raised an error, it isn't
                // ready yet.
                Console.Write(".");
            }
        }

        uiMethods.DisplayTitle("Clean up resources.");

        // Delete the table.
        success = await keyspacesWrapper.DeleteTable(keyspaceName, tableName);

        Console.WriteLine($"Table {tableName} successfully deleted from
 {keyspaceName}.");
        Console.WriteLine("Waiting for the table to be removed completely. ");

        // Loop and call GetTable until the table is gone. Once it has been
        // deleted completely, GetTable will raise a ResourceNotFoundException.
        bool wasDeleted = false;

        try
        {
            do
            {
                var resp = await keyspacesWrapper.GetTable(keyspaceName,
 tableName);
            } while (!wasDeleted);
        }
        catch (ResourceNotFoundException ex)
        {
            wasDeleted = true;
            Console.WriteLine($"{ex.Message} indicates that the table has been
 deleted.");
        }

        // Delete the keyspace.
        success = await keyspacesWrapper.DeleteKeyspace(keyspaceName);
        Console.WriteLine("The keyspace has been deleted and the demo is now
 complete.");
    }
}
```

```
namespace KeyspacesActions;

/// <summary>
/// Performs Amazon Keyspaces (for Apache Cassandra) actions.
/// </summary>
public class KeyspacesWrapper
{
    private readonly IAmazonKeyspaces _amazonKeyspaces;

    /// <summary>
    /// Constructor for the KeyspaceWrapper.
    /// </summary>
    /// <param name="amazonKeyspaces">An Amazon Keyspaces client object.</param>
    public KeyspacesWrapper(IAmazonKeyspaces amazonKeyspaces)
    {
        _amazonKeyspaces = amazonKeyspaces;
    }

    /// <summary>
    /// Create a new keyspace.
    /// </summary>
    /// <param name="keyspaceName">The name for the new keyspace.</param>
    /// <returns>The Amazon Resource Name (ARN) of the new keyspace.</returns>
    public async Task<string> CreateKeyspace(string keyspaceName)
    {
        var response =
            await _amazonKeyspaces.CreateKeyspaceAsync(
                new CreateKeyspaceRequest { KeyspaceName = keyspaceName });
        return response.ResourceArn;
    }


    /// <summary>
    /// Create a new Amazon Keyspaces table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace where the table will be
 created.</param>
    /// <param name="schema">The schema for the new table.</param>
    /// <param name="tableName">The name of the new table.</param>
    /// <returns>The Amazon Resource Name (ARN) of the new table.</returns>
    public async Task<string> CreateTable(string keyspaceName, SchemaDefinition
 schema, string tableName)
    {
```

```
        var request = new CreateTableRequest
        {
            KeyspaceName = keyspaceName,
            SchemaDefinition = schema,
            TableName = tableName,
            PointInTimeRecovery = new PointInTimeRecovery { Status =
PointInTimeRecoveryStatus.ENABLED }
        };

        var response = await _amazonKeyspaces.CreateTableAsync(request);
        return response.ResourceArn;
    }


    /// <summary>
    /// Delete an existing keyspace.
    /// </summary>
    /// <param name="keyspaceName"></param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> DeleteKeyspace(string keyspaceName)
    {
        var response = await _amazonKeyspaces.DeleteKeyspaceAsync(
            new DeleteKeyspaceRequest { KeyspaceName = keyspaceName });
        return response.HttpStatusCode == HttpStatusCode.OK;
    }


    /// <summary>
    /// Delete an Amazon Keyspaces table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to delete.</param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> DeleteTable(string keyspaceName, string tableName)
    {
        var response = await _amazonKeyspaces.DeleteTableAsync(
            new DeleteTableRequest { KeyspaceName = keyspaceName, TableName =
tableName });
        return response.HttpStatusCode == HttpStatusCode.OK;
    }


    /// <summary>
    /// Get data about a keyspace.
```

```
    /// </summary>
    /// <param name="keyspaceName">The name of the keyspace.</param>
    /// <returns>The Amazon Resource Name (ARN) of the keyspace.</returns>
    public async Task<string> GetKeyspace(string keyspaceName)
    {
        var response = await _amazonKeyspaces.GetKeyspaceAsync(
            new GetKeyspaceRequest { KeyspaceName = keyspaceName });
        return response.ResourceArn;
    }


    /// <summary>
    /// Get information about an Amazon Keyspaces table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the Amazon Keyspaces table.</param>
    /// <returns>The response containing data about the table.</returns>
    public async Task<GetTableResponse> GetTable(string keyspaceName, string
tableName)
    {
        var response = await _amazonKeyspaces.GetTableAsync(
            new GetTableRequest { KeyspaceName = keyspaceName, TableName =
tableName });
        return response;
    }


    /// <summary>
    /// Lists all keyspaces for the account.
    /// </summary>
    /// <returns>Async task.</returns>
    public async Task ListKeyspaces()
    {
        var paginator = _amazonKeyspaces.Paginators.ListKeyspaces(new
ListKeyspacesRequest());

        Console.WriteLine("{0, -30}\t{1}", "Keyspace name", "Keyspace ARN");
        Console.WriteLine(new string('-', Console.WindowWidth));
        await foreach (var keyspace in paginator.Keyspaces)
        {

Console.WriteLine($"{keyspace.KeyspaceName,-30}\t{keyspace.ResourceArn}");
        }
    }
```

```
    /// <summary>
    /// Lists the Amazon Keyspaces tables in a keyspace.
    /// </summary>
    /// <param name="keyspaceName">The name of the keyspace.</param>
    /// <returns>A list of TableSummary objects.</returns>
    public async Task<List<TableSummary>> ListTables(string keyspaceName)
    {
        var response = await _amazonKeyspaces.ListTablesAsync(new
 ListTablesRequest { KeyspaceName = keyspaceName });
        response.Tables.ForEach(table =>
        {

 Console.WriteLine($"{table.KeyspaceName}\t{table.TableName}\t{table.ResourceArn}");
        });

        return response.Tables;
    }


    /// <summary>
    /// Restores the specified table to the specified point in time.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to restore.</param>
    /// <param name="timestamp">The time to which the table will be restored.</
param>
    /// <returns>The Amazon Resource Name (ARN) of the restored table.</returns>
    public async Task<string> RestoreTable(string keyspaceName, string tableName,
 string restoredTableName, DateTime timestamp)
    {
        var request = new RestoreTableRequest
        {
            RestoreTimestamp = timestamp,
            SourceKeyspaceName = keyspaceName,
            SourceTableName = tableName,
            TargetKeyspaceName = keyspaceName,
            TargetTableName = restoredTableName
        };

        var response = await _amazonKeyspaces.RestoreTableAsync(request);
        return response.RestoredTableARN;
    }
```

```
    /// <summary>
    /// Updates the movie table to add a boolean column named watched.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to change.</param>
    /// <returns>The Amazon Resource Name (ARN) of the updated table.</returns>
    public async Task<string> UpdateTable(string keyspaceName, string tableName)
    {
        var newColumn = new ColumnDefinition { Name = "watched", Type =
 "boolean" };
        var request = new UpdateTableRequest
        {
            KeyspaceName = keyspaceName,
            TableName = tableName,
            AddColumns = new List<ColumnDefinition> { newColumn }
        };
        var response = await _amazonKeyspaces.UpdateTableAsync(request);
        return response.ResourceArn;
    }

}
```

```
using System.Net;
using Cassandra;

namespace KeyspacesScenario;

/// <summary>
/// Class to perform CRUD methods on an Amazon Keyspaces (for Apache Cassandra)
 database.
///
/// NOTE: This sample uses a plain text authenticator for example purposes only.
/// Recommended best practice is to use a SigV4 authentication plugin, if
 available.
/// </summary>
public class CassandraWrapper
{
    private readonly IConfiguration _configuration;
    private readonly string _localPathToFile;
```

```
    private const string _certLocation = "https://certs.secureserver.net/
repository/sf-class2-root.crt";
    private const string _certFileName = "sf-class2-root.crt";
    private readonly X509Certificate2Collection _certCollection;
    private X509Certificate2 _amazoncert;
    private Cluster _cluster;

    // User name and password for the service.
    private string _userName = null!;
    private string _pwd = null!;

    public CassandraWrapper()
    {
        _configuration = new ConfigurationBuilder()
            .SetBasePath(Directory.GetCurrentDirectory())
            .AddJsonFile("settings.json") // Load test settings from .json file.
            .AddJsonFile("settings.local.json",
                true) // Optionally load local settings.
            .Build();

        _localPathToFile = Path.GetTempPath();

        // Get the Starfield digital certificate and save it locally.
        var client = new WebClient();
        client.DownloadFile(_certLocation, $"{_localPathToFile}/
{_certFileName}");

        //var httpClient = new HttpClient();
        //var httpResult = httpClient.Get(fileUrl);
        //using var resultStream = await httpResult.Content.ReadAsStreamAsync();
        //using var fileStream = File.Create(pathToSave);
        //resultStream.CopyTo(fileStream);

        _certCollection = new X509Certificate2Collection();
        _amazoncert = new X509Certificate2($"{_localPathToFile}/
{_certFileName}");

        // Get the user name and password stored in the configuration file.
        _userName = _configuration["UserName"]!;
        _pwd = _configuration["Password"]!;

        // For a list of Service Endpoints for Amazon Keyspaces, see:
        // https://docs.aws.amazon.com/keyspaces/latest/devguide/
programmatic.endpoints.html
```

```
        var awsEndpoint = _configuration["ServiceEndpoint"];

        _cluster = Cluster.Builder()
            .AddContactPoints(awsEndpoint)
            .WithPort(9142)
            .WithAuthProvider(new PlainTextAuthProvider(_userName, _pwd))
            .WithSSL(new SSLOptions().SetCertificateCollection(_certCollection))
            .WithQueryOptions(
                new QueryOptions()
                    .SetConsistencyLevel(ConsistencyLevel.LocalQuorum)
                    .SetSerialConsistencyLevel(ConsistencyLevel.LocalSerial))
            .Build();
    }

    /// <summary>
    /// Loads the contents of a JSON file into a list of movies to be
    /// added to the Apache Cassandra table.
    /// </summary>
    /// <param name="movieFileName">The full path to the JSON file.</param>
    /// <returns>A list of movie objects.</returns>
    public List<Movie> ImportMoviesFromJson(string movieFileName, int numToImport
= 0)
    {
        if (!File.Exists(movieFileName))
        {
            return null!;
        }

        using var sr = new StreamReader(movieFileName);
        string json = sr.ReadToEnd();

        var allMovies = JsonConvert.DeserializeObject<List<Movie>>(json);

        // If numToImport = 0, return all movies in the collection.
        if (numToImport == 0)
        {
            // Now return the entire list of movies.
            return allMovies;
        }
        else
        {
            // Now return the first numToImport entries.
            return allMovies.GetRange(0, numToImport);
        }
```

```
    }

    /// <summary>
    /// Insert movies into the movie table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="movieTableName">The Amazon Keyspaces table.</param>
    /// <param name="movieFilePath">The path to the resource file containing
    /// movie data to insert into the table.</param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> InsertIntoMovieTable(string keyspaceName, string
movieTableName, string movieFilePath, int numToImport = 20)
    {
        // Get some movie data from the movies.json file
        var movies = ImportMoviesFromJson(movieFilePath, numToImport);

        var session = _cluster.Connect(keyspaceName);

        string insertCql;

        RowSet rs;

        // Now we insert the numToImport movies into the table.
        foreach (var movie in movies)
        {
            // Escape single quote characters in the plot.
            insertCql = $"INSERT INTO {keyspaceName}.{movieTableName}
(title, year, release_date, plot) values($${movie.Title}$$, {movie.Year},
'{movie.Info.Release_Date.ToString("yyyy-MM-dd")}', $${movie.Info.Plot}$$)";
            rs = await session.ExecuteAsync(new SimpleStatement(insertCql));
        }

        return true;
    }

    /// <summary>
    /// Gets all of the movies in the movies table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table.</param>
    /// <returns>A list of row objects containing movie data.</returns>
    public async Task<List<Row>> GetMovies(string keyspaceName, string tableName)
    {
        var session = _cluster.Connect();
```

```
        RowSet rs;
        try
        {
            rs = await session.ExecuteAsync(new SimpleStatement($"SELECT * FROM
{keyspaceName}.{tableName}"));

            // Extract the row data from the returned RowSet.
            var rows = rs.GetRows().ToList();
            return rows;
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.Message);
            return null!;
        }
    }

    /// <summary>
    /// Mark a movie in the movie table as watched.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table.</param>
    /// <param name="title">The title of the movie to mark as watched.</param>
    /// <param name="year">The year the movie was released.</param>
    /// <returns>A set of rows containing the changed data.</returns>
    public async Task<List<Row>> MarkMovieAsWatched(string keyspaceName, string
tableName, string title, int year)
    {
        var session = _cluster.Connect();
        string updateCql = $"UPDATE {keyspaceName}.{tableName} SET watched=true
WHERE title = $${title}$$ AND year = {year};";
        var rs = await session.ExecuteAsync(new SimpleStatement(updateCql));
        var rows = rs.GetRows().ToList();
        return rows;
    }

    /// <summary>
    /// Retrieve the movies in the movies table where watched is true.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table.</param>
    /// <returns>A list of row objects containing information about movies
    /// where watched is true.</returns>
```

```
    public async Task<List<Row>> GetWatchedMovies(string keyspaceName, string
 tableName)
    {
        var session = _cluster.Connect();
        RowSet rs;
        try
        {
            rs = await session.ExecuteAsync(new SimpleStatement($"SELECT
 title, year, plot FROM {keyspaceName}.{tableName} WHERE watched = true ALLOW
 FILTERING"));

            // Extract the row data from the returned RowSet.
            var rows = rs.GetRows().ToList();
            return rows;
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.Message);
            return null!;
        }
    }
}
```

- For API details, see the following topics in *AWS SDK for .NET API Reference*.
  - CreateKeyspace
  - CreateTable
  - DeleteKeyspace
  - DeleteTable
  - GetKeyspace
  - GetTable
  - ListKeyspaces
  - ListTables
  - RestoreTable
  - UpdateTable

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
/**
 * Before running this Java (v2) code example, set up your development
 * environment, including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-
started.html
 *
 * Before running this Java code example, you must create a
 * Java keystore (JKS) file and place it in your project's resources folder.
 *
 * This file is a secure file format used to hold certificate information for
 * Java applications. This is required to make a connection to Amazon Keyspaces.
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/keyspaces/latest/devguide/using_java_driver.html
 *
 * This Java example performs the following tasks:
 *
 * 1. Create a keyspace.
 * 2. Check for keyspace existence.
 * 3. List keyspaces using a paginator.
 * 4. Create a table with a simple movie data schema and enable point-in-time
 * recovery.
 * 5. Check for the table to be in an Active state.
 * 6. List all tables in the keyspace.
 * 7. Use a Cassandra driver to insert some records into the Movie table.
 * 8. Get all records from the Movie table.
 * 9. Get a specific Movie.
 * 10. Get a UTC timestamp for the current time.
 * 11. Update the table schema to add a ‘watched’ Boolean column.
```

```
 * 12. Update an item as watched.
 * 13. Query for items with watched = True.
 * 14. Restore the table back to the previous state using the timestamp.
 * 15. Check for completion of the restore action.
 * 16. Delete the table.
 * 17. Confirm that both tables are deleted.
 * 18. Delete the keyspace.
 */

public class ScenarioKeyspaces {
    public static final String DASHES = new String(new char[80]).replace("\0",
 "-");

    /*
     * Usage:
     * fileName - The name of the JSON file that contains movie data. (Get this
 file
     * from the GitHub repo at resources/sample_file.)
     * keyspaceName - The name of the keyspace to create.
     */
    public static void main(String[] args) throws InterruptedException,
 IOException {
        String fileName = "<Replace with the JSON file that contains movie
 data>";
        String keyspaceName = "<Replace with the name of the keyspace to
 create>";
        String titleUpdate = "The Family";
        int yearUpdate = 2013;
        String tableName = "Movie";
        String tableNameRestore = "MovieRestore";
        Region region = Region.US_EAST_1;
        KeyspacesClient keyClient = KeyspacesClient.builder()
                .region(region)
                .build();

        DriverConfigLoader loader =
 DriverConfigLoader.fromClasspath("application.conf");
        CqlSession session = CqlSession.builder()
                .withConfigLoader(loader)
                .build();

        System.out.println(DASHES);
        System.out.println("Welcome to the Amazon Keyspaces example scenario.");
        System.out.println(DASHES);
```

```
        System.out.println(DASHES);
        System.out.println("1. Create a keyspace.");
        createKeySpace(keyClient, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        Thread.sleep(5000);
        System.out.println("2. Check for keyspace existence.");
        checkKeyspaceExistence(keyClient, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("3. List keyspaces using a paginator.");
        listKeyspacesPaginator(keyClient);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("4. Create a table with a simple movie data schema and
enable point-in-time recovery.");
        createTable(keyClient, keyspaceName, tableName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("5. Check for the table to be in an Active state.");
        Thread.sleep(6000);
        checkTable(keyClient, keyspaceName, tableName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("6. List all tables in the keyspace.");
        listTables(keyClient, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("7. Use a Cassandra driver to insert some records into
the Movie table.");
        Thread.sleep(6000);
        loadData(session, fileName, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("8. Get all records from the Movie table.");
        getMovieData(session, keyspaceName);
```

```
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("9. Get a specific Movie.");
        getSpecificMovie(session, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("10. Get a UTC timestamp for the current time.");
        ZonedDateTime utc = ZonedDateTime.now(ZoneOffset.UTC);
        System.out.println("DATETIME = " + Date.from(utc.toInstant()));
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("11. Update the table schema to add a watched Boolean
column.");
        updateTable(keyClient, keyspaceName, tableName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("12. Update an item as watched.");
        Thread.sleep(10000); // Wait 10 secs for the update.
        updateRecord(session, keyspaceName, titleUpdate, yearUpdate);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("13. Query for items with watched = True.");
        getWatchedData(session, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("14. Restore the table back to the previous state
using the timestamp.");
        System.out.println("Note that the restore operation can take up to 20
minutes.");
        restoreTable(keyClient, keyspaceName, utc);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("15. Check for completion of the restore action.");
        Thread.sleep(5000);
        checkRestoredTable(keyClient, keyspaceName, "MovieRestore");
        System.out.println(DASHES);
```

```
        System.out.println(DASHES);
        System.out.println("16. Delete both tables.");
        deleteTable(keyClient, keyspaceName, tableName);
        deleteTable(keyClient, keyspaceName, tableNameRestore);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("17. Confirm that both tables are deleted.");
        checkTableDelete(keyClient, keyspaceName, tableName);
        checkTableDelete(keyClient, keyspaceName, tableNameRestore);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("18. Delete the keyspace.");
        deleteKeyspace(keyClient, keyspaceName);
        System.out.println(DASHES);

        System.out.println(DASHES);
        System.out.println("The scenario has completed successfully.");
        System.out.println(DASHES);
    }

    public static void deleteKeyspace(KeyspacesClient keyClient, String
keyspaceName) {
        try {
            DeleteKeyspaceRequest deleteKeyspaceRequest =
DeleteKeyspaceRequest.builder()
                    .keyspaceName(keyspaceName)
                    .build();

            keyClient.deleteKeyspace(deleteKeyspaceRequest);

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void checkTableDelete(KeyspacesClient keyClient, String
keyspaceName, String tableName)
            throws InterruptedException {
        try {
            String status;
            GetTableResponse response;
```

```
            GetTableRequest tableRequest = GetTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            // Keep looping until table cannot be found and a
ResourceNotFoundException is
            // thrown.
            while (true) {
                response = keyClient.getTable(tableRequest);
                status = response.statusAsString();
                System.out.println(". The table status is " + status);
                Thread.sleep(500);
            }

        } catch (ResourceNotFoundException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
        }
        System.out.println("The table is deleted");
    }

    public static void deleteTable(KeyspacesClient keyClient, String
keyspaceName, String tableName) {
        try {
            DeleteTableRequest tableRequest = DeleteTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            keyClient.deleteTable(tableRequest);

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void checkRestoredTable(KeyspacesClient keyClient, String
keyspaceName, String tableName)
            throws InterruptedException {
        try {
            boolean tableStatus = false;
            String status;
            GetTableResponse response = null;
```

```
            GetTableRequest tableRequest = GetTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            while (!tableStatus) {
                response = keyClient.getTable(tableRequest);
                status = response.statusAsString();
                System.out.println("The table status is " + status);

                if (status.compareTo("ACTIVE") == 0) {
                    tableStatus = true;
                }
                Thread.sleep(500);
            }

            List<ColumnDefinition> cols =
response.schemaDefinition().allColumns();
            for (ColumnDefinition def : cols) {
                System.out.println("The column name is " + def.name());
                System.out.println("The column type is " + def.type());
            }

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void restoreTable(KeyspacesClient keyClient, String
keyspaceName, ZonedDateTime utc) {
        try {
            Instant myTime = utc.toInstant();
            RestoreTableRequest restoreTableRequest =
RestoreTableRequest.builder()
                    .restoreTimestamp(myTime)
                    .sourceTableName("Movie")
                    .targetKeyspaceName(keyspaceName)
                    .targetTableName("MovieRestore")
                    .sourceKeyspaceName(keyspaceName)
                    .build();

            RestoreTableResponse response =
keyClient.restoreTable(restoreTableRequest);
```

```
            System.out.println("The ARN of the restored table is " +
response.restoredTableARN());

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void getWatchedData(CqlSession session, String keyspaceName) {
        ResultSet resultSet = session
                .execute("SELECT * FROM \"" + keyspaceName + "\".\"Movie\" WHERE
watched = true ALLOW FILTERING;");
        resultSet.forEach(item -> {
            System.out.println("The Movie title is " + item.getString("title"));
            System.out.println("The Movie year is " + item.getInt("year"));
            System.out.println("The plot is " + item.getString("plot"));
        });
    }

    public static void updateRecord(CqlSession session, String keySpace, String
titleUpdate, int yearUpdate) {
        String sqlStatement = "UPDATE \"" + keySpace
                + "\".\"Movie\" SET watched=true WHERE title = :k0 AND year
= :k1;";
        BatchStatementBuilder builder =
BatchStatement.builder(DefaultBatchType.UNLOGGED);
        builder.setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM);
        PreparedStatement preparedStatement = session.prepare(sqlStatement);
        builder.addStatement(preparedStatement.boundStatementBuilder()
                .setString("k0", titleUpdate)
                .setInt("k1", yearUpdate)
                .build());

        BatchStatement batchStatement = builder.build();
        session.execute(batchStatement);
    }

    public static void updateTable(KeyspacesClient keyClient, String keySpace,
String tableName) {
        try {
            ColumnDefinition def = ColumnDefinition.builder()
                    .name("watched")
                    .type("boolean")
```

```
                    .build();

            UpdateTableRequest tableRequest = UpdateTableRequest.builder()
                    .keyspaceName(keySpace)
                    .tableName(tableName)
                    .addColumns(def)
                    .build();

            keyClient.updateTable(tableRequest);

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void getSpecificMovie(CqlSession session, String keyspaceName)
{
        ResultSet resultSet = session.execute(
                "SELECT * FROM \"" + keyspaceName + "\".\"Movie\" WHERE title =
'The Family' ALLOW FILTERING ;");
        resultSet.forEach(item -> {
            System.out.println("The Movie title is " + item.getString("title"));
            System.out.println("The Movie year is " + item.getInt("year"));
            System.out.println("The plot is " + item.getString("plot"));
        });
    }

    // Get records from the Movie table.
    public static void getMovieData(CqlSession session, String keyspaceName) {
        ResultSet resultSet = session.execute("SELECT * FROM \"" + keyspaceName +
"\".\"Movie\";");
        resultSet.forEach(item -> {
            System.out.println("The Movie title is " + item.getString("title"));
            System.out.println("The Movie year is " + item.getInt("year"));
            System.out.println("The plot is " + item.getString("plot"));
        });
    }

    // Load data into the table.
    public static void loadData(CqlSession session, String fileName, String
keySpace) throws IOException {
        String sqlStatement = "INSERT INTO \"" + keySpace + "\".\"Movie\" (title,
year, plot) values (:k0, :k1, :k2)";
```

```
        JsonParser parser = new JsonFactory().createParser(new File(fileName));
        com.fasterxml.jackson.databind.JsonNode rootNode = new
ObjectMapper().readTree(parser);
        Iterator<JsonNode> iter = rootNode.iterator();
        ObjectNode currentNode;
        int t = 0;
        while (iter.hasNext()) {

            // Add 20 movies to the table.
            if (t == 20)
                break;
            currentNode = (ObjectNode) iter.next();

            int year = currentNode.path("year").asInt();
            String title = currentNode.path("title").asText();
            String plot = currentNode.path("info").path("plot").toString();

            // Insert the data into the Amazon Keyspaces table.
            BatchStatementBuilder builder =
BatchStatement.builder(DefaultBatchType.UNLOGGED);
            builder.setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM);
            PreparedStatement preparedStatement = session.prepare(sqlStatement);
            builder.addStatement(preparedStatement.boundStatementBuilder()
                    .setString("k0", title)
                    .setInt("k1", year)
                    .setString("k2", plot)
                    .build());

            BatchStatement batchStatement = builder.build();
            session.execute(batchStatement);
            t++;
        }

        System.out.println("You have added " + t + " records successfully!");
    }

    public static void listTables(KeyspacesClient keyClient, String keyspaceName)
{
        try {
            ListTablesRequest tablesRequest = ListTablesRequest.builder()
                    .keyspaceName(keyspaceName)
                    .build();
```

```
            ListTablesIterable listRes =
keyClient.listTablesPaginator(tablesRequest);
            listRes.stream()
                    .flatMap(r -> r.tables().stream())
                    .forEach(content -> System.out.println(" ARN: " +
content.resourceArn() +
                            " Table name: " + content.tableName()));

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void checkTable(KeyspacesClient keyClient, String keyspaceName,
String tableName)
            throws InterruptedException {
        try {
            boolean tableStatus = false;
            String status;
            GetTableResponse response = null;
            GetTableRequest tableRequest = GetTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            while (!tableStatus) {
                response = keyClient.getTable(tableRequest);
                status = response.statusAsString();
                System.out.println(". The table status is " + status);

                if (status.compareTo("ACTIVE") == 0) {
                    tableStatus = true;
                }
                Thread.sleep(500);
            }

            List<ColumnDefinition> cols =
response.schemaDefinition().allColumns();
            for (ColumnDefinition def : cols) {
                System.out.println("The column name is " + def.name());
                System.out.println("The column type is " + def.type());
            }
```

```
        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void createTable(KeyspacesClient keyClient, String keySpace,
String tableName) {
        try {
            // Set the columns.
            ColumnDefinition defTitle = ColumnDefinition.builder()
                    .name("title")
                    .type("text")
                    .build();

            ColumnDefinition defYear = ColumnDefinition.builder()
                    .name("year")
                    .type("int")
                    .build();

            ColumnDefinition defReleaseDate = ColumnDefinition.builder()
                    .name("release_date")
                    .type("timestamp")
                    .build();

            ColumnDefinition defPlot = ColumnDefinition.builder()
                    .name("plot")
                    .type("text")
                    .build();

            List<ColumnDefinition> colList = new ArrayList<>();
            colList.add(defTitle);
            colList.add(defYear);
            colList.add(defReleaseDate);
            colList.add(defPlot);

            // Set the keys.
            PartitionKey yearKey = PartitionKey.builder()
                    .name("year")
                    .build();

            PartitionKey titleKey = PartitionKey.builder()
                    .name("title")
                    .build();
```

```
            List<PartitionKey> keyList = new ArrayList<>();
            keyList.add(yearKey);
            keyList.add(titleKey);

            SchemaDefinition schemaDefinition = SchemaDefinition.builder()
                    .partitionKeys(keyList)
                    .allColumns(colList)
                    .build();

            PointInTimeRecovery timeRecovery = PointInTimeRecovery.builder()
                    .status(PointInTimeRecoveryStatus.ENABLED)
                    .build();

            CreateTableRequest tableRequest = CreateTableRequest.builder()
                    .keyspaceName(keySpace)
                    .tableName(tableName)
                    .schemaDefinition(schemaDefinition)
                    .pointInTimeRecovery(timeRecovery)
                    .build();

            CreateTableResponse response = keyClient.createTable(tableRequest);
            System.out.println("The table ARN is " + response.resourceArn());

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void listKeyspacesPaginator(KeyspacesClient keyClient) {
        try {
            ListKeyspacesRequest keyspacesRequest =
ListKeyspacesRequest.builder()
                    .maxResults(10)
                    .build();

            ListKeyspacesIterable listRes =
keyClient.listKeyspacesPaginator(keyspacesRequest);
            listRes.stream()
                    .flatMap(r -> r.keyspaces().stream())
                    .forEach(content -> System.out.println(" Name: " +
content.keyspaceName()));
```

```
        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void checkKeyspaceExistence(KeyspacesClient keyClient, String
 keyspaceName) {
        try {
            GetKeyspaceRequest keyspaceRequest = GetKeyspaceRequest.builder()
                    .keyspaceName(keyspaceName)
                    .build();

            GetKeyspaceResponse response =
 keyClient.getKeyspace(keyspaceRequest);
            String name = response.keyspaceName();
            System.out.println("The " + name + " KeySpace is ready");

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }

    public static void createKeySpace(KeyspacesClient keyClient, String
 keyspaceName) {
        try {
            CreateKeyspaceRequest keyspaceRequest =
 CreateKeyspaceRequest.builder()
                    .keyspaceName(keyspaceName)
                    .build();

            CreateKeyspaceResponse response =
 keyClient.createKeyspace(keyspaceRequest);
            System.out.println("The ARN of the KeySpace is " +
 response.resourceArn());

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
}
```

- For API details, see the following topics in *AWS SDK for Java 2.x API Reference*.
  - CreateKeyspace
  - CreateTable
  - DeleteKeyspace
  - DeleteTable
  - GetKeyspace
  - GetTable
  - ListKeyspaces
  - ListTables
  - RestoreTable
  - UpdateTable

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
/**
 Before running this Kotlin code example, set up your development environment,
 including your credentials.

 For more information, see the following documentation topic:

 https://docs.aws.amazon.com/sdk-for-kotlin/latest/developer-guide/setup.html

 This example uses a secure file format to hold certificate information for
 Kotlin applications. This is required to make a connection to Amazon Keyspaces.
 For more information, see the following documentation topic:
```

```
 https://docs.aws.amazon.com/keyspaces/latest/devguide/using_java_driver.html

 This Kotlin example performs the following tasks:

 1. Create a keyspace.
 2. Check for keyspace existence.
 3. List keyspaces using a paginator.
 4. Create a table with a simple movie data schema and enable point-in-time
 recovery.
 5. Check for the table to be in an Active state.
 6. List all tables in the keyspace.
 7. Use a Cassandra driver to insert some records into the Movie table.
 8. Get all records from the Movie table.
 9. Get a specific Movie.
 10. Get a UTC timestamp for the current time.
 11. Update the table schema to add a ‘watched’ Boolean column.
 12. Update an item as watched.
 13. Query for items with watched = True.
 14. Restore the table back to the previous state using the timestamp.
 15. Check for completion of the restore action.
 16. Delete the table.
 17. Confirm that both tables are deleted.
 18. Delete the keyspace.
 */

/*
   Usage:
     fileName - The name of the JSON file that contains movie data. (Get this
 file from the GitHub repo at resources/sample_file.)
     keyspaceName - The name of the keyspace to create.
 */
val DASHES: String = String(CharArray(80)).replace("\u0000", "-")

suspend fun main() {
    val fileName = "<Replace with the JSON file that contains movie data>"
    val keyspaceName = "<Replace with the name of the keyspace to create>"
    val titleUpdate = "The Family"
    val yearUpdate = 2013
    val tableName = "MovieKotlin"
    val tableNameRestore = "MovieRestore"

    val loader = DriverConfigLoader.fromClasspath("application.conf")
    val session =
        CqlSession
```

```
            .builder()
            .withConfigLoader(loader)
            .build()

    println(DASHES)
    println("Welcome to the Amazon Keyspaces example scenario.")
    println(DASHES)

    println(DASHES)
    println("1. Create a keyspace.")
    createKeySpace(keyspaceName)
    println(DASHES)

    println(DASHES)
    delay(5000)
    println("2. Check for keyspace existence.")
    checkKeyspaceExistence(keyspaceName)
    println(DASHES)

    println(DASHES)
    println("3. List keyspaces using a paginator.")
    listKeyspacesPaginator()
    println(DASHES)

    println(DASHES)
    println("4. Create a table with a simple movie data schema and enable point-
in-time recovery.")
    createTable(keyspaceName, tableName)
    println(DASHES)

    println(DASHES)
    println("5. Check for the table to be in an Active state.")
    delay(6000)
    checkTable(keyspaceName, tableName)
    println(DASHES)

    println(DASHES)
    println("6. List all tables in the keyspace.")
    listTables(keyspaceName)
    println(DASHES)

    println(DASHES)
    println("7. Use a Cassandra driver to insert some records into the Movie
 table.")
```

```
    delay(6000)
    loadData(session, fileName, keyspaceName)
    println(DASHES)

    println(DASHES)
    println("8. Get all records from the Movie table.")
    getMovieData(session, keyspaceName)
    println(DASHES)

    println(DASHES)
    println("9. Get a specific Movie.")
    getSpecificMovie(session, keyspaceName)
    println(DASHES)

    println(DASHES)
    println("10. Get a UTC timestamp for the current time.")
    val utc = ZonedDateTime.now(ZoneOffset.UTC)
    println("DATETIME = ${Date.from(utc.toInstant())}")
    println(DASHES)

    println(DASHES)
    println("11. Update the table schema to add a watched Boolean column.")
    updateTable(keyspaceName, tableName)
    println(DASHES)

    println(DASHES)
    println("12. Update an item as watched.")
    delay(10000) // Wait 10 seconds for the update.
    updateRecord(session, keyspaceName, titleUpdate, yearUpdate)
    println(DASHES)

    println(DASHES)
    println("13. Query for items with watched = True.")
    getWatchedData(session, keyspaceName)
    println(DASHES)

    println(DASHES)
    println("14. Restore the table back to the previous state using the
timestamp.")
    println("Note that the restore operation can take up to 20 minutes.")
    restoreTable(keyspaceName, utc)
    println(DASHES)

    println(DASHES)
```

```
    println("15. Check for completion of the restore action.")
    delay(5000)
    checkRestoredTable(keyspaceName, "MovieRestore")
    println(DASHES)

    println(DASHES)
    println("16. Delete both tables.")
    deleteTable(keyspaceName, tableName)
    deleteTable(keyspaceName, tableNameRestore)
    println(DASHES)

    println(DASHES)
    println("17. Confirm that both tables are deleted.")
    checkTableDelete(keyspaceName, tableName)
    checkTableDelete(keyspaceName, tableNameRestore)
    println(DASHES)

    println(DASHES)
    println("18. Delete the keyspace.")
    deleteKeyspace(keyspaceName)
    println(DASHES)

    println(DASHES)
    println("The scenario has completed successfully.")
    println(DASHES)
}

suspend fun deleteKeyspace(keyspaceNameVal: String?) {
    val deleteKeyspaceRequest =
        DeleteKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.deleteKeyspace(deleteKeyspaceRequest)
    }
}

suspend fun checkTableDelete(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    var status: String
    var response: GetTableResponse
```

```
    val tableRequest =
        GetTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }

    try {
        KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient
 ->
            // Keep looping until the table cannot be found and a
 ResourceNotFoundException is thrown.
            while (true) {
                response = keyClient.getTable(tableRequest)
                status = response.status.toString()
                println(". The table status is $status")
                delay(500)
            }
        }
    } catch (e: ResourceNotFoundException) {
        println(e.message)
    }
    println("The table is deleted")
}

suspend fun deleteTable(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    val tableRequest =
        DeleteTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.deleteTable(tableRequest)
    }
}

suspend fun checkRestoredTable(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    var tableStatus = false
```

```
    var status: String
    var response: GetTableResponse? = null

    val tableRequest =
        GetTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        while (!tableStatus) {
            response = keyClient.getTable(tableRequest)
            status = response!!.status.toString()
            println("The table status is $status")

            if (status.compareTo("ACTIVE") == 0) {
                tableStatus = true
            }
            delay(500)
        }

        val cols = response!!.schemaDefinition?.allColumns
        if (cols != null) {
            for (def in cols) {
                println("The column name is ${def.name}")
                println("The column type is ${def.type}")
            }
        }
    }
}

suspend fun restoreTable(
    keyspaceName: String?,
    utc: ZonedDateTime,
) {
    // Create an aws.smithy.kotlin.runtime.time.Instant value.
    val timeStamp =
        aws.smithy.kotlin.runtime.time
            .Instant(utc.toInstant())
    val restoreTableRequest =
        RestoreTableRequest {
            restoreTimestamp = timeStamp
            sourceTableName = "MovieKotlin"
            targetKeyspaceName = keyspaceName
```

```
            targetTableName = "MovieRestore"
            sourceKeyspaceName = keyspaceName
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.restoreTable(restoreTableRequest)
        println("The ARN of the restored table is ${response.restoredTableArn}")
    }
}

fun getWatchedData(
    session: CqlSession,
    keyspaceName: String,
) {
    val resultSet = session.execute("SELECT * FROM \"$keyspaceName\".
\"MovieKotlin\" WHERE watched = true ALLOW FILTERING;")
    resultSet.forEach { item: Row ->
        println("The Movie title is ${item.getString("title")}")
        println("The Movie year is ${item.getInt("year")}")
        println("The plot is ${item.getString("plot")}")
    }
}

fun updateRecord(
    session: CqlSession,
    keySpace: String,
    titleUpdate: String?,
    yearUpdate: Int,
) {
    val sqlStatement =
        "UPDATE \"$keySpace\".\"MovieKotlin\" SET watched=true WHERE title = :k0
 AND year = :k1;"
    val builder = BatchStatement.builder(DefaultBatchType.UNLOGGED)
    builder.setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM)
    val preparedStatement = session.prepare(sqlStatement)
    builder.addStatement(
        preparedStatement
            .boundStatementBuilder()
            .setString("k0", titleUpdate)
            .setInt("k1", yearUpdate)
            .build(),
    )
    val batchStatement = builder.build()
    session.execute(batchStatement)
```

```
}

suspend fun updateTable(
    keySpace: String?,
    tableNameVal: String?,
) {
    val def =
        ColumnDefinition {
            name = "watched"
            type = "boolean"
        }

    val tableRequest =
        UpdateTableRequest {
            keyspaceName = keySpace
            tableName = tableNameVal
            addColumns = listOf(def)
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.updateTable(tableRequest)
    }
}

fun getSpecificMovie(
    session: CqlSession,
    keyspaceName: String,
) {
    val resultSet =
        session.execute("SELECT * FROM \"$keyspaceName\".\"MovieKotlin\" WHERE
 title = 'The Family' ALLOW FILTERING ;")

    resultSet.forEach { item: Row ->
        println("The Movie title is ${item.getString("title")}")
        println("The Movie year is ${item.getInt("year")}")
        println("The plot is ${item.getString("plot")}")
    }
}

// Get records from the Movie table.
fun getMovieData(
    session: CqlSession,
    keyspaceName: String,
) {
```

```
    val resultSet = session.execute("SELECT * FROM \"$keyspaceName\".
\"MovieKotlin\";")
    resultSet.forEach { item: Row ->
        println("The Movie title is ${item.getString("title")}")
        println("The Movie year is ${item.getInt("year")}")
        println("The plot is ${item.getString("plot")}")
    }
}

// Load data into the table.
fun loadData(
    session: CqlSession,
    fileName: String,
    keySpace: String,
) {
    val sqlStatement =
        "INSERT INTO \"$keySpace\".\"MovieKotlin\" (title, year, plot) values
 (:k0, :k1, :k2)"
    val parser = JsonFactory().createParser(File(fileName))
    val rootNode = ObjectMapper().readTree<JsonNode>(parser)
    val iter: Iterator<JsonNode> = rootNode.iterator()
    var currentNode: ObjectNode

    var t = 0
    while (iter.hasNext()) {
        if (t == 50) {
            break
        }

        currentNode = iter.next() as ObjectNode
        val year = currentNode.path("year").asInt()
        val title = currentNode.path("title").asText()
        val info = currentNode.path("info").toString()

        // Insert the data into the Amazon Keyspaces table.
        val builder = BatchStatement.builder(DefaultBatchType.UNLOGGED)
        builder.setConsistencyLevel(ConsistencyLevel.LOCAL_QUORUM)
        val preparedStatement: PreparedStatement = session.prepare(sqlStatement)
        builder.addStatement(
            preparedStatement
                .boundStatementBuilder()
                .setString("k0", title)
                .setInt("k1", year)
                .setString("k2", info)
```

```
                .build(),
        )

        val batchStatement = builder.build()
        session.execute(batchStatement)
        t++
    }
}

suspend fun listTables(keyspaceNameVal: String?) {
    val tablesRequest =
        ListTablesRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient
            .listTablesPaginated(tablesRequest)
            .transform { it.tables?.forEach { obj -> emit(obj) } }
            .collect { obj ->
                println(" ARN: ${obj.resourceArn} Table name: ${obj.tableName}")
            }
    }
}

suspend fun checkTable(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    var tableStatus = false
    var status: String
    var response: GetTableResponse? = null

    val tableRequest =
        GetTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        while (!tableStatus) {
            response = keyClient.getTable(tableRequest)
            status = response!!.status.toString()
            println(". The table status is $status")
            if (status.compareTo("ACTIVE") == 0) {
```

```
                tableStatus = true
            }
            delay(500)
        }
        val cols: List<ColumnDefinition>? =
 response!!.schemaDefinition?.allColumns
        if (cols != null) {
            for (def in cols) {
                println("The column name is ${def.name}")
                println("The column type is ${def.type}")
            }
        }
    }
}

suspend fun createTable(
    keySpaceVal: String?,
    tableNameVal: String?,
) {
    // Set the columns.
    val defTitle =
        ColumnDefinition {
            name = "title"
            type = "text"
        }

    val defYear =
        ColumnDefinition {
            name = "year"
            type = "int"
        }

    val defReleaseDate =
        ColumnDefinition {
            name = "release_date"
            type = "timestamp"
        }

    val defPlot =
        ColumnDefinition {
            name = "plot"
            type = "text"
        }
```

```
    val colList = ArrayList<ColumnDefinition>()
    colList.add(defTitle)
    colList.add(defYear)
    colList.add(defReleaseDate)
    colList.add(defPlot)

    // Set the keys.
    val yearKey =
        PartitionKey {
            name = "year"
        }

    val titleKey =
        PartitionKey {
            name = "title"
        }

    val keyList = ArrayList<PartitionKey>()
    keyList.add(yearKey)
    keyList.add(titleKey)

    val schemaDefinitionOb =
        SchemaDefinition {
            partitionKeys = keyList
            allColumns = colList
        }

    val timeRecovery =
        PointInTimeRecovery {
            status = PointInTimeRecoveryStatus.Enabled
        }

    val tableRequest =
        CreateTableRequest {
            keyspaceName = keySpaceVal
            tableName = tableNameVal
            schemaDefinition = schemaDefinitionOb
            pointInTimeRecovery = timeRecovery
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.createTable(tableRequest)
        println("The table ARN is ${response.resourceArn}")
    }
```

```
}

suspend fun listKeyspacesPaginator() {
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient
            .listKeyspacesPaginated(ListKeyspacesRequest {})
            .transform { it.keyspaces?.forEach { obj -> emit(obj) } }
            .collect { obj ->
                println("Name: ${obj.keyspaceName}")
            }
    }
}

suspend fun checkKeyspaceExistence(keyspaceNameVal: String?) {
    val keyspaceRequest =
        GetKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response: GetKeyspaceResponse =
 keyClient.getKeyspace(keyspaceRequest)
        val name = response.keyspaceName
        println("The $name KeySpace is ready")
    }
}

suspend fun createKeySpace(keyspaceNameVal: String) {
    val keyspaceRequest =
        CreateKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.createKeyspace(keyspaceRequest)
        println("The ARN of the KeySpace is ${response.resourceArn}")
    }
}
```

- For API details, see the following topics in *AWS SDK for Kotlin API reference*.
  - CreateKeyspace
  - CreateTable

- DeleteKeyspace
- DeleteTable
- GetKeyspace
- GetTable
- ListKeyspaces
- ListTables
- RestoreTable
- UpdateTable

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

Run an interactive scenario at a command prompt.

```
class KeyspaceScenario:
    """Runs an interactive scenario that shows how to get started using Amazon
 Keyspaces."""

    def __init__(self, ks_wrapper):
        """
        :param ks_wrapper: An object that wraps Amazon Keyspace actions.
        """
        self.ks_wrapper = ks_wrapper

    @demo_func
    def create_keyspace(self):
        """
        1. Creates a keyspace.
        2. Lists up to 10 keyspaces in your account.
        """
        print("Let's create a keyspace.")
        ks_name = q.ask(
```

```
            "Enter a name for your new keyspace.\nThe name can contain only
letters, "
            "numbers and underscores: ",
            q.non_empty,
        )
        if self.ks_wrapper.exists_keyspace(ks_name):
            print(f"A keyspace named {ks_name} exists.")
        else:
            ks_arn = self.ks_wrapper.create_keyspace(ks_name)
            ks_exists = False
            while not ks_exists:
                wait(3)
                ks_exists = self.ks_wrapper.exists_keyspace(ks_name)
            print(f"Created a new keyspace.\n\t{ks_arn}.")
        print("The first 10 keyspaces in your account are:\n")
        self.ks_wrapper.list_keyspaces(10)

    @demo_func
    def create_table(self):
        """
        1. Creates a table in the keyspace. The table is configured with a schema
to hold
           movie data and has point-in-time recovery enabled.
        2. Waits for the table to be in an active state.
        3. Displays schema information for the table.
        4. Lists tables in the keyspace.
        """
        print("Let's create a table for movies in your keyspace.")
        table_name = q.ask("Enter a name for your table: ", q.non_empty)
        table = self.ks_wrapper.get_table(table_name)
        if table is not None:
            print(
                f"A table named {table_name} already exists in keyspace "
                f"{self.ks_wrapper.ks_name}."
            )
        else:
            table_arn = self.ks_wrapper.create_table(table_name)
            print(f"Created table {table_name}:\n\t{table_arn}")
            table = {"status": None}
            print("Waiting for your table to be ready...")
            while table["status"] != "ACTIVE":
                wait(5)
                table = self.ks_wrapper.get_table(table_name)
        print(f"Your table is {table['status']}. Its schema is:")
```

```
        pp(table["schemaDefinition"])
        print("\nThe tables in your keyspace are:\n")
        self.ks_wrapper.list_tables()

    @demo_func
    def ensure_tls_cert(self):
        """
        Ensures you have a TLS certificate available to use to secure the
connection
        to the keyspace. This function downloads a default certificate or lets
you
        specify your own.
        """
        print("To connect to your keyspace, you must have a TLS certificate.")
        print("Checking for TLS certificate...")
        cert_path = os.path.join(
            os.path.dirname(__file__), QueryManager.DEFAULT_CERT_FILE
        )
        if not os.path.exists(cert_path):
            cert_choice = q.ask(
                f"Press enter to download a certificate from
{QueryManager.CERT_URL} "
                f"or enter the full path to the certificate you want to use: "
            )
            if cert_choice:
                cert_path = cert_choice
            else:
                cert = requests.get(QueryManager.CERT_URL).text
                with open(cert_path, "w") as cert_file:
                    cert_file.write(cert)
        else:
            q.ask(f"Certificate {cert_path} found. Press Enter to continue.")
        print(
            f"Certificate {cert_path} will be used to secure the connection to
your keyspace."
        )
        return cert_path

    @demo_func
    def query_table(self, qm, movie_file):
        """
        1. Adds movies to the table from a sample movie data file.
        2. Gets a list of movies from the table and lets you select one.
        3. Displays more information about the selected movie.
```

```
        """
        qm.add_movies(self.ks_wrapper.table_name, movie_file)
        movies = qm.get_movies(self.ks_wrapper.table_name)
        print(f"Added {len(movies)} movies to the table:")
        sel = q.choose("Pick one to learn more about it: ", [m.title for m in
movies])
        movie_choice = qm.get_movie(
            self.ks_wrapper.table_name, movies[sel].title, movies[sel].year
        )
        print(movie_choice.title)
        print(f"\tReleased: {movie_choice.release_date}")
        print(f"\tPlot: {movie_choice.plot}")

    @demo_func
    def update_and_restore_table(self, qm):
        """
        1. Updates the table by adding a column to track watched movies.
        2. Marks some of the movies as watched.
        3. Gets the list of watched movies from the table.
        4. Restores to a movies_restored table at a previous point in time.
        5. Gets the list of movies from the restored table.
        """
        print("Let's add a column to record which movies you've watched.")
        pre_update_timestamp = datetime.utcnow()
        print(
            f"Recorded the current UTC time of {pre_update_timestamp} so we can
restore the table later."
        )
        self.ks_wrapper.update_table()
        print("Waiting for your table to update...")
        table = {"status": "UPDATING"}
        while table["status"] != "ACTIVE":
            wait(5)
            table = self.ks_wrapper.get_table(self.ks_wrapper.table_name)
        print("Column 'watched' added to table.")
        q.ask(
            "Let's mark some of the movies as watched. Press Enter when you're
ready.\n"
        )
        movies = qm.get_movies(self.ks_wrapper.table_name)
        for movie in movies[:10]:
            qm.watched_movie(self.ks_wrapper.table_name, movie.title, movie.year)
            print(f"Marked {movie.title} as watched.")
        movies = qm.get_movies(self.ks_wrapper.table_name, watched=True)
```

```
        print("-" * 88)
        print("The watched movies in our table are:\n")
        for movie in movies:
            print(movie.title)
        print("-" * 88)
        if q.ask(
            "Do you want to restore the table to the way it was before all of
these\n"
            "updates? Keep in mind, this can take up to 20 minutes. (y/n) ",
            q.is_yesno,
        ):
            starting_table_name = self.ks_wrapper.table_name
            table_name_restored =
self.ks_wrapper.restore_table(pre_update_timestamp)
            table = {"status": "RESTORING"}
            while table["status"] != "ACTIVE":
                wait(10)
                table = self.ks_wrapper.get_table(table_name_restored)
            print(
                f"Restored {starting_table_name} to {table_name_restored} "
                f"at a point in time of {pre_update_timestamp}."
            )
            movies = qm.get_movies(table_name_restored)
            print("Now the movies in our table are:")
            for movie in movies:
                print(movie.title)

    def cleanup(self, cert_path):
        """
        1. Deletes the table and waits for it to be removed.
        2. Deletes the keyspace.

        :param cert_path: The path of the TLS certificate used in the demo. If
the
                          certificate was downloaded during the demo, it is
removed.
        """
        if q.ask(
            f"Do you want to delete your {self.ks_wrapper.table_name} table and "
            f"{self.ks_wrapper.ks_name} keyspace? (y/n) ",
            q.is_yesno,
        ):
            table_name = self.ks_wrapper.table_name
            self.ks_wrapper.delete_table()
```

```
            table = self.ks_wrapper.get_table(table_name)
            print("Waiting for the table to be deleted.")
            while table is not None:
                wait(5)
                table = self.ks_wrapper.get_table(table_name)
            print("Table deleted.")
            self.ks_wrapper.delete_keyspace()
            print(
                "Keyspace deleted. If you chose to restore your table during the
 "
                "demo, the original table is also deleted."
            )
            if cert_path == os.path.join(
                os.path.dirname(__file__), QueryManager.DEFAULT_CERT_FILE
            ) and os.path.exists(cert_path):
                os.remove(cert_path)
                print("Removed certificate that was downloaded for this demo.")

    def run_scenario(self):
        logging.basicConfig(level=logging.INFO, format="%(levelname)s:
 %(message)s")

        print("-" * 88)
        print("Welcome to the Amazon Keyspaces (for Apache Cassandra) demo.")
        print("-" * 88)

        self.create_keyspace()
        self.create_table()
        cert_file_path = self.ensure_tls_cert()
        # Use a context manager to ensure the connection to the keyspace is
 closed.
        with QueryManager(
            cert_file_path, boto3.DEFAULT_SESSION, self.ks_wrapper.ks_name
        ) as qm:
            self.query_table(qm, "../../../resources/sample_files/movies.json")
            self.update_and_restore_table(qm)
        self.cleanup(cert_file_path)

        print("\nThanks for watching!")
        print("-" * 88)


if __name__ == "__main__":
    try:
```

```
        scenario = KeyspaceScenario(KeyspaceWrapper.from_client())
        scenario.run_scenario()
    except Exception:
        logging.exception("Something went wrong with the demo.")
```

Define a class that wraps keyspace and table actions.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def create_keyspace(self, name):
        """
        Creates a keyspace.

        :param name: The name to give the keyspace.
        :return: The Amazon Resource Name (ARN) of the new keyspace.
        """
        try:
            response = self.keyspaces_client.create_keyspace(keyspaceName=name)
            self.ks_name = name
            self.ks_arn = response["resourceArn"]
        except ClientError as err:
            logger.error(
                "Couldn't create %s. Here's why: %s: %s",
                name,
                err.response["Error"]["Code"],
```

```
                err.response["Error"]["Message"],
            )
            raise
        else:
            return self.ks_arn


    def exists_keyspace(self, name):
        """
        Checks whether a keyspace exists.

        :param name: The name of the keyspace to look up.
        :return: True when the keyspace exists. Otherwise, False.
        """
        try:
            response = self.keyspaces_client.get_keyspace(keyspaceName=name)
            self.ks_name = response["keyspaceName"]
            self.ks_arn = response["resourceArn"]
            exists = True
        except ClientError as err:
            if err.response["Error"]["Code"] == "ResourceNotFoundException":
                logger.info("Keyspace %s does not exist.", name)
                exists = False
            else:
                logger.error(
                    "Couldn't verify %s exists. Here's why: %s: %s",
                    name,
                    err.response["Error"]["Code"],
                    err.response["Error"]["Message"],
                )
                raise
        return exists


    def list_keyspaces(self, limit):
        """
        Lists the keyspaces in your account.

        :param limit: The maximum number of keyspaces to list.
        """
        try:
            ks_paginator = self.keyspaces_client.get_paginator("list_keyspaces")
            for page in ks_paginator.paginate(PaginationConfig={"MaxItems":
limit}):
```

```
                for ks in page["keyspaces"]:
                    print(ks["keyspaceName"])
                    print(f"\t{ks['resourceArn']}")
        except ClientError as err:
            logger.error(
                "Couldn't list keyspaces. Here's why: %s: %s",
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise


    def create_table(self, table_name):
        """
        Creates a table in the  keyspace.
        The table is created with a schema for storing movie data
        and has point-in-time recovery enabled.

        :param table_name: The name to give the table.
        :return: The ARN of the new table.
        """
        try:
            response = self.keyspaces_client.create_table(
                keyspaceName=self.ks_name,
                tableName=table_name,
                schemaDefinition={
                    "allColumns": [
                        {"name": "title", "type": "text"},
                        {"name": "year", "type": "int"},
                        {"name": "release_date", "type": "timestamp"},
                        {"name": "plot", "type": "text"},
                    ],
                    "partitionKeys": [{"name": "year"}, {"name": "title"}],
                },
                pointInTimeRecovery={"status": "ENABLED"},
            )
        except ClientError as err:
            logger.error(
                "Couldn't create table %s. Here's why: %s: %s",
                table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

```
        else:
            return response["resourceArn"]


    def get_table(self, table_name):
        """
        Gets data about a table in the keyspace.

        :param table_name: The name of the table to look up.
        :return: Data about the table.
        """
        try:
            response = self.keyspaces_client.get_table(
                keyspaceName=self.ks_name, tableName=table_name
            )
            self.table_name = table_name
        except ClientError as err:
            if err.response["Error"]["Code"] == "ResourceNotFoundException":
                logger.info("Table %s does not exist.", table_name)
                self.table_name = None
                response = None
            else:
                logger.error(
                    "Couldn't verify %s exists. Here's why: %s: %s",
                    table_name,
                    err.response["Error"]["Code"],
                    err.response["Error"]["Message"],
                )
                raise
        return response


    def list_tables(self):
        """
        Lists the tables in the keyspace.
        """
        try:
            table_paginator = self.keyspaces_client.get_paginator("list_tables")
            for page in table_paginator.paginate(keyspaceName=self.ks_name):
                for table in page["tables"]:
                    print(table["tableName"])
                    print(f"\t{table['resourceArn']}")
        except ClientError as err:
            logger.error(
```

```
                "Couldn't list tables in keyspace %s. Here's why: %s: %s",
                self.ks_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise


    def update_table(self):
        """
        Updates the schema of the table.

        This example updates a table of movie data by adding a new column
        that tracks whether the movie has been watched.
        """
        try:
            self.keyspaces_client.update_table(
                keyspaceName=self.ks_name,
                tableName=self.table_name,
                addColumns=[{"name": "watched", "type": "boolean"}],
            )
        except ClientError as err:
            logger.error(
                "Couldn't update table %s. Here's why: %s: %s",
                self.table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise


    def restore_table(self, restore_timestamp):
        """
        Restores the table to a previous point in time. The table is restored
        to a new table in the same keyspace.

        :param restore_timestamp: The point in time to restore the table. This
time
                                  must be in UTC format.
        :return: The name of the restored table.
        """
        try:
            restored_table_name = f"{self.table_name}_restored"
            self.keyspaces_client.restore_table(
```

```
                sourceKeyspaceName=self.ks_name,
                sourceTableName=self.table_name,
                targetKeyspaceName=self.ks_name,
                targetTableName=restored_table_name,
                restoreTimestamp=restore_timestamp,
            )
        except ClientError as err:
            logger.error(
                "Couldn't restore table %s. Here's why: %s: %s",
                restore_timestamp,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
        else:
            return restored_table_name


    def delete_table(self):
        """
        Deletes the table from the keyspace.
        """
        try:
            self.keyspaces_client.delete_table(
                keyspaceName=self.ks_name, tableName=self.table_name
            )
            self.table_name = None
        except ClientError as err:
            logger.error(
                "Couldn't delete table %s. Here's why: %s: %s",
                self.table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise


    def delete_keyspace(self):
        """
        Deletes the keyspace.
        """
        try:
            self.keyspaces_client.delete_keyspace(keyspaceName=self.ks_name)
            self.ks_name = None
```

```
        except ClientError as err:
            logger.error(
                "Couldn't delete keyspace %s. Here's why: %s: %s",
                self.ks_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

Define a class that creates a TLS connection to a keyspace, authenticates with SigV4, and sends CQL queries to a table in the keyspace.

```
class QueryManager:
    """
    Manages queries to an Amazon Keyspaces (for Apache Cassandra) keyspace.
    Queries are secured by TLS and authenticated by using the Signature V4
 (SigV4)
    AWS signing protocol. This is more secure than sending username and password
    with a plain-text authentication provider.

    This example downloads a default certificate to secure TLS, or lets you
 specify
    your own.

    This example uses a table of movie data to demonstrate basic queries.
    """

    DEFAULT_CERT_FILE = "sf-class2-root.crt"
    CERT_URL = f"https://certs.secureserver.net/repository/sf-class2-root.crt"

    def __init__(self, cert_file_path, boto_session, keyspace_name):
        """
        :param cert_file_path: The path and file name of the certificate used for
 TLS.
        :param boto_session: A Boto3 session. This is used to acquire your AWS
 credentials.
        :param keyspace_name: The name of the keyspace to connect.
        """
        self.cert_file_path = cert_file_path
```

```
        self.boto_session = boto_session
        self.ks_name = keyspace_name
        self.cluster = None
        self.session = None

    def __enter__(self):
        """
        Creates a session connection to the keyspace that is secured by TLS and
        authenticated by SigV4.
        """
        ssl_context = SSLContext(PROTOCOL_TLSv1_2)
        ssl_context.load_verify_locations(self.cert_file_path)
        ssl_context.verify_mode = CERT_REQUIRED
        auth_provider = SigV4AuthProvider(self.boto_session)
        contact_point = f"cassandra.
{self.boto_session.region_name}.amazonaws.com"
        exec_profile = ExecutionProfile(
            consistency_level=ConsistencyLevel.LOCAL_QUORUM,
            load_balancing_policy=DCAwareRoundRobinPolicy(),
        )
        self.cluster = Cluster(
            [contact_point],
            ssl_context=ssl_context,
            auth_provider=auth_provider,
            port=9142,
            execution_profiles={EXEC_PROFILE_DEFAULT: exec_profile},
            protocol_version=4,
        )
        self.cluster.__enter__()
        self.session = self.cluster.connect(self.ks_name)
        return self

    def __exit__(self, *args):
        """
        Exits the cluster. This shuts down all existing session connections.
        """
        self.cluster.__exit__(*args)

    def add_movies(self, table_name, movie_file_path):
        """
        Gets movies from a JSON file and adds them to a table in the keyspace.

        :param table_name: The name of the table.
```

```
        :param movie_file_path: The path and file name of a JSON file that
 contains movie data.
        """
        with open(movie_file_path, "r") as movie_file:
            movies = json.loads(movie_file.read())
        stmt = self.session.prepare(
            f"INSERT INTO {table_name} (year, title, release_date, plot) VALUES
 (?, ?, ?, ?);"
        )
        for movie in movies[:20]:
            self.session.execute(
                stmt,
                parameters=[
                    movie["year"],
                    movie["title"],
                    date.fromisoformat(movie["info"]
["release_date"].partition("T")[0]),
                    movie["info"]["plot"],
                ],
            )

    def get_movies(self, table_name, watched=None):
        """
        Gets the title and year of the full list of movies from the table.

        :param table_name: The name of the movie table.
        :param watched: When specified, the returned list of movies is filtered
 to
                        either movies that have been watched or movies that have
 not
                        been watched. Otherwise, all movies are returned.
        :return: A list of movies in the table.
        """
        if watched is None:
            stmt = SimpleStatement(f"SELECT title, year from {table_name}")
            params = None
        else:
            stmt = SimpleStatement(
                f"SELECT title, year from {table_name} WHERE watched = %s ALLOW
 FILTERING"
            )
            params = [watched]
        return self.session.execute(stmt, parameters=params).all()
```

```
    def get_movie(self, table_name, title, year):
        """
        Gets a single movie from the table, by title and year.

        :param table_name: The name of the movie table.
        :param title: The title of the movie.
        :param year: The year of the movie's release.
        :return: The requested movie.
        """
        return self.session.execute(
            SimpleStatement(
                f"SELECT * from {table_name} WHERE title = %s AND year = %s"
            ),
            parameters=[title, year],
        ).one()

    def watched_movie(self, table_name, title, year):
        """
        Updates a movie as having been watched.

        :param table_name: The name of the movie table.
        :param title: The title of the movie.
        :param year: The year of the movie's release.
        """
        self.session.execute(
            SimpleStatement(
                f"UPDATE {table_name} SET watched=true WHERE title = %s AND year
= %s"
            ),
            parameters=[title, year],
        )
```

- For API details, see the following topics in *AWS SDK for Python (Boto3) API Reference*.
  - CreateKeyspace
  - CreateTable
  - DeleteKeyspace
  - DeleteTable
  - GetKeyspace

- GetTable
- ListKeyspaces
- ListTables
- RestoreTable
- UpdateTable

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Actions for Amazon Keyspaces using AWS SDKs

The following code examples demonstrate how to perform individual Amazon Keyspaces actions with AWS SDKs. Each example includes a link to GitHub, where you can find instructions for setting up and running the code.

The following examples include only the most commonly used actions. For a complete list, see the Amazon Keyspaces (for Apache Cassandra) API Reference.

Examples

- Use CreateKeyspace with an AWS SDK
- Use CreateTable with an AWS SDK
- Use DeleteKeyspace with an AWS SDK
- Use DeleteTable with an AWS SDK
- Use GetKeyspace with an AWS SDK
- Use GetTable with an AWS SDK
- Use ListKeyspaces with an AWS SDK
- Use ListTables with an AWS SDK
- Use RestoreTable with an AWS SDK
- Use UpdateTable with an AWS SDK

Use `CreateKeyspace` with an AWS SDK

The following code examples show how to use `CreateKeyspace`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
/// <summary>
/// Create a new keyspace.
/// </summary>
/// <param name="keyspaceName">The name for the new keyspace.</param>
/// <returns>The Amazon Resource Name (ARN) of the new keyspace.</returns>
public async Task<string> CreateKeyspace(string keyspaceName)
{
    var response =
        await _amazonKeyspaces.CreateKeyspaceAsync(
            new CreateKeyspaceRequest { KeyspaceName = keyspaceName });
    return response.ResourceArn;
}
```

- For API details, see CreateKeyspace in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
   public static void createKeySpace(KeyspacesClient keyClient, String
keyspaceName) {
       try {
           CreateKeyspaceRequest keyspaceRequest =
CreateKeyspaceRequest.builder()
                   .keyspaceName(keyspaceName)
                   .build();

           CreateKeyspaceResponse response =
keyClient.createKeyspace(keyspaceRequest);
           System.out.println("The ARN of the KeySpace is " +
response.resourceArn());

       } catch (KeyspacesException e) {
           System.err.println(e.awsErrorDetails().errorMessage());
           System.exit(1);
       }
   }
```

- For API details, see CreateKeyspace in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun createKeySpace(keyspaceNameVal: String) {
    val keyspaceRequest =
        CreateKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.createKeyspace(keyspaceRequest)
        println("The ARN of the KeySpace is ${response.resourceArn}")
    }
}
```

- For API details, see CreateKeyspace in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
```

```
        return cls(keyspaces_client)


    def create_keyspace(self, name):
        """
        Creates a keyspace.

        :param name: The name to give the keyspace.
        :return: The Amazon Resource Name (ARN) of the new keyspace.
        """
        try:
            response = self.keyspaces_client.create_keyspace(keyspaceName=name)
            self.ks_name = name
            self.ks_arn = response["resourceArn"]
        except ClientError as err:
            logger.error(
                "Couldn't create %s. Here's why: %s: %s",
                name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
        else:
            return self.ks_arn
```

- For API details, see CreateKeyspace in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->createkeyspace(
          iv_keyspacename = iv_keyspace_name ).
```

```
        MESSAGE 'Keyspace created successfully.' TYPE 'I'.
      CATCH /aws1/cx_kysconflictexception.
        MESSAGE 'Keyspace already exists.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see CreateKeyspace in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `CreateTable` with an AWS SDK

The following code examples show how to use `CreateTable`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Create a new Amazon Keyspaces table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace where the table will be
created.</param>
```

```
    /// <param name="schema">The schema for the new table.</param>
    /// <param name="tableName">The name of the new table.</param>
    /// <returns>The Amazon Resource Name (ARN) of the new table.</returns>
    public async Task<string> CreateTable(string keyspaceName, SchemaDefinition
schema, string tableName)
    {
        var request = new CreateTableRequest
        {
            KeyspaceName = keyspaceName,
            SchemaDefinition = schema,
            TableName = tableName,
            PointInTimeRecovery = new PointInTimeRecovery { Status =
PointInTimeRecoveryStatus.ENABLED }
        };

        var response = await _amazonKeyspaces.CreateTableAsync(request);
        return response.ResourceArn;
    }
```

- For API details, see CreateTable in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    public static void createTable(KeyspacesClient keyClient, String keySpace,
String tableName) {
        try {
            // Set the columns.
            ColumnDefinition defTitle = ColumnDefinition.builder()
                    .name("title")
                    .type("text")
                    .build();
```

```
            ColumnDefinition defYear = ColumnDefinition.builder()
                    .name("year")
                    .type("int")
                    .build();

            ColumnDefinition defReleaseDate = ColumnDefinition.builder()
                    .name("release_date")
                    .type("timestamp")
                    .build();

            ColumnDefinition defPlot = ColumnDefinition.builder()
                    .name("plot")
                    .type("text")
                    .build();

            List<ColumnDefinition> colList = new ArrayList<>();
            colList.add(defTitle);
            colList.add(defYear);
            colList.add(defReleaseDate);
            colList.add(defPlot);

            // Set the keys.
            PartitionKey yearKey = PartitionKey.builder()
                    .name("year")
                    .build();

            PartitionKey titleKey = PartitionKey.builder()
                    .name("title")
                    .build();

            List<PartitionKey> keyList = new ArrayList<>();
            keyList.add(yearKey);
            keyList.add(titleKey);

            SchemaDefinition schemaDefinition = SchemaDefinition.builder()
                    .partitionKeys(keyList)
                    .allColumns(colList)
                    .build();

            PointInTimeRecovery timeRecovery = PointInTimeRecovery.builder()
                    .status(PointInTimeRecoveryStatus.ENABLED)
                    .build();

            CreateTableRequest tableRequest = CreateTableRequest.builder()
```

```
                    .keyspaceName(keySpace)
                    .tableName(tableName)
                    .schemaDefinition(schemaDefinition)
                    .pointInTimeRecovery(timeRecovery)
                    .build();

            CreateTableResponse response = keyClient.createTable(tableRequest);
            System.out.println("The table ARN is " + response.resourceArn());

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see CreateTable in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun createTable(
    keySpaceVal: String?,
    tableNameVal: String?,
) {
    // Set the columns.
    val defTitle =
        ColumnDefinition {
            name = "title"
            type = "text"
        }

    val defYear =
        ColumnDefinition {
            name = "year"
```

```
            type = "int"
        }

    val defReleaseDate =
        ColumnDefinition {
            name = "release_date"
            type = "timestamp"
        }

    val defPlot =
        ColumnDefinition {
            name = "plot"
            type = "text"
        }

    val colList = ArrayList<ColumnDefinition>()
    colList.add(defTitle)
    colList.add(defYear)
    colList.add(defReleaseDate)
    colList.add(defPlot)

    // Set the keys.
    val yearKey =
        PartitionKey {
            name = "year"
        }

    val titleKey =
        PartitionKey {
            name = "title"
        }

    val keyList = ArrayList<PartitionKey>()
    keyList.add(yearKey)
    keyList.add(titleKey)

    val schemaDefinitionOb =
        SchemaDefinition {
            partitionKeys = keyList
            allColumns = colList
        }

    val timeRecovery =
        PointInTimeRecovery {
```

```
            status = PointInTimeRecoveryStatus.Enabled
        }

    val tableRequest =
        CreateTableRequest {
            keyspaceName = keySpaceVal
            tableName = tableNameVal
            schemaDefinition = schemaDefinitionOb
            pointInTimeRecovery = timeRecovery
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.createTable(tableRequest)
        println("The table ARN is ${response.resourceArn}")
    }
}
```

- For API details, see CreateTable in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None
```

```
    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def create_table(self, table_name):
        """
        Creates a table in the  keyspace.
        The table is created with a schema for storing movie data
        and has point-in-time recovery enabled.

        :param table_name: The name to give the table.
        :return: The ARN of the new table.
        """
        try:
            response = self.keyspaces_client.create_table(
                keyspaceName=self.ks_name,
                tableName=table_name,
                schemaDefinition={
                    "allColumns": [
                        {"name": "title", "type": "text"},
                        {"name": "year", "type": "int"},
                        {"name": "release_date", "type": "timestamp"},
                        {"name": "plot", "type": "text"},
                    ],
                    "partitionKeys": [{"name": "year"}, {"name": "title"}],
                },
                pointInTimeRecovery={"status": "ENABLED"},
            )
        except ClientError as err:
            logger.error(
                "Couldn't create table %s. Here's why: %s: %s",
                table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
        else:
            return response["resourceArn"]
```

- For API details, see CreateTable in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        " Define schema with columns
        DATA(lt_columns) = VALUE /aws1/
cl_kyscolumndefinition=>tt_columndefinitionlist(
          ( NEW /aws1/cl_kyscolumndefinition( iv_name = 'title' iv_type =
 'text' ) )
          ( NEW /aws1/cl_kyscolumndefinition( iv_name = 'year' iv_type =
 'int' ) )
          ( NEW /aws1/cl_kyscolumndefinition( iv_name = 'release_date' iv_type =
 'timestamp' ) )
          ( NEW /aws1/cl_kyscolumndefinition( iv_name = 'plot' iv_type =
 'text' ) )
        ).

        " Define partition keys
        DATA(lt_partition_keys) = VALUE /aws1/
cl_kyspartitionkey=>tt_partitionkeylist(
          ( NEW /aws1/cl_kyspartitionkey( iv_name = 'year' ) )
          ( NEW /aws1/cl_kyspartitionkey( iv_name = 'title' ) )
        ).

        " Create schema definition
        DATA(lo_schema) = NEW /aws1/cl_kysschemadefinition(
          it_allcolumns = lt_columns
          it_partitionkeys = lt_partition_keys ).

        " Enable point-in-time recovery
        DATA(lo_pitr) = NEW /aws1/cl_kyspointintimerec(
          iv_status = 'ENABLED' ).
```

```
        oo_result = lo_kys->createtable(
          iv_keyspacename = iv_keyspace_name
          iv_tablename = iv_table_name
          io_schemadefinition = lo_schema
          io_pointintimerecovery = lo_pitr ).
        MESSAGE 'Table created successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see CreateTable in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `DeleteKeyspace` with an AWS SDK

The following code examples show how to use `DeleteKeyspace`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Delete an existing keyspace.
```

```
    /// </summary>
    /// <param name="keyspaceName"></param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> DeleteKeyspace(string keyspaceName)
    {
        var response = await _amazonKeyspaces.DeleteKeyspaceAsync(
            new DeleteKeyspaceRequest { KeyspaceName = keyspaceName });
        return response.HttpStatusCode == HttpStatusCode.OK;
    }
```

- For API details, see DeleteKeyspace in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
   public static void deleteKeyspace(KeyspacesClient keyClient, String
keyspaceName) {
       try {
           DeleteKeyspaceRequest deleteKeyspaceRequest =
DeleteKeyspaceRequest.builder()
                   .keyspaceName(keyspaceName)
                   .build();

           keyClient.deleteKeyspace(deleteKeyspaceRequest);

       } catch (KeyspacesException e) {
           System.err.println(e.awsErrorDetails().errorMessage());
           System.exit(1);
       }
   }
```

- For API details, see DeleteKeyspace in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun deleteKeyspace(keyspaceNameVal: String?) {
    val deleteKeyspaceRequest =
        DeleteKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.deleteKeyspace(deleteKeyspaceRequest)
    }
}
```

- For API details, see DeleteKeyspace in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""
```

```
    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def delete_keyspace(self):
        """
        Deletes the keyspace.
        """
        try:
            self.keyspaces_client.delete_keyspace(keyspaceName=self.ks_name)
            self.ks_name = None
        except ClientError as err:
            logger.error(
                "Couldn't delete keyspace %s. Here's why: %s: %s",
                self.ks_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

- For API details, see DeleteKeyspace in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        lo_kys->deletekeyspace(
          iv_keyspacename = iv_keyspace_name ).
        MESSAGE 'Keyspace deleted successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see DeleteKeyspace in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `DeleteTable` with an AWS SDK

The following code examples show how to use `DeleteTable`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Delete an Amazon Keyspaces table.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to delete.</param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> DeleteTable(string keyspaceName, string tableName)
    {
        var response = await _amazonKeyspaces.DeleteTableAsync(
            new DeleteTableRequest { KeyspaceName = keyspaceName, TableName =
tableName });
        return response.HttpStatusCode == HttpStatusCode.OK;
    }
```

- For API details, see DeleteTable in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    public static void deleteTable(KeyspacesClient keyClient, String
keyspaceName, String tableName) {
```

```
        try {
            DeleteTableRequest tableRequest = DeleteTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            keyClient.deleteTable(tableRequest);

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see DeleteTable in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun deleteTable(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    val tableRequest =
        DeleteTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.deleteTable(tableRequest)
    }
}
```

- For API details, see DeleteTable in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def delete_table(self):
        """
        Deletes the table from the keyspace.
        """
        try:
            self.keyspaces_client.delete_table(
                keyspaceName=self.ks_name, tableName=self.table_name
            )
            self.table_name = None
```

```
        except ClientError as err:
            logger.error(
                "Couldn't delete table %s. Here's why: %s: %s",
                self.table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

- For API details, see DeleteTable in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        lo_kys->deletetable(
          iv_keyspacename = iv_keyspace_name
          iv_tablename = iv_table_name ).
        MESSAGE 'Table deleted successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see DeleteTable in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `GetKeyspace` with an AWS SDK

The following code examples show how to use `GetKeyspace`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
/// <summary>
/// Get data about a keyspace.
/// </summary>
/// <param name="keyspaceName">The name of the keyspace.</param>
/// <returns>The Amazon Resource Name (ARN) of the keyspace.</returns>
public async Task<string> GetKeyspace(string keyspaceName)
{
    var response = await _amazonKeyspaces.GetKeyspaceAsync(
        new GetKeyspaceRequest { KeyspaceName = keyspaceName });
    return response.ResourceArn;
}
```

- For API details, see GetKeyspace in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
   public static void checkKeyspaceExistence(KeyspacesClient keyClient, String
keyspaceName) {
       try {
           GetKeyspaceRequest keyspaceRequest = GetKeyspaceRequest.builder()
                   .keyspaceName(keyspaceName)
                   .build();

           GetKeyspaceResponse response =
keyClient.getKeyspace(keyspaceRequest);
           String name = response.keyspaceName();
           System.out.println("The " + name + " KeySpace is ready");

       } catch (KeyspacesException e) {
           System.err.println(e.awsErrorDetails().errorMessage());
           System.exit(1);
       }
   }
```

- For API details, see GetKeyspace in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun checkKeyspaceExistence(keyspaceNameVal: String?) {
    val keyspaceRequest =
        GetKeyspaceRequest {
            keyspaceName = keyspaceNameVal
        }
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response: GetKeyspaceResponse =
 keyClient.getKeyspace(keyspaceRequest)
        val name = response.keyspaceName
        println("The $name KeySpace is ready")
    }
}
```

- For API details, see GetKeyspace in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
```

```
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def exists_keyspace(self, name):
        """
        Checks whether a keyspace exists.

        :param name: The name of the keyspace to look up.
        :return: True when the keyspace exists. Otherwise, False.
        """
        try:
            response = self.keyspaces_client.get_keyspace(keyspaceName=name)
            self.ks_name = response["keyspaceName"]
            self.ks_arn = response["resourceArn"]
            exists = True
        except ClientError as err:
            if err.response["Error"]["Code"] == "ResourceNotFoundException":
                logger.info("Keyspace %s does not exist.", name)
                exists = False
            else:
                logger.error(
                    "Couldn't verify %s exists. Here's why: %s: %s",
                    name,
                    err.response["Error"]["Code"],
                    err.response["Error"]["Message"],
                )
                raise
        return exists
```

- For API details, see GetKeyspace in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->getkeyspace(
          iv_keyspacename = iv_keyspace_name ).
        MESSAGE 'Keyspace retrieved successfully.' TYPE 'I'.
      CATCH /aws1/cx_kysresourcenotfoundex.
        MESSAGE 'Keyspace does not exist.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see GetKeyspace in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `GetTable` with an AWS SDK

The following code examples show how to use `GetTable`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Get information about an Amazon Keyspaces table.
```

```
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the Amazon Keyspaces table.</param>
    /// <returns>The response containing data about the table.</returns>
    public async Task<GetTableResponse> GetTable(string keyspaceName, string
tableName)
    {
        var response = await _amazonKeyspaces.GetTableAsync(
            new GetTableRequest { KeyspaceName = keyspaceName, TableName =
tableName });
        return response;
    }
```

- For API details, see GetTable in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    public static void checkTable(KeyspacesClient keyClient, String keyspaceName,
String tableName)
            throws InterruptedException {
        try {
            boolean tableStatus = false;
            String status;
            GetTableResponse response = null;
            GetTableRequest tableRequest = GetTableRequest.builder()
                    .keyspaceName(keyspaceName)
                    .tableName(tableName)
                    .build();

            while (!tableStatus) {
                response = keyClient.getTable(tableRequest);
                status = response.statusAsString();
```

```
                System.out.println(". The table status is " + status);

                if (status.compareTo("ACTIVE") == 0) {
                    tableStatus = true;
                }
                Thread.sleep(500);
            }

            List<ColumnDefinition> cols =
 response.schemaDefinition().allColumns();
            for (ColumnDefinition def : cols) {
                System.out.println("The column name is " + def.name());
                System.out.println("The column type is " + def.type());
            }

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see GetTable in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun checkTable(
    keyspaceNameVal: String?,
    tableNameVal: String?,
) {
    var tableStatus = false
    var status: String
    var response: GetTableResponse? = null
```

```
    val tableRequest =
        GetTableRequest {
            keyspaceName = keyspaceNameVal
            tableName = tableNameVal
        }
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        while (!tableStatus) {
            response = keyClient.getTable(tableRequest)
            status = response!!.status.toString()
            println(". The table status is $status")
            if (status.compareTo("ACTIVE") == 0) {
                tableStatus = true
            }
            delay(500)
        }
        val cols: List<ColumnDefinition>? =
 response!!.schemaDefinition?.allColumns
        if (cols != null) {
            for (def in cols) {
                println("The column name is ${def.name}")
                println("The column type is ${def.type}")
            }
        }
    }
}
```

- For API details, see GetTable in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""
```

```
    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def get_table(self, table_name):
        """
        Gets data about a table in the keyspace.

        :param table_name: The name of the table to look up.
        :return: Data about the table.
        """
        try:
            response = self.keyspaces_client.get_table(
                keyspaceName=self.ks_name, tableName=table_name
            )
            self.table_name = table_name
        except ClientError as err:
            if err.response["Error"]["Code"] == "ResourceNotFoundException":
                logger.info("Table %s does not exist.", table_name)
                self.table_name = None
                response = None
            else:
                logger.error(
                    "Couldn't verify %s exists. Here's why: %s: %s",
                    table_name,
                    err.response["Error"]["Code"],
                    err.response["Error"]["Message"],
                )
                raise
        return response
```

- For API details, see GetTable in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->gettable(
          iv_keyspacename = iv_keyspace_name
          iv_tablename = iv_table_name ).
        MESSAGE 'Table information retrieved successfully.' TYPE 'I'.
      CATCH /aws1/cx_kysresourcenotfoundex.
        MESSAGE 'Table does not exist.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see GetTable in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `ListKeyspaces` with an AWS SDK

The following code examples show how to use `ListKeyspaces`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Lists all keyspaces for the account.
    /// </summary>
    /// <returns>Async task.</returns>
    public async Task ListKeyspaces()
    {
        var paginator = _amazonKeyspaces.Paginators.ListKeyspaces(new
ListKeyspacesRequest());

        Console.WriteLine("{0, -30}\t{1}", "Keyspace name", "Keyspace ARN");
        Console.WriteLine(new string('-', Console.WindowWidth));
        await foreach (var keyspace in paginator.Keyspaces)
        {

Console.WriteLine($"{keyspace.KeyspaceName,-30}\t{keyspace.ResourceArn}");
        }
    }
```

- For API details, see ListKeyspaces in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
   public static void listKeyspacesPaginator(KeyspacesClient keyClient) {
       try {
           ListKeyspacesRequest keyspacesRequest =
ListKeyspacesRequest.builder()
                   .maxResults(10)
                   .build();

           ListKeyspacesIterable listRes =
keyClient.listKeyspacesPaginator(keyspacesRequest);
           listRes.stream()
                   .flatMap(r -> r.keyspaces().stream())
                   .forEach(content -> System.out.println(" Name: " +
content.keyspaceName()));

       } catch (KeyspacesException e) {
           System.err.println(e.awsErrorDetails().errorMessage());
           System.exit(1);
       }
   }
```

- For API details, see ListKeyspaces in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun listKeyspacesPaginator() {
    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient
            .listKeyspacesPaginated(ListKeyspacesRequest {})
            .transform { it.keyspaces?.forEach { obj -> emit(obj) } }
            .collect { obj ->
                println("Name: ${obj.keyspaceName}")
            }
    }
}
```

- For API details, see ListKeyspaces in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
```

```
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def list_keyspaces(self, limit):
        """
        Lists the keyspaces in your account.

        :param limit: The maximum number of keyspaces to list.
        """
        try:
            ks_paginator = self.keyspaces_client.get_paginator("list_keyspaces")
            for page in ks_paginator.paginate(PaginationConfig={"MaxItems":
limit}):
                for ks in page["keyspaces"]:
                    print(ks["keyspaceName"])
                    print(f"\t{ks['resourceArn']}")
        except ClientError as err:
            logger.error(
                "Couldn't list keyspaces. Here's why: %s: %s",
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

- For API details, see ListKeyspaces in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->listkeyspaces(
          iv_maxresults = iv_max_results ).
        MESSAGE 'Keyspaces listed successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see ListKeyspaces in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `ListTables` with an AWS SDK

The following code examples show how to use `ListTables`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Lists the Amazon Keyspaces tables in a keyspace.
    /// </summary>
    /// <param name="keyspaceName">The name of the keyspace.</param>
    /// <returns>A list of TableSummary objects.</returns>
    public async Task<List<TableSummary>> ListTables(string keyspaceName)
    {
        var response = await _amazonKeyspaces.ListTablesAsync(new
ListTablesRequest { KeyspaceName = keyspaceName });
        response.Tables.ForEach(table =>
        {

Console.WriteLine($"{table.KeyspaceName}\t{table.TableName}\t{table.ResourceArn}");
        });

        return response.Tables;
    }
```

- For API details, see ListTables in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    public static void listTables(KeyspacesClient keyClient, String keyspaceName)
{
        try {
            ListTablesRequest tablesRequest = ListTablesRequest.builder()
                    .keyspaceName(keyspaceName)
                    .build();

            ListTablesIterable listRes =
keyClient.listTablesPaginator(tablesRequest);
            listRes.stream()
                    .flatMap(r -> r.tables().stream())
                    .forEach(content -> System.out.println(" ARN: " +
content.resourceArn() +
                            " Table name: " + content.tableName()));

        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see ListTables in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun listTables(keyspaceNameVal: String?) {
    val tablesRequest =
        ListTablesRequest {
            keyspaceName = keyspaceNameVal
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
```

```
        keyClient
            .listTablesPaginated(tablesRequest)
            .transform { it.tables?.forEach { obj -> emit(obj) } }
            .collect { obj ->
                println(" ARN: ${obj.resourceArn} Table name: ${obj.tableName}")
            }
    }
}
```

- For API details, see ListTables in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def list_tables(self):
```

```
        """
        Lists the tables in the keyspace.
        """
        try:
            table_paginator = self.keyspaces_client.get_paginator("list_tables")
            for page in table_paginator.paginate(keyspaceName=self.ks_name):
                for table in page["tables"]:
                    print(table["tableName"])
                    print(f"\t{table['resourceArn']}")
        except ClientError as err:
            logger.error(
                "Couldn't list tables in keyspace %s. Here's why: %s: %s",
                self.ks_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

- For API details, see ListTables in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->listtables(
          iv_keyspacename = iv_keyspace_name ).
        MESSAGE 'Tables listed successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see ListTables in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `RestoreTable` with an AWS SDK

The following code examples show how to use `RestoreTable`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Restores the specified table to the specified point in time.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to restore.</param>
    /// <param name="timestamp">The time to which the table will be restored.</
param>
    /// <returns>The Amazon Resource Name (ARN) of the restored table.</returns>
    public async Task<string> RestoreTable(string keyspaceName, string tableName,
 string restoredTableName, DateTime timestamp)
    {
        var request = new RestoreTableRequest
        {
```

```
            RestoreTimestamp = timestamp,
            SourceKeyspaceName = keyspaceName,
            SourceTableName = tableName,
            TargetKeyspaceName = keyspaceName,
            TargetTableName = restoredTableName
        };

        var response = await _amazonKeyspaces.RestoreTableAsync(request);
        return response.RestoredTableARN;
    }
```

- For API details, see RestoreTable in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
   public static void restoreTable(KeyspacesClient keyClient, String
keyspaceName, ZonedDateTime utc) {
       try {
           Instant myTime = utc.toInstant();
           RestoreTableRequest restoreTableRequest =
RestoreTableRequest.builder()
                   .restoreTimestamp(myTime)
                   .sourceTableName("Movie")
                   .targetKeyspaceName(keyspaceName)
                   .targetTableName("MovieRestore")
                   .sourceKeyspaceName(keyspaceName)
                   .build();

           RestoreTableResponse response =
keyClient.restoreTable(restoreTableRequest);
           System.out.println("The ARN of the restored table is " +
response.restoredTableARN());
```

```
        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see RestoreTable in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun restoreTable(
    keyspaceName: String?,
    utc: ZonedDateTime,
) {
    // Create an aws.smithy.kotlin.runtime.time.Instant value.
    val timeStamp =
        aws.smithy.kotlin.runtime.time
            .Instant(utc.toInstant())
    val restoreTableRequest =
        RestoreTableRequest {
            restoreTimestamp = timeStamp
            sourceTableName = "MovieKotlin"
            targetKeyspaceName = keyspaceName
            targetTableName = "MovieRestore"
            sourceKeyspaceName = keyspaceName
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        val response = keyClient.restoreTable(restoreTableRequest)
        println("The ARN of the restored table is ${response.restoredTableArn}")
    }
}
```

- For API details, see RestoreTable in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def restore_table(self, restore_timestamp):
        """
        Restores the table to a previous point in time. The table is restored
        to a new table in the same keyspace.

        :param restore_timestamp: The point in time to restore the table. This
 time
                                  must be in UTC format.
        :return: The name of the restored table.
```

```
        """
        try:
            restored_table_name = f"{self.table_name}_restored"
            self.keyspaces_client.restore_table(
                sourceKeyspaceName=self.ks_name,
                sourceTableName=self.table_name,
                targetKeyspaceName=self.ks_name,
                targetTableName=restored_table_name,
                restoreTimestamp=restore_timestamp,
            )
        except ClientError as err:
            logger.error(
                "Couldn't restore table %s. Here's why: %s: %s",
                restore_timestamp,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
        else:
            return restored_table_name
```

- For API details, see RestoreTable in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        oo_result = lo_kys->restoretable(
          iv_sourcekeyspacename = iv_source_keyspace_name
          iv_sourcetablename = iv_source_table_name
          iv_targetkeyspacename = iv_target_keyspace_name
          iv_targettablename = iv_target_table_name
          iv_restoretimestamp = iv_restore_timestamp ).
```

```
        MESSAGE 'Table restore initiated successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see RestoreTable in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Use `UpdateTable` with an AWS SDK

The following code examples show how to use `UpdateTable`.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Learn the basics

.NET

SDK for .NET

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    /// <summary>
    /// Updates the movie table to add a boolean column named watched.
    /// </summary>
    /// <param name="keyspaceName">The keyspace containing the table.</param>
    /// <param name="tableName">The name of the table to change.</param>
    /// <returns>The Amazon Resource Name (ARN) of the updated table.</returns>
    public async Task<string> UpdateTable(string keyspaceName, string tableName)
```

```
    {
        var newColumn = new ColumnDefinition { Name = "watched", Type =
"boolean" };
        var request = new UpdateTableRequest
        {
            KeyspaceName = keyspaceName,
            TableName = tableName,
            AddColumns = new List<ColumnDefinition> { newColumn }
        };
        var response = await _amazonKeyspaces.UpdateTableAsync(request);
        return response.ResourceArn;
    }
```

- For API details, see UpdateTable in *AWS SDK for .NET API Reference*.

Java

SDK for Java 2.x

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    public static void updateTable(KeyspacesClient keyClient, String keySpace,
String tableName) {
        try {
            ColumnDefinition def = ColumnDefinition.builder()
                    .name("watched")
                    .type("boolean")
                    .build();

            UpdateTableRequest tableRequest = UpdateTableRequest.builder()
                    .keyspaceName(keySpace)
                    .tableName(tableName)
                    .addColumns(def)
                    .build();

            keyClient.updateTable(tableRequest);
```

```
        } catch (KeyspacesException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
```

- For API details, see UpdateTable in *AWS SDK for Java 2.x API Reference*.

Kotlin

SDK for Kotlin

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
suspend fun updateTable(
    keySpace: String?,
    tableNameVal: String?,
) {
    val def =
        ColumnDefinition {
            name = "watched"
            type = "boolean"
        }

    val tableRequest =
        UpdateTableRequest {
            keyspaceName = keySpace
            tableName = tableNameVal
            addColumns = listOf(def)
        }

    KeyspacesClient.fromEnvironment { region = "us-east-1" }.use { keyClient ->
        keyClient.updateTable(tableRequest)
    }
}
```

- For API details, see UpdateTable in *AWS SDK for Kotlin API reference*.

Python

SDK for Python (Boto3)

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
class KeyspaceWrapper:
    """Encapsulates Amazon Keyspaces (for Apache Cassandra) keyspace and table
 actions."""

    def __init__(self, keyspaces_client):
        """
        :param keyspaces_client: A Boto3 Amazon Keyspaces client.
        """
        self.keyspaces_client = keyspaces_client
        self.ks_name = None
        self.ks_arn = None
        self.table_name = None

    @classmethod
    def from_client(cls):
        keyspaces_client = boto3.client("keyspaces")
        return cls(keyspaces_client)


    def update_table(self):
        """
        Updates the schema of the table.

        This example updates a table of movie data by adding a new column
        that tracks whether the movie has been watched.
        """
        try:
            self.keyspaces_client.update_table(
```

```
                keyspaceName=self.ks_name,
                tableName=self.table_name,
                addColumns=[{"name": "watched", "type": "boolean"}],
            )
        except ClientError as err:
            logger.error(
                "Couldn't update table %s. Here's why: %s: %s",
                self.table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
            raise
```

- For API details, see UpdateTable in *AWS SDK for Python (Boto3) API Reference*.

SAP ABAP

SDK for SAP ABAP

> **Note**
>
> There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
    TRY.
        " Add a new column to track watched movies
        DATA(lt_add_columns) = VALUE /aws1/
cl_kyscolumndefinition=>tt_columndefinitionlist(
          ( NEW /aws1/cl_kyscolumndefinition( iv_name = 'watched' iv_type =
 'boolean' ) )
        ).

        oo_result = lo_kys->updatetable(
          iv_keyspacename = iv_keyspace_name
          iv_tablename = iv_table_name
          it_addcolumns = lt_add_columns ).
        MESSAGE 'Table updated successfully.' TYPE 'I'.
      CATCH /aws1/cx_rt_service_generic INTO DATA(lo_exception).
```

```
        DATA(lv_error) = |"{ lo_exception->av_err_code }" - { lo_exception-
>av_err_msg }|.
        MESSAGE lv_error TYPE 'E'.
    ENDTRY.
```

- For API details, see UpdateTable in *AWS SDK for SAP ABAP API reference*.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Amazon Keyspaces (for Apache Cassandra) libraries and tools

This section provides information about Amazon Keyspaces (for Apache Cassandra) libraries, code examples, and tools.

Topics

- Libraries and examples
- Highlighted sample and developer tool repos

Libraries and examples

You can find Amazon Keyspaces open-source libraries and developer tools on GitHub in the AWS and AWS samples repos.

Amazon Keyspaces (for Apache Cassandra) developer toolkit

This repository provides a docker image with helpful developer tools for Amazon Keyspaces. For example, it includes a CQLSHRC file with best practices, an optional AWS authentication expansion for cqlsh, and helper tools to perform common tasks. The toolkit is optimized for Amazon Keyspaces, but also works with Apache Cassandra clusters.

https://github.com/aws-samples/amazon-keyspaces-toolkit.

Amazon Keyspaces (for Apache Cassandra) examples

This repo is our official list of Amazon Keyspaces example code. The repo is subdivided into sections by language (see Examples). Each language has its own subsection of examples. These examples demonstrate common Amazon Keyspaces service implementations and patterns that you can use when building applications.

https://github.com/aws-samples/amazon-keyspaces-examples/.

AWS Signature Version 4 (SigV4) authentication plugins

The plugins enable you to manage access to Amazon Keyspaces by using AWS Identity and Access Management (IAM) users and roles.

Java: https://github.com/aws/aws-sigv4-auth-cassandra-java-driver-plugin.

Node.js: https://github.com/aws/aws-sigv4-auth-cassandra-nodejs-driver-plugin.

Python: https://github.com/aws/aws-sigv4-auth-cassandra-python-driver-plugin.

Go: https://github.com/aws/aws-sigv4-auth-cassandra-gocql-driver-plugin.

Highlighted sample and developer tool repos

Below are a selection of helpful community tools for Amazon Keyspaces (for Apache Cassandra).

Amazon Keyspaces Protocol Buffers

You can use Protocol Buffers (Protobuf) with Amazon Keyspaces to provide an alternative to Apache Cassandra User Defined Types (UDTs). Protobuf is a free and open-source cross-platform data format which is used to serialize structured data. You can store Protobuf data using the CQL BLOB data type and refactor UDTs while preserving structured data across applications and programming languages.

This repository provides a code example that connects to Amazon Keyspaces, creates a new table, and inserts a row containing a Protobuf message. Then the row is read with strong consistency.

https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/java/datastax-v4/protobuf-user-defined-types

CloudFormation template to create Amazon CloudWatch dashboard for Amazon Keyspaces (for Apache Cassandra) metrics

This repository provides CloudFormation templates to quickly set up CloudWatch metrics for Amazon Keyspaces. Using this template will allow you to get started more easily by providing deployable prebuilt CloudWatch dashboards with commonly used metrics.

https://github.com/aws-samples/amazon-keyspaces-cloudwatch-cloudformation-templates.

Using Amazon Keyspaces (for Apache Cassandra) with AWS Lambda

The repository contains examples that show how to connect to Amazon Keyspaces from Lambda. Below are some examples.

C#/.NET: https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/dotnet/datastax-v3/connection-lambda.

Java: https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/java/datastax-v4/connection-lambda.

Another Lambda example that shows how to deploy and use Amazon Keyspaces from a Python Lambda is available from the following repo.

https://github.com/aws-samples/aws-keyspaces-lambda-python

Using Amazon Keyspaces (for Apache Cassandra) with Spring

This is an example that shows you how to use Amazon Keyspaces with Spring Boot.

https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/java/datastax-v4/spring

Using Amazon Keyspaces (for Apache Cassandra) with Scala

This is an example that shows how to connect to Amazon Keyspaces using the SigV4 authentication plugin with Scala.

https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/scala/datastax-v4/connection-sigv4

Using Amazon Keyspaces (for Apache Cassandra) with AWS Glue

This is an example that shows how to use Amazon Keyspaces with AWS Glue.

https://github.com/aws-samples/amazon-keyspaces-examples/tree/main/scala/datastax-v4/aws-glue

Amazon Keyspaces (for Apache Cassandra) Cassandra query language (CQL) to CloudFormation converter

This package implements a command-line tool for converting Apache Cassandra Query Language (CQL) scripts to CloudFormation (CloudFormation) templates, which allows Amazon Keyspaces schemas to be easily managed in CloudFormation stacks.

https://github.com/aws/amazon-keyspaces-cql-to-cfn-converter.

Amazon Keyspaces (for Apache Cassandra) helpers for Apache Cassandra driver for Java

This repository contains driver policies, examples, and best practices when using the DataStax Java Driver with Amazon Keyspaces (for Apache Cassandra).

https://github.com/aws-samples/amazon-keyspaces-java-driver-helpers.

Amazon Keyspaces (for Apache Cassandra) snappy compression demo

This repository demonstrates how to compress, store, and read/write large objects for faster performance and lower throughput and storage costs.

https://github.com/aws-samples/amazon-keyspaces-compression-example.

Amazon Keyspaces (for Apache Cassandra) and Amazon S3 codec demo

Custom Amazon S3 Codec supports transparent, user-configurable mapping of UUID pointers to Amazon S3 objects.

https://github.com/aws-samples/amazon-keyspaces-large-object-s3-demo.

Best practices for designing and architecting with Amazon Keyspaces (for Apache Cassandra)

Use this section to quickly find recommendations for maximizing performance and minimizing throughput costs when working with Amazon Keyspaces.

Contents

- Key differences and design principles of NoSQL design
  - Differences between relational data design and NoSQL
  - Two key concepts for NoSQL design
  - Approaching NoSQL design
- Optimize client driver connections for the serverless environment
  - How connections work in Amazon Keyspaces
  - How to configure connections in Amazon Keyspaces
  - How to configure the retry policy for connections in Amazon Keyspaces
  - How to configure connections over VPC endpoints in Amazon Keyspaces
  - How to monitor connections in Amazon Keyspaces
  - How to handle connection errors in Amazon Keyspaces
- Data modeling best practices: recommendations for designing data models
  - How to use partition keys effectively in Amazon Keyspaces
    - Use write sharding to evenly distribute workloads across partitions
      - Sharding using compound partition keys and random values
      - Sharding using compound partition keys and calculated values
- Optimizing costs of Amazon Keyspaces tables
  - Evaluate your costs at the table level
    - How to view the costs of a single Amazon Keyspaces table
    - Cost Explorer's default view
    - How to use and apply table tags in Cost Explorer
  - Evaluate your table's capacity mode
    - What table capacity modes are available
    - When to select on-demand capacity mode

    - When to select provisioned capacity mode
    - Additional factors to consider when choosing a table capacity mode
- Evaluate your table's Application Auto Scaling settings
    - Understanding your Application Auto Scaling settings
    - How to identify tables with low target utilization (<=50%)
    - How to address workloads with seasonal variance
    - How to address spiky workloads with unknown patterns
    - How to address workloads with linked applications
- Identify your unused resources to optimize costs in Amazon Keyspaces
    - How to identify unused resources
    - Identifying unused table resources
    - Cleaning up unused table resources
    - Cleaning up unused point-in-time recovery (PITR) backups
- Evaluate your table usage patterns to optimize performance and cost
    - Perform fewer strongly-consistent read operations
    - Enable Time to Live (TTL)
- Evaluate your provisioned capacity for right-sized provisioning
    - How to retrieve consumption metrics from your Amazon Keyspaces tables
    - How to identify under-provisioned Amazon Keyspaces tables
    - How to identify over-provisioned Amazon Keyspaces tables

Key differences and design principles of NoSQL design

NoSQL database systems like Amazon Keyspaces use alternative models for data management, such as key-value pairs or document storage. When you switch from a relational database management system to a NoSQL database system like Amazon Keyspaces, it's important to understand the key differences and specific design approaches.

Topics

- Differences between relational data design and NoSQL
- Two key concepts for NoSQL design
- Approaching NoSQL design

Differences between relational data design and NoSQL

Relational database systems (RDBMS) and NoSQL databases have different strengths and weaknesses:

- In RDBMS, data can be queried flexibly, but queries are relatively expensive and don't scale well in high-traffic situations (see the section called “Data modeling”).
- In a NoSQL database such as Amazon Keyspaces, data can be queried efficiently in a limited number of ways, outside of which queries can be expensive and slow.

These differences make database design different between the two systems:

- In RDBMS, you design for flexibility without worrying about implementation details or performance. Query optimization generally doesn't affect schema design, but normalization is important.
- In Amazon Keyspaces, you design your schema specifically to make the most common and important queries as fast and as inexpensive as possible. Your data structures are tailored to the specific requirements of your business use cases.

Two key concepts for NoSQL design

NoSQL design requires a different mindset than RDBMS design. For an RDBMS, you can go ahead and create a normalized data model without thinking about access patterns. You can then extend it later when new questions and query requirements arise. You can organize each type of data into its own table.

How NoSQL design is different

- By contrast, you shouldn't start designing your schema for Amazon Keyspaces until you know the questions it needs to answer. Understanding the business problems and the application use cases up front is essential.
- You should maintain as few tables as possible in an Amazon Keyspaces application. Having fewer tables keeps things more scalable, requires less permissions management, and reduces overhead for your Amazon Keyspaces application. It can also help keep backup costs lower overall.

Approaching NoSQL design

The first step in designing your Amazon Keyspaces application is to identify the specific query patterns that the system must satisfy.

In particular, it is important to understand three fundamental properties of your application's access patterns before you begin:

- **Data size**: Knowing how much data will be stored and requested at one time helps to determine the most effective way to partition the data.
- **Data shape**: Instead of reshaping data when a query is processed (as an RDBMS system does), a NoSQL database organizes data so that its shape in the database corresponds with what will be queried. This is a key factor in increasing speed and scalability.
- **Data velocity**: Amazon Keyspaces scales by increasing the number of physical partitions that are available to process queries, and by efficiently distributing data across those partitions. Knowing in advance what the peak query loads will be might help determine how to partition data to best use I/O capacity.

After you identify specific query requirements, you can organize data according to general principles that govern performance:

- **Keep related data together.** Research on routing-table optimization 20 years ago found that "locality of reference" was the single most important factor in speeding up response time: keeping related data together in one place. This is equally true in NoSQL systems today, where keeping related data in close proximity has a major impact on cost and performance. Instead of distributing related data items across multiple tables, you should keep related items in your NoSQL system as close together as possible.

  As a general rule, you should maintain as few tables as possible in an Amazon Keyspaces application.

  Exceptions are cases where high-volume time series data are involved, or datasets that have very different access patterns. A single table with inverted indexes can usually enable simple queries to create and retrieve the complex hierarchical data structures required by your application.
- **Use sort order.** Related items can be grouped together and queried efficiently if their key design causes them to sort together. This is an important NoSQL design strategy.

- **Distribute queries.** It is also important that a high volume of queries not be focused on one part of the database, where they can exceed I/O capacity. Instead, you should design data keys to distribute traffic evenly across partitions as much as possible, avoiding "hot spots."

These general principles translate into some common design patterns that you can use to model data efficiently in Amazon Keyspaces.

Optimize client driver connections for the serverless environment

To communicate with Amazon Keyspaces, you can use any of the existing Apache Cassandra client drivers of your choice. Because Amazon Keyspaces is a serverless service, we recommend that you optimize the connection configuration of your client driver for the throughput needs of your application. This topic introduces best practices including how to calculate how many connections your application requires, as well as monitoring and error handling of connections.

Topics

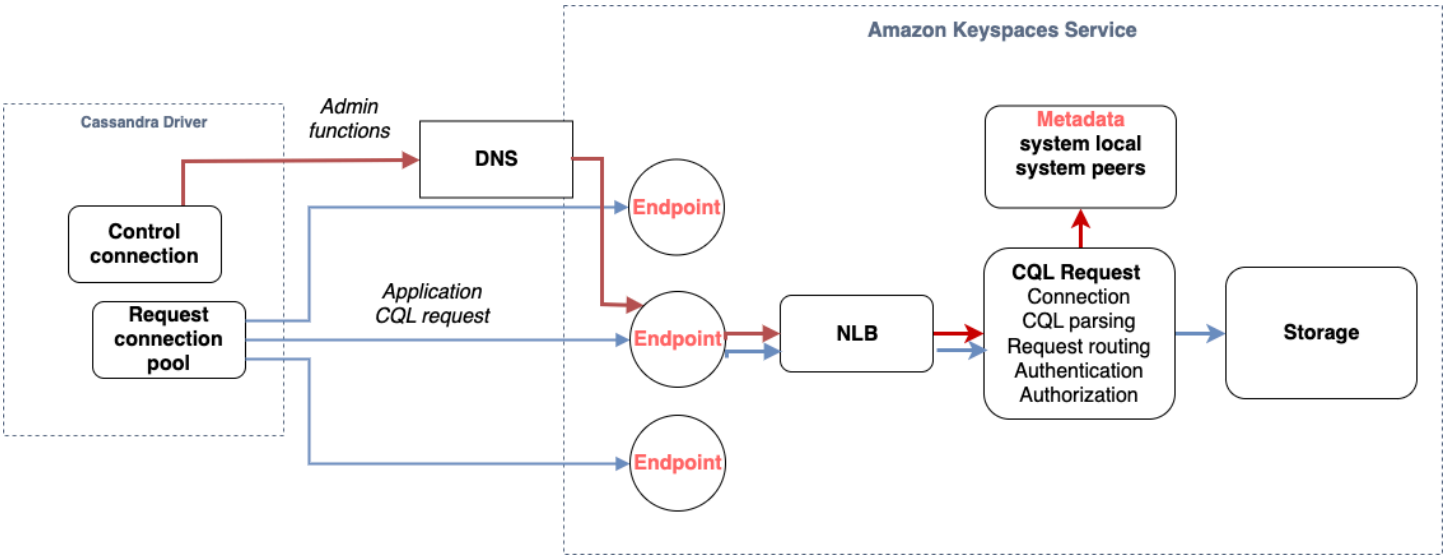
- How connections work in Amazon Keyspaces
- How to configure connections in Amazon Keyspaces
- How to configure the retry policy for connections in Amazon Keyspaces
- How to configure connections over VPC endpoints in Amazon Keyspaces
- How to monitor connections in Amazon Keyspaces
- How to handle connection errors in Amazon Keyspaces

How connections work in Amazon Keyspaces

This sections gives an overview of how client driver connections work in Amazon Keyspaces. Because Cassandra client driver misconfiguration can result in `PerConnectionRequestExceeded` events in Amazon Keyspaces, configuring the right amount of connections in the client driver configuration is required to avoid these and similar connection errors.

When connecting to Amazon Keyspaces, the driver requires a seed endpoint to establish an initial connection. Amazon Keyspaces uses DNS to route the initial connection to one of the many available endpoints. The endpoints are attached to network load balancers that in turn establish

a connection to one of the request handlers in the fleet. After the initial connection is established, the client driver gathers information about all available endpoints from the `system.peers` table. With this information, the client driver can create additional connections to the listed endpoints. The number of connections the client driver can create is limited by the number of local connections specified in the client driver settings. By default, most client drivers establish one connection per endpoint and establish a connection pool to Cassandra and load balance queries over that pool of connections. Although multiple connections can be established to the same endpoint, behind the network load balancer they may be connected to many different request handlers. When connecting through the public endpoint, establishing one connection to each of the nine endpoints listed in the `system.peers` table results in nine connections to different request handlers.



How to configure connections in Amazon Keyspaces

Amazon Keyspaces supports up to 3,000 CQL queries per TCP connection per second. Because there's no limit on the number of connections a driver can establish, we recommend to target only **500 CQL requests per second per connection** to allow for overhead, traffic bursts, and better load balancing. Follow these steps to ensure that your driver's connection is correctly configured for the needs of your application.

Increase the number of connections per IP address your driver is maintaining in its connection pool.

- Most Cassandra drivers establish a connection pool to Cassandra and load balance queries over that pool of connections. The default behavior of most drivers is to establish a single connection to each endpoint. Amazon Keyspaces exposes nine peer IP addresses to drivers, so

based on the default behavior of most drivers, this results in 9 connections. Amazon Keyspaces supports up to 3,000 CQL queries per TCP connection per second, therefore, the maximum CQL query throughput of a driver using the default settings is 27,000 CQL queries per second. If you use the driver's default settings, a single connection may have to process more than the maximum CQL query throughput of 3,000 CQL queries per second. This could result in `PerConnectionRequestExceeded` events.

- To avoid `PerConnectionRequestExceeded` events, you must configure the driver to create additional connections per endpoint to distribute the throughput.
- As a best practice in Amazon Keyspaces, assume that each connection can support **500 CQL queries per second**.
- That means that for a production application that needs to support an estimated 27,000 CQL queries per second distributed over the nine available endpoints, you must configure six connections per endpoint. This ensures that each connection processes no more than 500 requests per second.

Calculate the number of connections per IP address you need to configure for your driver based on the needs of your application.

To determine the number of connections you need to configure per endpoint for your application, consider the following example. You have an application that needs to support 20,000 CQL queries per second consisting of 10,000 `INSERT`, 5,000 `SELECT`, and 5,000 `DELETE` operations. The Java application is running on three instances on Amazon Elastic Container Service (Amazon ECS) where each instance establishes a single session to Amazon Keyspaces. The calculation you can use to estimate how many connections you need to configure for your driver uses the following input.

1. The number of requests per second your application needs to support.
2. The number of the available instances with one subtracted to account for maintenance or failure.
3. The number of available endpoints. If you're connecting over public endpoints, you have nine available endpoints. If you're using VPC endpoints, you have between two and five available endpoints, depending on the Region.
4. Use 500 CQL queries per second per connection as a best practice for Amazon Keyspaces.
5. Round up the result.

For this example, the formula looks like this.

```
20,000 CQL queries / (3 instances - 1 failure) / 9 public endpoints / 500 CQL queries
 per second = ROUND(2.22) = 3
```

Based on this calculation, you need to specify three local connections per endpoint in the driver configuration. For remote connections, configure only one connection per endpoint.

How to configure the retry policy for connections in Amazon Keyspaces

When configuring the retry policy for a connection to Amazon Keyspaces, we recommend that you implement the Amazon Keyspaces retry policy `AmazonKeyspacesExponentialRetryPolicy`. This retry policy is better suited to retry across different connections to Amazon Keyspaces than the driver's `DefaultRetryPolicy`.

With the `AmazonKeyspacesExponentialRetryPolicy`, you can configure the number of retry attempts for the connection that meet your needs. By default, the number of retry attempts for the `AmazonKeyspacesExponentialRetryPolicy` is set to 3.

An additional advantage is that the Amazon Keyspaces retry policy passes back the original exception returned by the service, which indicates why the request attempt failed. The default retry policy only returns the generic `NoHostAvailableException`, which might hide insights into the request failure.

To configure the request retry policy using the `AmazonKeyspacesExponentialRetryPolicy`, we recommend that you configure a small number of retries, and handle any returned exceptions in your application code.

For code examples implementing retry policies, see Amazon Keyspaces retry policies on Github.

How to configure connections over VPC endpoints in Amazon Keyspaces

When connecting over private VPC endpoints, you have most likely 3 endpoints available. The number of VPC endpoints can be different per Region, based on the number of Availability Zones, and the number of subnets in the assigned VPC. US East (N. Virginia) Region has five Availability Zones and you can have up to five Amazon Keyspaces endpoints. US West (N. California) Region has two Availability Zones and you can have up to two Amazon Keyspaces endpoints. The number of endpoints does not impact scale, but it does increase the number of connections you need to establish in the driver configuration. Consider the following example. Your application needs to support 20,000 CQL queries and is running on three instances on Amazon ECS where each instance

establishes a single session to Amazon Keyspaces. The only difference is how many endpoints are available in the different AWS Regions.

Connections required in the US East (N. Virginia) Region:

```
20,000 CQL queries / (3 instances - 1 failure) / 5 private VPC endpoints / 500 CQL
 queries per second = 4 local connections
```

Connections required in the US West (N. California) Region:

```
20,000 CQL queries / (3 instances - 1 failure) / 2 private VPC endpoints / 500 CQL
 queries per second = 10 local connections
```

Important

When using private VPC endpoints, additional permissions are required for Amazon Keyspaces to discover the available VPC endpoints dynamically and populate the `system.peers` table. For more information, see the section called “Populating `system.peers` table entries with interface VPC endpoint information”.

When accessing Amazon Keyspaces through a private VPC endpoint using a different AWS account, it’s likely that you only see a single Amazon Keyspaces endpoint. Again this doesn't impact the scale of possible throughput to Amazon Keyspaces, but it may require you to increase the number of connections in your driver configuration. This example shows the same calculation for a single available endpoint.

```
20,000 CQL queries / (3 instances - 1 failure) / 1 private VPC endpoints / 500 CQL
 queries per second = 20 local connections
```

To learn more about cross-account access to Amazon Keyspaces using a shared VPC, see the section called “Configure cross-account access in a shared VPC”.

How to monitor connections in Amazon Keyspaces

To help identify the number of endpoints your application is connected to, you can log the number of peers discovered in the `system.peers` table. The following example is an example of Java code which prints the number of peers after the connection has been established.

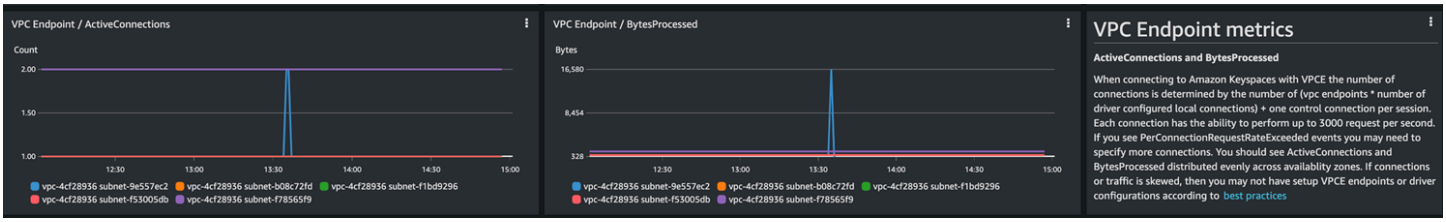
```
ResultSet result = session.execute(new SimpleStatement("SELECT * FROM system.peers"));

logger.info("number of Amazon Keyspaces endpoints:" + result.all().stream().count());
```

Note

The CQL console or AWS console are not deployed within a VPC and therefore use the public endpoint. As a result, running the `system.peers` query from applications located outside of the VPCE often results in 9 peers. It may also be helpful to print the IP addresses of each peer.

You can also observe the number of peers when using a VPC endpoint by setting up VPCE Amazon CloudWatch metrics. In CloudWatch, you can see the number of connections established to the VPC endpoint. The Cassandra drivers establish a connection for each endpoint to send CQL queries and a control connection to gather system table information. The image below shows the VPC endpoint CloudWatch metrics after connecting to Amazon Keyspaces with 1 connection configured in the driver settings. The metric is showing six active connections consisting of one control connection and five connections (1 per endpoint across Availability Zones).



To get started with monitoring the number of connections using a CloudWatch graph, you can deploy this CloudFormation template available on GitHub in the Amazon Keyspaces template repository.

How to handle connection errors in Amazon Keyspaces

When exceeding the 3,000 request per connection quota, Amazon Keyspaces returns a `PerConnectionRequestExceeded`event and the Cassandra driver receives a `WriteTimeout` or `ReadTimeout` exception. You should retry this exception with exponential backoff in your Cassandra retry policy or in your application. You should provide exponential backoff to avoid sending additional request.

The default retry policy attempts to `try next host` in the query plan. Because Amazon Keyspaces may have one to three available endpoints when connecting to the VPC endpoint, you may also see the `NoHostAvailableException` in addition to the `WriteTimeout` and `ReadTimeout` exceptions in your application logs. You can use Amazon Keyspaces provided retry policies, which retry on the same endpoint but across different connections.

You can find examples for exponential retry policies for Java on GitHub in the Amazon Keyspaces Java code examples repository. You can find additional language examples on Github in the Amazon Keyspaces code examples repository.

Data modeling best practices: recommendations for designing data models

Effective data modeling is crucial for optimizing performance and minimizing costs when working with Amazon Keyspaces (for Apache Cassandra). This topic covers key considerations and recommendations for designing data models that suit your application's data access patterns.

- **Partition Key Design** – The partition key plays a critical role in determining how data is distributed across partitions in Amazon Keyspaces. Choosing an appropriate partition key can significantly impact query performance and throughput costs. This section discusses strategies for designing partition keys that promote even distribution of read and write activity across partitions.
- **Key Considerations:**
  - **Uniform activity distribution** – Aim for uniform read and write activity across all partitions to minimize throughput costs and leverage burst capacity effectively.
  - **Access patterns** – Align your partition key design with your application's primary data access patterns.
  - **Partition size** – Avoid creating partitions that grow too large, as this can impact performance and increase costs.

To visualize and design data models more easily, you can use the NoSQL Workbench.

Topics

- How to use partition keys effectively in Amazon Keyspaces

How to use partition keys effectively in Amazon Keyspaces

The primary key that uniquely identifies each row in an Amazon Keyspaces table can consist of one or multiple partition key columns, which determine which partitions the data is stored in, and one or more optional clustering column, which define how data is clustered and sorted within a partition.

Because the partition key establishes the number of partitions your data is stored in and how the data is distributed across these partitions, how you chose your partition key can have a significant impact upon the performance of your queries. In general, you should design your application for uniform activity across all partitions on disk.

Distributing read and write activity of your application evenly across all partitions helps to minimize throughput costs and this applies to on-demand as well as provisioned read/write capacity modes. For example, if you are using provisioned capacity mode, you can determine the access patterns that your application needs, and estimate the total read capacity units (RCU) and write capacity units (WCU) that each table requires. Amazon Keyspaces supports your access patterns using the throughput that you provisioned as long as the traffic against a given partition does not exceed 3,000 RCUs and 1,000 WCUs.

When a partition experiences sustained high read or write throughput, depending on traffic patterns Amazon Keyspaces may automatically split the partition into two new partitions. Each new partition contains a subset of the original partition's rows, distributing the throughput evenly across both partitions.

Amazon Keyspaces offers additional flexibility in your per-partition throughput provisioning by providing burst capacity, for more information see the section called “Use burst capacity”.

Topics

- Use write sharding to evenly distribute workloads across partitions

Use write sharding to evenly distribute workloads across partitions

One way to better distribute writes across a partition in Amazon Keyspaces is to expand the space. You can do this in several different ways. You can add an additional partition key column to which you write random numbers to distribute the rows among partitions. Or you can use a number that is calculated based on something that you're querying on.

Sharding using compound partition keys and random values

One strategy for distributing loads more evenly across a partition is to add an additional partition key column to which you write random numbers. Then you randomize the writes across the larger space.

For example, consider the following table which has a single partition key representing a date.

```
CREATE TABLE IF NOT EXISTS tracker.blogs (
   publish_date date,
   title text,
   description int,
   PRIMARY KEY (publish_date));
```

To more evenly distribute this table across partitions, you could include an additional partition key column `shard` that stores random numbers. For example:

```
CREATE TABLE IF NOT EXISTS tracker.blogs (
   publish_date date,
   shard int,
   title text,
   description int,
   PRIMARY KEY ((publish_date, shard)));
```

When inserting data you might choose a random number between `1` and `200` for the `shard` column. This yields compound partition key values like `(2020-07-09, 1)`, `(2020-07-09, 2)`, and so on, through `(2020-07-09, 200)`. Because you are randomizing the partition key, the writes to the table on each day are spread evenly across multiple partitions. This results in better parallelism and higher overall throughput.

However, to read all the rows for a given day, you would have to query the rows for all the shards and then merge the results. For example, you would first issue a `SELECT` statement for the partition key value `(2020-07-09, 1)`. Then issue another `SELECT` statement for `(2020-07-09, 2)`, and so on, through `(2020-07-09, 200)`. Finally, your application would have to merge the results from all those `SELECT` statements.

Sharding using compound partition keys and calculated values

A randomizing strategy can greatly improve write throughput. But it's difficult to read a specific row because you don't know which value was written to the `shard` column when the row was

written. To make it easier to read individual rows, you can use a different strategy. Instead of using a random number to distribute the rows among partitions, use a number that you can calculate based upon something that you want to query on.

Consider the previous example, in which a table uses today's date in the partition key. Now suppose that each row has an accessible `title` column, and that you most often need to find rows by title in addition to date. Before your application writes the row to the table, it could calculate a hash value based on the title and use it to populate the `shard` column. The calculation might generate a number between 1 and 200 that is fairly evenly distributed, similar to what the random strategy produces.

A simple calculation would likely suffice, such as the product of the UTF-8 code point values for the characters in the title, modulo 200, + 1. The compound partition key value would then be the combination of the date and calculation result.

With this strategy, the writes are spread evenly across the partition key values, and thus across the physical partitions. You can easily perform a `SELECT` statement for a particular row and date because you can calculate the partition key value for a specific `title` value.

To read all the rows for a given day, you still must `SELECT` each of the `(2020-07-09, N)` keys (where `N` is 1–200), and your application then has to merge all the results. The benefit is that you avoid having a single "hot" partition key value taking all of the workload.

Optimizing costs of Amazon Keyspaces tables

This section covers best practices on how to optimize costs for your existing Amazon Keyspaces tables. You should look at the following strategies to see which cost optimization strategy best suits your needs and approach them iteratively. Each strategy provides an overview of what might be impacting your costs, how to look for opportunities to optimize costs, and prescriptive guidance on how to implement these best practices to help you save.

Topics

- Evaluate your costs at the table level
- Evaluate your table's capacity mode
- Evaluate your table's Application Auto Scaling settings
- Identify your unused resources to optimize costs in Amazon Keyspaces
- Evaluate your table usage patterns to optimize performance and cost

- Evaluate your provisioned capacity for right-sized provisioning

Evaluate your costs at the table level

The Cost Explorer tool found within the AWS Management Console allows you to see costs broken down by type, for example read, write, storage, and backup charges. You can also see these costs summarized by period such as month or day.

One common challenge with Cost Explorer is that you can't review the costs of only one particular table easily, because Cost Explorer doesn't let you filter or group by costs of a specific table. You can view the metric **Billable table size (Bytes)** of each table in the Amazon Keyspaces console on the table's **Monitor** tab. If you need more cost related information per table, this section shows you how to use tagging to perform individual table cost analysis in Cost Explorer.

Topics

- How to view the costs of a single Amazon Keyspaces table
- Cost Explorer's default view
- How to use and apply table tags in Cost Explorer

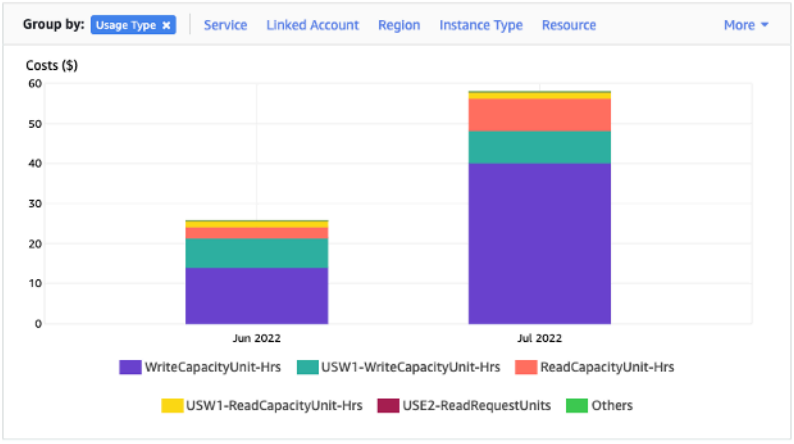
How to view the costs of a single Amazon Keyspaces table

You can see basic information about an Amazon Keyspaces table in the console, including the primary key schema, the billable table size, and capacity related metrics. You can use the size of the table to calculate the monthly storage cost for the table. For example, $0.25 per GB in the US East (N. Virginia) AWS Region.

If the table is using provisioned capacity mode, the current read capacity unit (RCU) and write capacity unit (WCU) settings are returned as well. You can use this information to calculate the current read and write costs for the table. Note that these costs could change, especially if you have configured the table with Amazon Keyspaces automatic scaling.

Cost Explorer's default view

The default view in Cost Explorer provides charts showing the cost of consumed resources, for example throughput and storage. You can choose to group these costs by period, such as totals by month or by day. The costs of storage, reads, writes, and other categories can be broken out and compared as well.



How to use and apply table tags in Cost Explorer

By default, Cost Explorer does not provide a summary of the costs for any one specific table, because it combines the costs of multiple tables into a total. However, you can use AWS resource tagging to identify each table by a metadata tag. Tags are key-value pairs that you can use for a variety of purposes, for example to identify all resources belonging to a project or department. For more information, see the section called “Working with tags”.

For this example, we use a table with the name **MyTable**.

1. Set a tag with the key of **table_name** and the value of **MyTable**.
2. Activate the tag within Cost Explorer and then filter on the tag value to gain more visibility into each table's costs.

> **Note**
>
> It may take one or two days for the tag to start appearing in Cost Explorer

You can set metadata tags yourself in the console, or programmatically with CQL, the AWS CLI, or the AWS SDK. Consider requiring a **table_name** tag to be set as part of your organization’s new table creation process. For more information, see the section called “Create cost allocation reports”.

Evaluate your table's capacity mode

This section provides an overview of how to select the appropriate capacity mode for your Amazon Keyspaces table. Each mode is tuned to meet the needs of a different workload in terms of

responsiveness to change in throughput, as well as how that usage is billed. You must balance these factors when making your decision.

Topics

- What table capacity modes are available
- When to select on-demand capacity mode
- When to select provisioned capacity mode
- Additional factors to consider when choosing a table capacity mode

What table capacity modes are available

When you create an Amazon Keyspaces table, you must select either on-demand or provisioned capacity mode. For more information, see the section called “Configure read/write capacity modes”.

On-demand capacity mode

The on-demand capacity mode is designed to eliminate the need to plan or provision the capacity of your Amazon Keyspaces table. In this mode, your table instantly accommodates requests without the need to scale any resources up or down (up to twice the previous peak throughput of the table).

On-demand tables are billed by counting the number of actual requests against the table, so you only pay for what you use rather than what has been provisioned.

Provisioned capacity mode

The provisioned capacity mode is a more traditional model where you can define how much capacity the table has available for requests either directly or with the assistance of Application Auto Scaling. Because a specific capacity is provisioned for the table at any given time, billing is based off of the capacity provisioned rather than the number of requests. Going over the allocated capacity can also cause the table to reject requests and reduce the experience of your application's users.

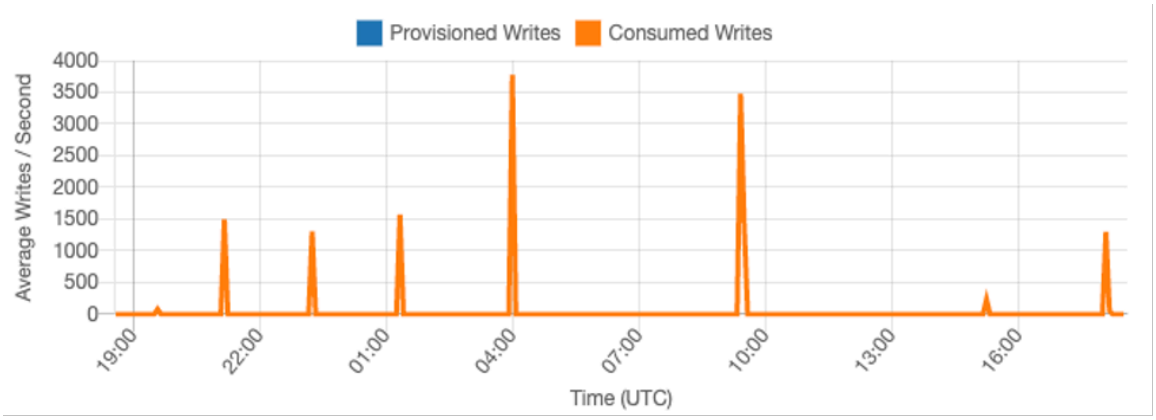
Provisioned capacity mode requires a balance between not over-provisioning or under provisioning the table to achieve both, low occurrence of insufficient throughput capacity errors, and optimized costs.

When to select on-demand capacity mode

When optimizing for cost, on-demand mode is your best choice when you have an unpredictable workload similar to the one shown in the following graph.

These factors contribute to this type of workload:

- Unpredictable request timing (resulting in traffic spikes)
- Variable volume of requests (resulting from batch workloads)
- Drops to zero or below 18% of the peak for a given hour (resulting from development or test environments)



For workloads with the above characteristics, using Application Auto Scaling to maintain enough capacity for the table to respond to spikes in traffic may lead to undesirable outcomes. Either the table could be over-provisioned and costing more than necessary, or the table could be under provisioned and requests are leading to unnecessary low capacity throughput errors. In cases like this, on-demand tables are the better choice.

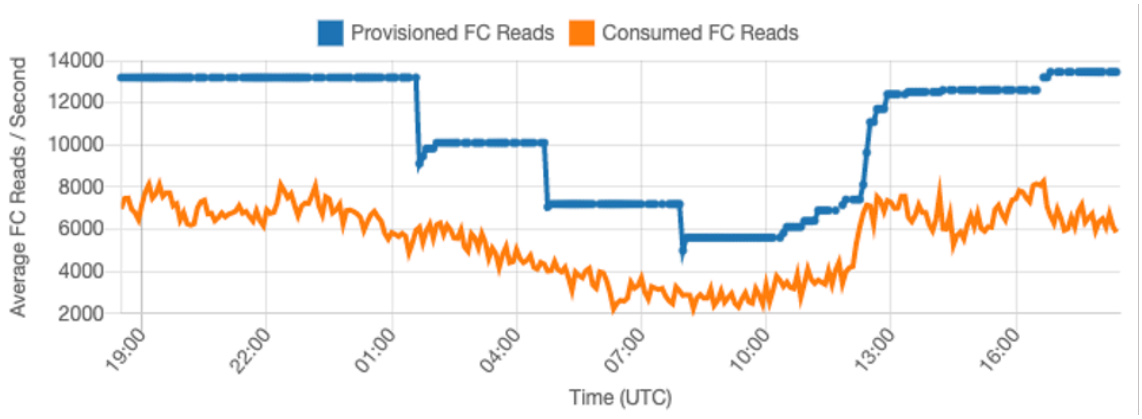
Because on-demand tables are billed by request, there is nothing further you need to do at the table level to optimize for cost. You should regularly evaluate your on-demand tables to verify the workload still has the above characteristics. If the workload has stabilized, consider changing to provisioned mode to maintain cost optimization.

When to select provisioned capacity mode

An ideal workload for provisioned capacity mode is one with a more predictable usage pattern like shown in the graph below.

The following factors contribute to a predictable workload:

- Predicable/cyclical traffic for a given hour or day
- Limited short term bursts of traffic



Since the traffic volumes within a given time or day are more stable, you can set the provisioned capacity relatively close to the actual consumed capacity of the table. Cost optimizing a provisioned capacity table is ultimately an exercise in getting the provisioned capacity (blue line) as close to the consumed capacity (orange line) as possible without increasing `ThrottledRequests` events for the table. The space between the two lines is both, wasted capacity as well as insurance against a bad user experience due to insufficient throughput capacity errors.

Amazon Keyspaces provides Application Auto Scaling for provisioned capacity tables, which automatically balances this on your behalf. You can track your consumed capacity throughout the day and configure the provisioned capacity of the table based on a handful of variables.

Minimum capacity units

You can set the minimum capacity of a table to limit the occurrence of insufficient throughput capacity errors, but it doesn't reduce the cost of the table. If your table has periods of low usage followed by a sudden burst of high usage, setting the minimum can prevent Application Auto Scaling from setting the table capacity too low.

Maximum capacity units

You can set the maximum capacity of a table to limit a table scaling higher than intended. Consider applying a maximum for development or test tables, where large-scale load testing is not desired. You can set a maximum for any table, but be sure to regularly evaluate this setting against the table baseline when using it in production, to prevent accidental insufficient throughput capacity errors.

Target utilization

Setting the target utilization of the table is the primary means of cost optimization for a provisioned capacity table. Setting a lower percent value here increases how much the table is over-provisioned, increasing cost, but reducing the risk of insufficient throughput capacity errors. Setting a higher percentage value decreases by how much the table is over-provisioned, but increases the risk of insufficient throughput capacity errors.

Additional factors to consider when choosing a table capacity mode

When deciding between the two capacity modes, there are some additional factors worth considering.

When deciding between the two table modes, consider how much this additional discount affects the cost of the table. In many cases, even a relatively unpredictable workload can be more cost effective to run on an over-provisioned provisioned capacity table with reserved capacity.

Improving predictability of your workload

In some situations, a workload may seemingly have both, a predictable and an unpredictable pattern. While this can be easily supported with an on-demand table, costs will likely be lower if the unpredictable patterns in the workload can be improved.

One of the most common causes of these patterns are batch imports. This type of traffic can often exceed the baseline capacity of the table to such a degree that insufficient throughput capacity errors would occur if it were to run. To keep a workload like this running on a provisioned capacity table, consider the following options:

- If the batch occurs at scheduled times, you can schedule an increase to your application auto-scaling capacity before it runs.
- If the batch occurs randomly, consider trying to extend the time it takes to run rather than executing as fast as possible.
- Add a ramp up period to the import, where the velocity of the import starts small but is slowly increased over a few minutes until Application Auto Scaling has had the opportunity to start adjusting table capacity.

Evaluate your table's Application Auto Scaling settings

This section provides an overview of how to evaluate the Application Auto Scaling settings of your Amazon Keyspaces tables. Amazon Keyspaces Application Auto Scaling is a feature that manages table throughput based on your application traffic and your target utilization metric. This ensures your tables have the required capacity required for your application patterns.

The Application Auto Scaling service monitors your current table utilization and compares it to the target utilization value: `TargetValue`. It notifies you if it is time to increase or decrease the allocated capacity.

Topics

- Understanding your Application Auto Scaling settings
- How to identify tables with low target utilization (<=50%)
- How to address workloads with seasonal variance
- How to address spiky workloads with unknown patterns
- How to address workloads with linked applications

Understanding your Application Auto Scaling settings

Defining the correct value for the target utilization, initial step, and final values is an activity that requires involvement from your operations team. This allows you to properly define the values based on historical application usage, which is used to trigger the Application Auto Scaling policies. The utilization target is the percentage of your total capacity that needs to be met during a period of time before the Application Auto Scaling rules apply.

When you set a **high utilization target (a target around 90%)** it means your traffic needs to be higher than 90% for a period of time before the Application Auto Scaling is activated. You should not use a high utilization target unless your application is very constant and doesn't receive spikes in traffic.

When you set a very **low utilization (a target less than 50%)** it means your application would need to reach 50% of the provisioned capacity before it triggers an Application Auto Scaling policy. Unless your application traffic grows at a very aggressive rate, this usually translates into unused capacity and wasted resources.

How to identify tables with low target utilization (<=50%)

You can use either the AWS CLI or AWS Management Console to monitor and identify the `TargetValues` for your Application Auto Scaling policies in your Amazon Keyspaces resources.

> **Note**
>
> When you're using multi-Region tables in provisioned capacity mode with Amazon Keyspaces auto scaling, make sure to use the Amazon Keyspaces API operations to configure auto scaling. The underlying Application Auto Scaling API operations that Amazon Keyspaces calls on your behalf don't have multi-Region capabilities. For more information, see the section called “View provisioned capacity and auto scaling settings for a multi-Region table”.

AWS CLI

1. Return the entire list of resources by running the following command:

   ```
   aws application-autoscaling describe-scaling-policies --service-namespace
    cassandra
   ```

   This command will return the entire list of Application Auto Scaling policies that are issued to any Amazon Keyspaces resource. If you only want to retrieve the resources from a particular table, you can add the `–resource-id parameter`. For example:

   ```
   aws application-autoscaling describe-scaling-policies --service-namespace
    cassandra --resource-id "keyspace/keyspace-name/table/table-name”
   ```

2. Return only the auto scaling policies for a particular table by running the following command

   ```
   aws application-autoscaling describe-scaling-policies --service-namespace
    cassandra --resource-id "keyspace/keyspace-name/table/table-name”
   ```

   The values for the Application Auto Scaling policies are highlighted below. You need to ensure that the target value is greater than 50% to avoid over-provisioning. You should obtain a result similar to the following:

```
{
    "ScalingPolicies": [
        {
            "PolicyARN": "arn:aws:autoscaling:us-
east-1:111122223333:scalingPolicy:<uuid>:resource/keyspaces/table/table-name-
scaling-policy",
            "PolicyName": $<full-table-name>”,
            "ServiceNamespace": "cassandra",
            "ResourceId": "keyspace/keyspace-name/table/table-name",
            "ScalableDimension": "cassandra:table:WriteCapacityUnits",
            "PolicyType": "TargetTrackingScaling",
            "TargetTrackingScalingPolicyConfiguration": {
                "TargetValue": 70.0,
                "PredefinedMetricSpecification": {
                    "PredefinedMetricType": "KeyspacesWriteCapacityUtilization"
                }
            },
            "Alarms": [
                ...
            ],
            "CreationTime": "2022-03-04T16:23:48.641000+10:00"
        },
        {
            "PolicyARN": "arn:aws:autoscaling:us-
east-1:111122223333:scalingPolicy:<uuid>:resource/keyspaces/table/table-name-
scaling-policy",
            "PolicyName":$<full-table-name>”,
            "ServiceNamespace": "cassandra",
            "ResourceId": "keyspace/keyspace-name/table/table-name",
            "ScalableDimension": "cassandra:table:ReadCapacityUnits",
            "PolicyType": "TargetTrackingScaling",
            "TargetTrackingScalingPolicyConfiguration": {
                "TargetValue": 70.0,
                "PredefinedMetricSpecification": {
                    "PredefinedMetricType": "KeyspacesReadCapacityUtilization"
                }
            },
            "Alarms": [
                ...
            ],
            "CreationTime": "2022-03-04T16:23:47.820000+10:00"
        }
    ]
```

```
}
```

AWS Management Console

1. Log into the AWS Management Console and navigate to the CloudWatch service page at Getting Started with the AWS Management Console. Select the appropriate AWS Region if necessary.
2. On the left navigation bar, select **Tables**. On the **Tables** page, select the table's **Name**.
3. On the **Table Details** page on the **Capacity** tab, review your table's Application Auto Scaling settings.

If your target utilization values are less than or equal to 50%, you should explore your table utilization metrics to see if they are under-provisioned or over-provisioned.

How to address workloads with seasonal variance

Consider the following scenario: your application is operating under a minimum average value most of the time, but the utilization target is low so your application can react quickly to events that happen at certain hours in the day and you have enough capacity and avoid getting throttled. This scenario is common when you have an application that is very busy during normal office hours (9 AM to 5 PM) but then it works at a base level during after hours. Since some users start to connect before 9 am, the application uses this low threshold to ramp up quickly to get to the *required* capacity during peak hours.

This scenario could look like this:

- Between 5 PM and 9 AM the `ConsumedWriteCapacityUnits` units stay between 90 and 100
- Users start to connect to the application before 9 AM and the capacity units increases considerably (the maximum value you've seen is 1500 WCU)
- On average, your application usage varies between 800 to 1200 during working hours

If the previous scenario applies to your application, consider using scheduled application auto scaling, where your table could still have an Application Auto Scaling rule configured, but with a less aggressive target utilization that only provisions the extra capacity at the specific intervals you require.

You can use the AWS CLI to execute the following steps to create a scheduled auto scaling rule that executes based on the time of day and the day of the week.

1. Register your Amazon Keyspaces table as a scalable target with Application Auto Scaling. A scalable target is a resource that Application Auto Scaling can scale out or in.

```
aws application-autoscaling register-scalable-target \
    --service-namespace cassandra \
    --scalable-dimension cassandra:table:WriteCapacityUnits \
    --resource-id keyspace/keyspace-name/table/table-name \
    --min-capacity 90 \
    --max-capacity 1500
```

2. Set up scheduled actions according to your requirements.

   You need two rules to cover the scenario: one to scale up and another to scale down. The first rule to scale up the scheduled action is shown in the following example.

```
aws application-autoscaling put-scheduled-action \
    --service-namespace cassandra \
    --scalable-dimension cassandra:table:WriteCapacityUnits \
    --resource-id keyspace/keyspace-name/table/table-name \
    --scheduled-action-name my-8-5-scheduled-action \
    --scalable-target-action MinCapacity=800,MaxCapacity=1500 \
    --schedule "cron(45 8 ? * MON-FRI *)" \
    --timezone "Australia/Brisbane"
```

   The second rule to scale down the scheduled action is shown in this example.

```
aws application-autoscaling put-scheduled-action \
    --service-namespace cassandra \
    --scalable-dimension cassandra:table:WriteCapacityUnits \
    --resource-id keyspace/keyspace-name/table/table-name \
    --scheduled-action-name my-5-8-scheduled-down-action \
    --scalable-target-action MinCapacity=90,MaxCapacity=1500 \
    --schedule "cron(15 17 ? * MON-FRI *)" \
    --timezone "Australia/Brisbane"
```

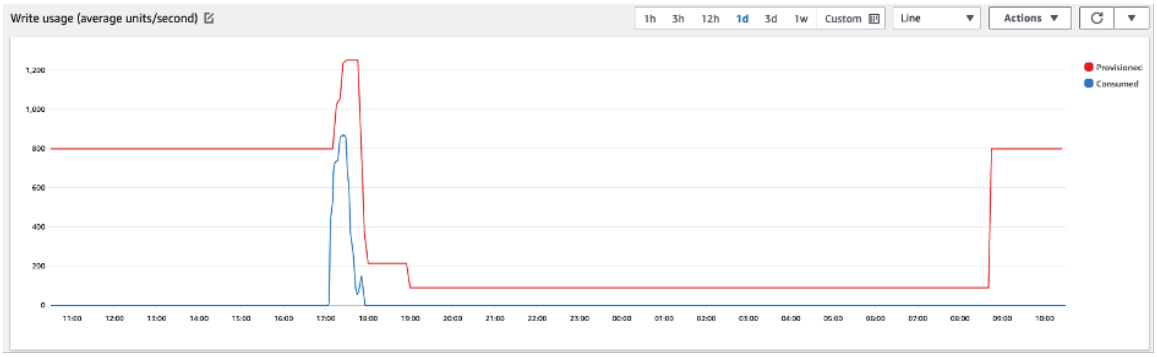
3. Run the following command to validate both rules have been activated:

```
aws application-autoscaling describe-scheduled-actions --service-namespace
 cassandra
```

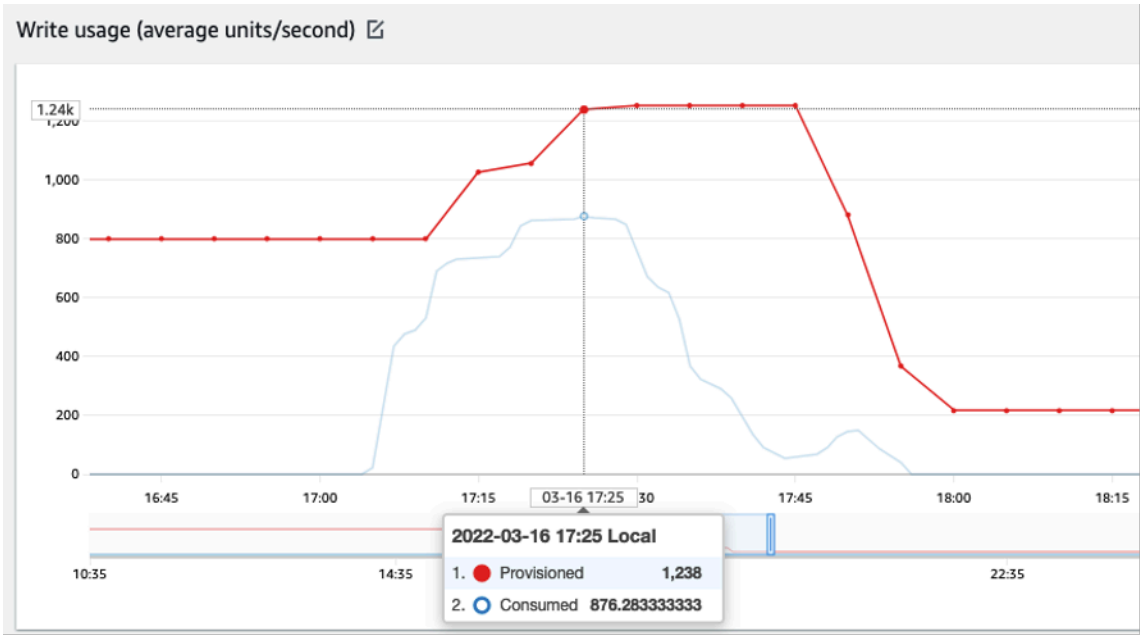
You should get a result like this:

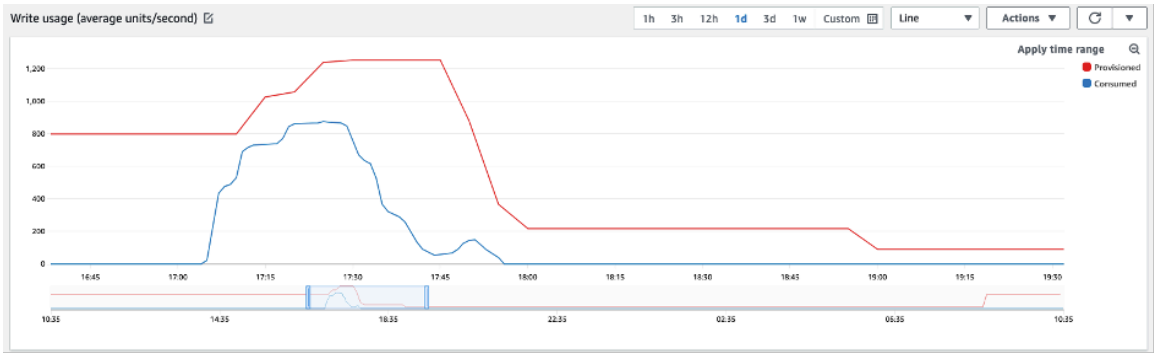
```
{
    "ScheduledActions": [
        {
            "ScheduledActionName": "my-5-8-scheduled-down-action",
            "ScheduledActionARN": "arn:aws:autoscaling:us-
east-1:111122223333:scheduledAction:<uuid>:resource/keyspaces/table/table-
name:scheduledActionName/my-5-8-scheduled-down-action",
            "ServiceNamespace": "cassandra",
            "Schedule": "cron(15 17 ? * MON-FRI *)",
            "Timezone": "Australia/Brisbane",
            "ResourceId": "keyspace/keyspace-name/table/table-name",
            "ScalableDimension": "cassandra:table:WriteCapacityUnits",
            "ScalableTargetAction": {
                "MinCapacity": 90,
                "MaxCapacity": 1500
            },
            "CreationTime": "2022-03-15T17:30:25.100000+10:00"
        },
        {
            "ScheduledActionName": "my-8-5-scheduled-action",
            "ScheduledActionARN": "arn:aws:autoscaling:us-
east-1:111122223333:scheduledAction:<uuid>:resource/keyspaces/table/table-
name:scheduledActionName/my-8-5-scheduled-action",
            "ServiceNamespace": "cassandra",
            "Schedule": "cron(45 8 ? * MON-FRI *)",
            "Timezone": "Australia/Brisbane",
            "ResourceId": "keyspace/keyspace-name/table/table-name",
            "ScalableDimension": "cassandra:table:WriteCapacityUnits",
            "ScalableTargetAction": {
                "MinCapacity": 800,
                "MaxCapacity": 1500
            },
            "CreationTime": "2022-03-15T17:28:57.816000+10:00"
        }
    ]
}
```

The following picture shows a sample workload that always keeps the 70% target utilization. Notice how the auto scaling rules are still applying and the throughput is not getting reduced.



Zooming in, we can see there was a spike in the application that triggered the 70% auto scaling threshold, forcing the autoscaling to kick in and provide the extra capacity required for the table. The scheduled auto scaling action will affect maximum and minimum values, and it's your responsibility to set them up.





How to address spiky workloads with unknown patterns

In this scenario, the application uses a very low utilization target, because you don't know the application patterns yet, and you want to ensure your workload is not experiencing low capacity throughput errors.

Consider using on-demand capacity mode instead. On-demand tables are perfect for spiky workloads where you don't know the traffic patterns. With on-demand capacity mode, you pay per request for the data reads and writes your application performs on your tables. You do not need to specify how much read and write throughput you expect your application to perform, as Amazon Keyspaces instantly accommodates your workloads as they ramp up or down.

How to address workloads with linked applications

In this scenario, the application depends on other systems, like batch processing scenarios where you can have big spikes in traffic according to events in the application logic.

Consider developing custom application auto-scaling logic that reacts to those events where you can increase table capacity and `TargetValues` depending on your specific needs. You could benefit from Amazon EventBridge and use a combination of AWS services like Λ and Step Functions to react to your specific application needs.

Identify your unused resources to optimize costs in Amazon Keyspaces

This section provides an overview of how to evaluate your unused resources regularly. As your application requirements evolve, you should ensure no resources are unused and contributing to unnecessary Amazon Keyspaces costs. The procedures described below use Amazon CloudWatch metrics to identify unused resources and take action to reduce costs.

You can monitor Amazon Keyspaces using CloudWatch, which collects and processes raw data from Amazon Keyspaces into readable, near real-time metrics. These statistics are retained for a period of time, so that you can access historical information to better understand your utilization. By default, Amazon Keyspaces metric data is sent to CloudWatch automatically. For more information, see What is Amazon CloudWatch? and Metrics retention in the *Amazon CloudWatch User Guide*.

Topics

- How to identify unused resources
- Identifying unused table resources
- Cleaning up unused table resources

- Cleaning up unused point-in-time recovery (PITR) backups

How to identify unused resources

To identify unused tables you can take a look at the following CloudWatch metrics over a period of 30 days to understand if there are any active reads or writes on a specific table:

`ConsumedReadCapacityUnits`

The number of read capacity units consumed over the specified time period, so you can track how much consumed capacity you have used. You can retrieve the total consumed read capacity for a table.

`ConsumedWriteCapacityUnits`

The number of write capacity units consumed over the specified time period, so you can track how much consumed capacity you have used. You can retrieve the total consumed write capacity for a table.

Identifying unused table resources

Amazon CloudWatch is a monitoring and observability service which provides the Amazon Keyspaces table metrics you can use to identify unused resources. CloudWatch metrics can be viewed through the AWS Management Console as well as through the AWS Command Line Interface.

AWS Command Line Interface

To view your tables metrics through the AWS Command Line Interface, you can use the following commands.

1. First, evaluate your table's reads:

> **Note**
>
> If the table name is not unique within your account, you must also specify the name of the keyspace.

```
aws cloudwatch get-metric-statistics --metric-name
```

```
ConsumedReadCapacityUnits --start-time <start-time> --end-time <end-
time> --period <period> --namespace AWS/Cassandra --statistics Sum --
dimensions Name=TableName,Value=<table-name>
```

To avoid falsely identifying a table as unused, evaluate metrics over a longer period. Choose an appropriate start-time and end-time range, such as **30 days**, and an appropriate period, such as **86400**.

In the returned data, any **Sum** above **0** indicates that the table you are evaluating received read traffic during that period.

The following result shows a table receiving read traffic in the evaluated period:

```
        {
            "Timestamp": "2022-08-25T19:40:00Z",
            "Sum": 36023355.0,
            "Unit": "Count"
        },
        {
            "Timestamp": "2022-08-12T19:40:00Z",
            "Sum": 38025777.5,
            "Unit": "Count"
        },
```

The following result shows a table not receiving read traffic in the evaluated period:

```
        {
            "Timestamp": "2022-08-01T19:50:00Z",
            "Sum": 0.0,
            "Unit": "Count"
        },
        {
            "Timestamp": "2022-08-20T19:50:00Z",
            "Sum": 0.0,
            "Unit": "Count"
        },
```

2. Next, evaluate your table's writes:

```
aws cloudwatch get-metric-statistics --metric-name
ConsumedWriteCapacityUnits --start-time <start-time> --end-time <end-
time> --period <period> --namespace AWS/Cassandra --statistics Sum --
```

```
dimensions Name=TableName,Value=<table-name>
```

To avoid falsely identifying a table as unused, you will want to evaluate metrics over a longer period. Choose an appropriate start-time and end-time range, such as **30 days**, and an appropriate period, such as **86400**.

In the returned data, any **Sum** above **0** indicates that the table you are evaluating received read traffic during that period.

The following result shows a table receiving write traffic in the evaluated period:

```
        {
            "Timestamp": "2022-08-19T20:15:00Z",
            "Sum": 41014457.0,
            "Unit": "Count"
        },
        {
            "Timestamp": "2022-08-18T20:15:00Z",
            "Sum": 40048531.0,
            "Unit": "Count"
        },
```

The following result shows a table not receiving write traffic in the evaluated period:

```
        {
            "Timestamp": "2022-07-31T20:15:00Z",
            "Sum": 0.0,
            "Unit": "Count"
        },
        {
            "Timestamp": "2022-08-19T20:15:00Z",
            "Sum": 0.0,
            "Unit": "Count"
        },
```

AWS Management Console

The following steps allow you to evaluate your resource utilization through the AWS Management Console.

1. Log into the AWS Management Console and navigate to the CloudWatch service page at https://console.aws.amazon.com/cloudwatch/. Select the appropriate AWS Region in the top right of the console, if necessary.
2. On the left navigation bar, locate the **Metrics** section and choose **All metrics**.
3. The action above opens a dashboard with two panels. In the top panel, you can see currently graphed metrics. On the bottom you can select the metrics available to graph. Choose Amazon Keyspaces in the bottom panel.
4. In the Amazon Keyspaces metrics selection panel, choose the **Table Metrics** category to show the metrics for your tables in the current region.
5. Identify your table name by scrolling down the menu, then choose the metrics `ConsumedReadCapacityUnits` and `ConsumedWriteCapacityUnits` for your table.
6. Choose the **Graphed metrics (2)** tab and adjust the **Statistic** column to **Sum**.
7. To avoid falsely identifying a table as unused, evaluate the table metrics over a longer period. At the top of the graph panel, choose an appropriate time frame, such as 1 month, to evaluate your table. Choose **Custom**, choose **1 Months** in the drop-down menu, and choose **Apply**.
8. Evaluate the graphed metrics for your table to determine if it is being used. Metrics that have gone above **0** indicate that a table has been used during the evaluated time period. A flat graph at **0** for both read and write indicates that a table is unused.

Cleaning up unused table resources

If you have identified unused table resources, you can reduce their ongoing costs in the following ways.

> **Note**
>
> If you have identified an unused table but would still like to keep it available in case it needs to be accessed in the future, consider switching it to on-demand mode. Otherwise, you can consider deleting the table.

Capacity modes

Amazon Keyspaces charges for reading, writing, and storing data in your Amazon Keyspaces tables.

Amazon Keyspaces has two capacity modes, which come with specific billing options for processing reads and writes on your tables: on-demand and provisioned. The read/write capacity mode controls how you are charged for read and write throughput and how you manage capacity.

For on-demand mode tables, you don't need to specify how much read and write throughput you expect your application to perform. Amazon Keyspaces charges you for the reads and writes that your application performs on your tables in terms of read request units and write request units. If there is no activity on your table, you do not pay for throughput but you still incur a storage charge.

Deleting tables

If you've discovered an unused table and would like to delete it, consider to make a backup or export the data first.

Backups taken through AWS Backup can leverage cold storage tiering, further reducing cost. Refer to the Managing backup plans documentation for information on how to use a lifecycle to move your backup to cold storage.

After your table has been backed up, you may choose to delete it either through the AWS Management Console or through the AWS Command Line Interface.

Cleaning up unused point-in-time recovery (PITR) backups

Amazon Keyspaces offers Point-in-time recovery, which provides continuous backups for 35 days to help you protect against accidental writes or deletes. PITR backups have costs associated with them.

Refer to the documentation at the section called "Backup and restore with point-in-time recovery" to determine if your tables have backups enabled that may no longer be needed.

Evaluate your table usage patterns to optimize performance and cost

This section provides an overview of how to evaluate if you are efficiently using your Amazon Keyspaces tables. There are certain usage patterns which are not optimal for Amazon Keyspaces, and they allow room for optimization from both a performance and a cost perspective.

Topics

- Perform fewer strongly-consistent read operations

- Enable Time to Live (TTL)

Perform fewer strongly-consistent read operations

Amazon Keyspaces allows you to configure read consistency on a per-request basis. Read requests are eventually consistent by default. Eventually consistent reads are charged at 0.5 RCU for up to 4 KB of data.

Most parts of distributed workloads are flexible and can tolerate eventual consistency. However, there can be access patterns requiring strongly consistent reads. Strongly consistent reads are charged at 1 RCU for up to 4 KB of data, essentially doubling your read costs. Amazon Keyspaces provides you with the flexibility to use both consistency models on the same table.

You can evaluate your workload and application code to confirm if strongly consistent reads are used only where required.

Enable Time to Live (TTL)

Time to Live (TTL) helps you simplify your application logic and optimize the price of storage by expiring data from tables automatically. Data that you no longer need is automatically deleted from your table based on the Time to Live value that you set.

Evaluate your provisioned capacity for right-sized provisioning

This section provides an overview of how to evaluate if you have right-sized provisioning on your Amazon Keyspaces tables. As your workload evolves, you should modify your operational procedures appropriately, especially when your Amazon Keyspaces table is configured in provisioned mode and you have the risk to over-provision or under-provision your tables.

The procedures described in this section require statistical information that should be captured from the Amazon Keyspaces tables that are supporting your production application. To understand your application behavior, you should define a period of time that is significant enough to capture the data seasonality of your application. For example, if your application shows weekly patterns, using a three week period should give you enough room for analysing application throughput needs.

If you don’t know where to start, use at least one month’s worth of data usage for the calculations below.

While evaluating capacity, for Amazon Keyspaces tables you can configure **Read Capacity Units (RCUs)** and **Write Capacity Units (WCU)** independently.

Topics

- How to retrieve consumption metrics from your Amazon Keyspaces tables
- How to identify under-provisioned Amazon Keyspaces tables
- How to identify over-provisioned Amazon Keyspaces tables

How to retrieve consumption metrics from your Amazon Keyspaces tables

To evaluate the table capacity, monitor the following CloudWatch metrics and select the appropriate dimension to retrieve table information:

Read Capacity Units	Write Capacity Units
`ConsumedReadCapacityUnits`	`ConsumedWriteCapacityUnits`
`ProvisionedReadCapacityUnits`	`ProvisionedWriteCapacityUnits`
`ReadThrottleEvents`	`WriteThrottleEvents`

You can do this either through the AWS CLI or the AWS Management Console.

AWS CLI

Before you retrieve the table consumption metrics, you need to start by capturing some historical data points using the CloudWatch API.

Start by creating two files: `write-calc.json` and `read-calc.json`. These files represent the calculations for the table. You need to update some of the fields, as indicated in the table below, to match your environment.

> **Note**
>
> If the table name is not unique within your account, you must also specify the name of the keyspace.

Field Name	Definition	Example
`<table-name>`	The name of the table that you are analysing	SampleTable
`<period>`	The period of time that you are using to evaluate the utilization target, based in seconds	For a 1-hour period you should specify: 3600
`<start-time>`	The beginning of your evaluation interval, specified in ISO8601 format	2022-02-21T23:00:00
`<end-time>`	The end of your evaluatio n interval, specified in ISO8601 format	2022-02-22T06:00:00

The write calculations file retrieves the number of WCU provisioned and consumed in the time period for the date range specified. It also generates a utilization percentage that can be used for analysis. The full content of the `write-calc.json` file should look like in the following example.

```
{
  "MetricDataQueries": [
    {
      "Id": "provisionedWCU",
      "MetricStat": {
        "Metric": {
          "Namespace": "AWS/Cassandra",
          "MetricName": "ProvisionedWriteCapacityUnits",
          "Dimensions": [
            {
              "Name": "TableName",
              "Value": "<table-name>"
            }
          ]
        },
        "Period": <period>,
```

```
        "Stat": "Average"
      },
      "Label": "Provisioned",
      "ReturnData": false
    },
    {
      "Id": "consumedWCU",
      "MetricStat": {
        "Metric": {
          "Namespace": "AWS/Cassandra",
          "MetricName": "ConsumedWriteCapacityUnits",
          "Dimensions": [
            {
              "Name": "TableName",
              "Value": "<table-name>""
            }
          ]
        },
        "Period": <period>,
        "Stat": "Sum"
      },
      "Label": "",
      "ReturnData": false
    },
    {
      "Id": "m1",
      "Expression": "consumedWCU/PERIOD(consumedWCU)",
      "Label": "Consumed WCUs",
      "ReturnData": false
    },
    {
      "Id": "utilizationPercentage",
      "Expression": "100*(m1/provisionedWCU)",
      "Label": "Utilization Percentage",
      "ReturnData": true
    }
  ],
  "StartTime": "<start-time>",
  "EndTime": "<end-time>",
  "ScanBy": "TimestampDescending",
  "MaxDatapoints": 24
}
```

The read calculations file uses a similar metrics. This file retrieves how many RCUs were provisioned and consumed during the time period for the date range specified. The contents of the `read-calc.json` file should look like in this example.

```
{
  "MetricDataQueries": [
    {
      "Id": "provisionedRCU",
      "MetricStat": {
        "Metric": {
          "Namespace": "AWS/Cassandra",
          "MetricName": "ProvisionedReadCapacityUnits",
          "Dimensions": [
            {
              "Name": "TableName",
              "Value": "<table-name>"
            }
          ]
        },
        "Period": <period>,
        "Stat": "Average"
      },
      "Label": "Provisioned",
      "ReturnData": false
    },
    {
      "Id": "consumedRCU",
      "MetricStat": {
        "Metric": {
          "Namespace": "AWS/Cassandra",
          "MetricName": "ConsumedReadCapacityUnits",
          "Dimensions": [
            {
              "Name": "TableName",
              "Value": "<table-name>"
            }
          ]
        },
        "Period": <period>,
        "Stat": "Sum"
      },
      "Label": "",
      "ReturnData": false
```

```
    },
    {
      "Id": "m1",
      "Expression": "consumedRCU/PERIOD(consumedRCU)",
      "Label": "Consumed RCUs",
      "ReturnData": false
    },
    {
      "Id": "utilizationPercentage",
      "Expression": "100*(m1/provisionedRCU)",
      "Label": "Utilization Percentage",
      "ReturnData": true
    }
  ],
  "StartTime": "<start-time>",
  "EndTime": "<end-time>",
  "ScanBy": "TimestampDescending",
  "MaxDatapoints": 24
}
```

Once you've created the files, you can start retrieving utilization data.

1. To retrieve the write utilization data, issue the following command:

   ```
   aws cloudwatch get-metric-data --cli-input-json file://write-calc.json
   ```

2. To retrieve the read utilization data, issue the following command:

   ```
   aws cloudwatch get-metric-data --cli-input-json file://read-calc.json
   ```

The result for both queries is a series of data points in JSON format that can be used for analysis. Your results depend on the number of data points you specified, the period, and your own specific workload data. It could look like in the following example.

```
{
    "MetricDataResults": [
        {
            "Id": "utilizationPercentage",
            "Label": "Utilization Percentage",
            "Timestamps": [
                "2022-02-22T05:00:00+00:00",
```

```
                "2022-02-22T04:00:00+00:00",
                "2022-02-22T03:00:00+00:00",
                "2022-02-22T02:00:00+00:00",
                "2022-02-22T01:00:00+00:00",
                "2022-02-22T00:00:00+00:00",
                "2022-02-21T23:00:00+00:00"
            ],
            "Values": [
                91.55364583333333,
                55.066631944444445,
                2.6114930555555556,
                24.9496875,
                40.94725694444445,
                25.61819444444444,
                0.0
            ],
            "StatusCode": "Complete"
        }
    ],
    "Messages": []
}
```

> **Note**
>
> If you specify a short period and a long time range, you might need to modify the `MaxDatapoints` value, which is by default set to 24 in the script. This represents one data point per hour and 24 per day.

AWS Management Console

1. Log into the AWS Management Console and navigate to the CloudWatch service page at Getting Started with the AWS Management Console. Select the appropriate AWS Region if necessary.
2. Locate the Metrics section on the left navigation bar and choose **All metrics**.
3. This opens a dashboard with two panels. The top panel shows you the graphic, and the bottom panel has the metrics that you want to graph. Choose the Amazon Keyspaces panel.
4. Choose the **Table Metrics** category from the sub panels. This shows you the tables in your current AWS Region.

5. Identify your table name by scrolling down the menu and selecting the write operation metrics: `ConsumedWriteCapacityUnits` and `ProvisionedWriteCapacityUnits`

   > **Note**
   >
   > This example talks about write operation metrics, but you can also use these steps to graph the read operation metrics.

6. Select the **Graphed metrics (2)** tab to modify the formulas. By default CloudWatch chooses the statistical function **Average** for the graphs.
7. While having both graphed metrics selected (the checkbox on the left) select the menu **Add math**, followed by **Common**, and then select the **Percentage** function. Repeat the procedure twice.

   First time selecting the **Percentage** function.

   Second time selecting the **Percentage** function.
8. At this point you should have four metrics in the bottom menu. Let's work on the `ConsumedWriteCapacityUnits` calculation. To be consistent, you need to match the names with the ones you used in the AWS CLI section. Click on the **m1 ID** and change this value to **consumedWCU**.
9. Change the statistic from **Average** to **Sum**. This action automatically creates another metric called **ANOMALY_DETECTION_BAND**. For the scope of this procedure, you can ignore this by removing the checkbox on the newly generated **ad1 metric**.
10. Repeat step 8 to rename the **m2 ID** to **provisionedWCU**. Leave the statistic set to **Average**.
11. Choose the **Expression1** label and update the value to **m1** and the label to **Consumed WCUs**.

    > **Note**
    >
    > Make sure you have only selected **m1** (checkbox on the left) and **provisionedWCU** to properly visualize the data. Update the formula by clicking in **Details** and changing the formula to **consumedWCU/PERIOD(consumedWCU)**. This step might also generate another **ANOMALY_DETECTION_BAND** metric, but for the scope of this procedure you can ignore it.

12. You should now have two graphics: one that indicates your provisioned WCUs on the table and another that indicates the consumed WCUs.
13. Update the percentage formula by selecting the Expression2 graphic (**e2**). Rename the labels and IDs to **utilizationPercentage**. Rename the formula to match **100*(m1/provisionedWCU)**.
14. Remove the checkbox from all the metrics except **utilizationPercentage** to visualize your utilization patterns. The default interval is set to 1 minute, but feel free to modify it as needed.

The results you get depend on the actual data from your workload. Intervals with more than 100% utilization are prone to low throughput capacity error events. Amazon Keyspaces offers burst capacity, but as soon as the burst capacity is exhausted, anything above 100% experiences low throughput capacity error events.

How to identify under-provisioned Amazon Keyspaces tables

For most workloads, a table is considered under-provisioned when it constantly consumes more than 80% of its provisioned capacity.

Burst capacity is an Amazon Keyspaces feature that allow customers to temporarily consume more RCUs/WCUs than originally provisioned (more than the per-second provisioned throughput that was defined for the table). The burst capacity was created to absorb sudden increases in traffic due to special events or usage spikes. This burst capacity limited, for more information, see the section called “Use burst capacity”. As soon as the unused RCUs and WCUs are depleted, you can experience low capacity throughput error events if you try to consume more capacity than provisioned. When your application traffic is getting close to the 80% utilization rate, your risk of experiencing low capacity throughput error events is significantly higher.

The 80% utilization rate rule varies from the seasonality of your data and your traffic growth. Consider the following scenarios:

- If your traffic has been **stable** at ~90% utilization rate for the last 12 months, your table has just the right capacity
- If your application traffic is **growing** at a rate of 8% monthly in less than 3 months, you will arrive at 100%
- If your application traffic is **growing** at a rate of 5% in a little more than 4 months, you will still arrive at 100%

The results from the queries above provide a picture of your utilization rate. Use them as a guide to further evaluate other metrics that can help you choose to increase your table capacity as required (for example: a monthly or weekly growth rate). Work with your operations team to define what is a good percentage for your workload and your tables.

There are special scenarios where the data is skewed when you analyse it on a daily or weekly basis. For example, with seasonal applications that have spikes in usage during working hours (but then drop to almost zero outside of working hours), you could benefit from scheduling application auto-scaling, where you specify the hours of the day (and the days of the week) to increase the provisioned capacity, as well as when to reduce it. Instead of aiming for higher capacity so you can cover the busy hours, you can also benefit from Amazon Keyspaces table auto-scaling configurations if your seasonality is less pronounced.

How to identify over-provisioned Amazon Keyspaces tables

The query results obtained from the scripts above provide the data points required to perform some initial analysis. If your data set presents values lower than 20% utilization for several intervals, your table might be over-provisioned. To further define if you need to reduce the number of WCUs and RCUS, you should revisit the other readings in the intervals.

When your table contains several low usage intervals, you can benefit from using Application Auto Scaling policies, either by scheduling Application Auto Scaling or by just configuring the default Application Auto Scaling policies for the table that are based on utilization.

If you have a workload with a low utilization to high throttle ratio (**Max(ThrottleEvents)/ Min(ThrottleEvents)** in the interval), this could happen when you have a very spiky workload where traffic increases significantly on specific days (or times of day), but is otherwise consistently low. In these scenarios, it might be beneficial to use scheduled Application Auto Scaling.

Troubleshooting Amazon Keyspaces (for Apache Cassandra)

This guide covers troubleshooting steps for various scenarios when working with Amazon Keyspaces (for Apache Cassandra). It includes information on resolving general errors, connection issues, capacity management problems, and Data Definition Language (DDL) errors.

- **General errors**
  - Troubleshooting top-level exceptions like `NoNodeAvailableException`, `NoHostAvailableException`, and `AllNodesFailedException`.
  - Isolating underlying errors from Java driver exceptions.
  - Implementing retry policies and configuring connections correctly.
- **Connection issues**
  - Resolving errors when connecting to Amazon Keyspaces endpoints using `cqlsh` or Apache Cassandra client drivers.
  - Troubleshooting VPC endpoint connections, Cassandra-stress connections, and IAM configuration errors.
  - Handling connection losses during data imports.
- **Capacity management errors**
  - Recognizing and resolving insufficient capacity errors related to tables, partitions, and connections.
  - Monitoring relevant Amazon Keyspaces metrics in Amazon CloudWatch Logs.
  - Optimizing connections and throughput for improved performance.
- **Data Definition Language (DDL) errors**
  - Troubleshooting errors when creating, accessing, or restoring keyspaces and tables.
  - Handling failures related to custom Time to Live (TTL) settings, column limits, and range deletes.
  - Considerations for heavy delete workloads.

For troubleshooting guidance specific to IAM access, see the section called “Troubleshooting”. For more information about security best practices, see the section called “Security best practices”.

Topics

- Troubleshooting general errors in Amazon Keyspaces
- Troubleshooting connection errors in Amazon Keyspaces
- Troubleshooting capacity management errors in Amazon Keyspaces
- Troubleshooting data definition language errors in Amazon Keyspaces

Troubleshooting general errors in Amazon Keyspaces

Getting general errors? Here are some common issues and how to resolve them.

General errors

You're getting one of the following top-level exceptions that can occur due to many different reasons.

- `NoNodeAvailableException`
- `NoHostAvailableException`
- `AllNodesFailedException`

These exceptions are generated by the client driver and can occur either when you're establishing the control connection or when you're performing read/write/prepare/execute/batch requests.

When the error occurs while you're establishing the control connection, it's a sign that all the contact points specified in your application are unreachable. When the error occurs while performing read/write/prepare/execute queries, it indicates that all of the retries for that request have been exhausted. Each retry is attempted on a different node when you're using the default retry policy.

How to isolate the underlying error from top-level Java driver exceptions

These general errors can be caused either by connection issues or when performing read/write/prepare/execute operations. Transient failures have to be expected in distributed systems, and should be handled by retrying the request. The Java driver doesn't automatically retry when connection errors are encountered, so it's recommended to implement the retry policy when establishing the driver connection in your application. For a detailed overview of connection best practices, see the section called “Connections”.

By default, the Java driver sets `idempotence` to false for all request, which means the Java driver doesn't automatically retry failed read/write/prepare request. To set `idempotence` to `true` and tell the driver to retry failed requests, you can do so in a few different ways. Here's one example how you can set idempotence programmatically for a single request in your Java application.

```
Statement s = new SimpleStatement("SELECT * FROM my_table WHERE id = 1");
s.setIdempotent(true);
```

Or you can set the default idempotence for your entire Java application programmatically as shown in the following example.

```
// Make all statements idempotent by default:
cluster.getConfiguration().getQueryOptions().setDefaultIdempotence(true);
//Set the default idempotency to true in your Cassandra configuration
basic.request.default-idempotence = true
```

Another recommendation is to create a retry policy at the application level. In this case, the application needs to catch the `NoNodeAvailableException` and retry the request. We recommend 10 retries with exponential backoff starting at 10ms and working up to 100ms with a total time of 1 second for all retries.

Another option is to apply the Amazon Keyspaces exponential retry policy when establishing the Java driver connection available on Github.

Confirm that you have established connections to more than one node when using the default retry policy. You can do so using the following query in Amazon Keyspaces.

```
SELECT * FROM system.peers;
```

If the response for this query is empty, this indicates that you're working with a single node for Amazon Keyspaces. If you're using the default retry policy, there will be no retries because the default retry always occurs on a different node. To learn more about establishing connections over VPC endpoints, see the section called “VPC endpoint connections”.

For a step-by-step tutorial that shows how to establish a connection to Amazon Keyspaces using the Datastax 4.x Cassandra driver, see the section called “Authentication plugin for Java 4.x”.

Troubleshooting connection errors in Amazon Keyspaces

Having trouble connecting? Here are some common issues and how to resolve them.

Errors connecting to an Amazon Keyspaces endpoint

Failed connections and connection errors can result in different error messages. The following section covers the most common scenarios.

Topics

- I can't connect to Amazon Keyspaces with cqlsh
- I can't connect to Amazon Keyspaces using a Cassandra client driver

I can't connect to Amazon Keyspaces with cqlsh

You're trying to connect to an Amazon Keyspaces endpoint using cqlsh and the connection fails with a `Connection error`.

If you try to connect to an Amazon Keyspaces table and cqlsh hasn't been configured properly, the connection fails. The following section provides examples of the most common configuration issues that result in connection errors when you're trying to establish a connection using cqlsh.

> **Note**
>
> If you're trying to connect to Amazon Keyspaces from a VPC, additional permissions are required. To successfully configure a connection using VPC endpoints, follow the steps in the the section called “Connecting with VPC endpoints”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you get a connection `timed out` error.

This might be the case if you didn't supply the correct port, which results in the following error.

```
#  cqlsh cassandra.us-east-1.amazonaws.com 9140 -u "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.199': error(None,
 "Tried connecting to [('3.234.248.199', 9140)]. Last error: timed out")})
```

To resolve this issue, verify that you're using port 9142 for the connection.

You're trying to connect to Amazon Keyspaces using cqlsh, but you get a `Name or service not known` error.

This might be the case if you used an endpoint that is misspelled or doesn't exist. In the following example, the name of the endpoint is misspelled.

```
#  cqlsh cassandra.us-east-1.amazon.com 9142 -u "USERNAME" -p "PASSWORD" --ssl
Traceback (most recent call last):
  File "/usr/bin/cqlsh.py", line 2458, in >module>
    main(*read_options(sys.argv[1:], os.environ))
  File "/usr/bin/cqlsh.py", line 2436, in main
    encoding=options.encoding)
  File "/usr/bin/cqlsh.py", line 484, in __init__
    load_balancing_policy=WhiteListRoundRobinPolicy([self.hostname]),
  File "/usr/share/cassandra/lib/cassandra-driver-internal-only-3.11.0-bb96859b.zip/
cassandra-driver-3.11.0-bb96859b/cassandra/policies.py", line 417, in __init__
socket.gaierror: [Errno -2] Name or service not known
```

To resolve this issue when you're using public endpoints to connect, select an available endpoint from the section called “Service endpoints”, and verify that the name of the endpoint doesn't have any errors. If you're using VPC endpoints to connect, verify that the VPC endpoint information is correct in your cqlsh configuration.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive an `OperationTimedOut` error.

Amazon Keyspaces requires that SSL is enabled for connections to ensure strong security. The SSL parameter might be missing if you receive the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com -u "USERNAME" -p "PASSWORD"
Connection error: ('Unable to connect to any servers', {'3.234.248.192':
 OperationTimedOut('errors=Timed out creating connection (5 seconds),
 last_host=None',)})
#
```

To resolve this issue, add the following flag to the cqlsh connection command.

```
--ssl
```

You're trying to connect to Amazon Keyspaces using cqlsh, and you receive a `SSL transport factory requires a valid certfile to be specified` error.

In this case, the path to the SSL/TLS certificate is missing, which results in the following error.

```
# cat .cassandra/cqlshrc
[connection]
port = 9142
factory = cqlshlib.ssl.ssl_transport_factory
#


# cqlsh cassandra.us-east-1.amazonaws.com -u "USERNAME" -p "PASSWORD" --ssl
Validation is enabled; SSL transport factory requires a valid certfile to be specified.
 Please provide path to the certfile in [ssl] section as 'certfile' option in /
root/.cassandra/cqlshrc (or use [certfiles] section) or set SSL_CERTFILE environment
 variable.
#
```

To resolve this issue, add the path to the certfile on your computer. For more information, see the section called “How to manually configure cqlsh connections for TLS”.

```
certfile =  path_to_file/keyspaces-bundle.pem
```

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive a `No such file or directory` error.

This might be the case if the path to the certificate file on your computer is wrong, which results in the following error.

```
# cat .cassandra/cqlshrc
[connection]
port = 9142
factory = cqlshlib.ssl.ssl_transport_factory

[ssl]
validate = true
certfile = /root/wrong_path/keyspaces-bundle.pem
#



# cqlsh cassandra.us-east-1.amazonaws.com -u "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.192': IOError(2, 'No
 such file or directory')})
```

```
#
```

To resolve this issue, verify that the path to the certfile on your computer is correct. For more information, see the section called “How to manually configure cqlsh connections for TLS”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive a `[X509] PEM lib` error.

This might be the case if the SSL/TLS certificate pem file is not valid, which results in the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com -u "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.241':
 error(185090057, u"Tried connecting to [('3.234.248.241', 9142)]. Last error: [X509]
 PEM lib (_ssl.c:3063)")})
#
```

To resolve this issue make sure that you downloaded the required digital certificates. For more information, see the section called “How to manually configure cqlsh connections for TLS”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive an unknown SSL error.

This might be the case if the SSL/TLS certificate pem file is empty, which results in the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com -u "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.220': error(0,
 u"Tried connecting to [('3.234.248.220', 9142)]. Last error: unknown error
 (_ssl.c:3063)")})
#
```

To resolve this issue make sure that you downloaded the required digital certificates. You can confirm this using the steps in the following topic the section called “How to manually configure cqlsh connections for TLS”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive a `SSL: CERTIFICATE_VERIFY_FAILED` error.

This might be the case if the SSL/TLS certificate file could not be verified, which results in the following error.

```
Connection error: ('Unable to connect to any servers', {'3.234.248.223':
 error(1, u"Tried connecting to [('3.234.248.223', 9142)]. Last error: [SSL:
 CERTIFICATE_VERIFY_FAILED] certificate verify failed (_ssl.c:727)")})
```

To resolve this issue make sure that you downloaded the required digital certificates. You can confirm this using the steps in the following topic the section called “How to manually configure cqlsh connections for TLS”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you're receiving a `Last error: timed out` error.

This might be the case if you didn't configure an outbound rule for Amazon Keyspaces in your Amazon EC2 security group, which results in the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com 9142 -u  "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.206': error(None,
 "Tried connecting to [('3.234.248.206', 9142)]. Last error: timed out")})
#
```

To confirm that this issue is caused by the configuration of the Amazon EC2 instance and not `cqlsh`, you can try to connect to your keyspace using the AWS CLI, for example with the following command.

```
aws keyspaces list-tables --keyspace-name 'my_keyspace'
```

If this command also times out, the Amazon EC2 instance is not correctly configured.

To confirm that you have sufficient permissions to access Amazon Keyspaces, you can use the AWS CloudShell to connect with `cqlsh`. If that connections gets established, you need to configure the Amazon EC2 instance.

To resolve this issue, confirm that your Amazon EC2 instance has an outbound rule that allows traffic to Amazon Keyspaces. If that is not the case, you need to create a new security group for the EC2 instance, and add a rule that allows outbound traffic to Amazon Keyspaces resources. To update the outbound rule to allow traffic to Amazon Keyspaces, choose **CQLSH/CASSANDRA** from the **Type** drop-down menu.

After creating the new security group with the outbound traffic rule, you need to add it to the instance. Select the instance and then choose **Actions**, then **Security**, and then **Change security**

groups. Add the new security group with the outbound rule, but make sure that the default group also remains available.

For more information about how to view and edit EC2 outbound rules, see Add rules to a security group in the Amazon EC2 User Guide.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive an `Unauthorized` error.

This might be the case if you're missing Amazon Keyspaces permissions in the IAM user policy, which results in the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com 9142 -u  "testuser-at-12345678910" -p
 "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.241':
 AuthenticationFailed('Failed to authenticate to 3.234.248.241: Error from server:
 code=2100 [Unauthorized] message="User arn:aws:iam::12345678910:user/testuser has no
 permissions."',)})
#
```

To resolve this issue, ensure that the IAM user `testuser-at-12345678910` has permissions to access Amazon Keyspaces. For examples of IAM policies that grant access to Amazon Keyspaces, see the section called “Identity-based policy examples”.

For troubleshooting guidance that's specific to IAM access, see the section called “Troubleshooting”.

You're trying to connect to Amazon Keyspaces using cqlsh, but you receive a `Bad credentials` error.

This might be the case if the user name or password is wrong, which results in the following error.

```
# cqlsh cassandra.us-east-1.amazonaws.com 9142 -u  "USERNAME" -p "PASSWORD" --ssl
Connection error: ('Unable to connect to any servers', {'3.234.248.248':
 AuthenticationFailed('Failed to authenticate to 3.234.248.248: Error from server:
 code=0100 [Bad credentials] message="Provided username USERNAME and/or password are
 incorrect"',)})
#
```

To resolve this issue, verify that the *USERNAME* and *PASSWORD* in your code match the user name and password you obtained when you generated service-specific credentials.

> **Important**
>
> If you continue to see errors when trying to connect with cqlsh, rerun the command with the `--debug` option and include the detailed output when contacting Support.

I can't connect to Amazon Keyspaces using a Cassandra client driver

The following sections shows the most common errors when connecting with a Cassandra client driver.

You're trying to connect to an Amazon Keyspaces table using the DataStax Java driver, but you receive an `NodeUnavailableException` error.

If the connection on which the request is attempted is broken, it results in the following error.

```
[com.datastax.oss.driver.api.core.NodeUnavailableException: No connection
 was available to Node(endPoint=vpce-22ff22f2f22222fff-aa1bb234.cassandra.us-
west-2.vpce.amazonaws.com/11.1.1111.222:9142, hostId=1a23456b-
c77d-8888-9d99-146cb22d6ef6, hashCode=123ca4567)]
```

To resolve this issue, find the heartbeat value and lower it to 30 seconds if it's higher.

```
advanced.heartbeat.interval = 30 seconds
```

Then look for the associated time out and ensure the value is set to at least 5 seconds.

```
advanced.connection.init-query-timeout = 5 seconds
```

You're trying to connect to an Amazon Keyspaces table using a driver and the SigV4 plugin, but you receive an `AttributeError` error.

If the credentials are not correctly configured, it results in the following error.

```
cassandra.cluster.NoHostAvailable: ('Unable to connect to any servers',
 {'44.234.22.154:9142': AttributeError("'NoneType' object has no attribute
 'access_key'")})
```

To resolve this issue, verify that you're passing the credentials associated with your IAM user or role when using the SigV4 plugin. The SigV4 plugin requires the following credentials.

- AWS_ACCESS_KEY_ID – Specifies an AWS access key associated with an IAM user or role.
- AWS_SECRET_ACCESS_KEY– Specifies the secret key associated with the access key. This is essentially the "password" for the access key.

To learn more about access keys and the SigV4 plugin, see the section called “Create IAM credentials for AWS authentication”.

You're trying to connect to an Amazon Keyspaces table using a driver, but you receive a `PartialCredentialsError` error.

If the AWS_SECRET_ACCESS_KEY is missing, it can result in the following error.

```
cassandra.cluster.NoHostAvailable: (‘Unable to connect to any servers’,
 {‘44.234.22.153:9142’:
 PartialCredentialsError(‘Partial credentials found in config-file, missing:
 aws_secret_access_key’)})
```

To resolve this issue, verify that you're passing both the AWS_ACCESS_KEY_ID and the AWS_SECRET_ACCESS_KEY when using the SigV4 plugin. To learn more about access keys and the SigV4 plugin, see the section called “Create IAM credentials for AWS authentication”.

You're trying to connect to an Amazon Keyspaces table using a driver, but you receive an `Invalid signature` error.

This might be the case if any of the components required for the signature are wrong or not correctly defined for the session.

- AWS_ACCESS_KEY_ID
- AWS_SECRET_ACCESS_KEY
- AWS_DEFAULT_REGION

The following error is an examples of invalid access keys.

```
cassandra.cluster.NoHostAvailable: (‘Unable to connect to any servers’,
 {‘11.234.11.234:9142’:
 AuthenticationFailed(‘Failed to authenticate to 11.234.11.234:9142: Error from server:
 code=0100
 [Bad credentials] message=“Authentication failure: Invalid signature”’)})
```

To resolve this issue, verify that the access keys and the AWS Region have been correctly configured for the SigV4 plugin to access Amazon Keyspaces. To learn more about access keys and the SigV4 plugin, see the section called “Create IAM credentials for AWS authentication”.

My VPC endpoint connection doesn't work properly

You're trying to connect to Amazon Keyspaces using VPC endpoints, but you're receiving token map errors or you are experiencing low throughput.

This might be the case if the VPC endpoint connection isn't correctly configured.

To resolve these issues, verify the following configuration details. To follow a step-by-step tutorial to learn how to configure a connection over interface VPC endpoints for Amazon Keyspaces see the section called “Connecting with VPC endpoints”.

1. Confirm that the IAM entity used to connect to Amazon Keyspaces has read/write access to the user table and read access to the system tables as shown in the following example.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select",
            "cassandra:Modify"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

2. Confirm that the IAM entity used to connect to Amazon Keyspaces has the required read permissions to access the VPC endpoint information on your Amazon EC2 instance as shown in the following example.

```
{
   "Version":"2012-10-17",
```

```
   "Statement":[
      {
         "Sid":"ListVPCEndpoints",
         "Effect":"Allow",
         "Action":[
            "ec2:DescribeNetworkInterfaces",
            "ec2:DescribeVpcEndpoints"
         ],
         "Resource":"*"
      }
   ]
}
```

> **Note**
>
> The managed policies `AmazonKeyspacesReadOnlyAccess_v2` and `AmazonKeyspacesFullAccess` include the required permissions to let Amazon Keyspaces access the Amazon EC2 instance to read information about available interface VPC endpoints.

For more information about VPC endpoints, see the section called “Using interface VPC endpoints for Amazon Keyspaces”

3. Confirm that the SSL configuration of the Java driver sets hostname validation to false as shown in this example.

```
hostname-validation = false
```

For more information about driver configuration, see the section called “Step 2: Configure the driver”.

4. To confirm that the VPC endpoint has been configured correctly, you can run the following statement from *within* your VPC.

> **Note**
>
> You can't use your local developer environment or the Amazon Keyspaces CQL editor to confirm this configuration, because they use the public endpoint.

```
SELECT peer FROM system.peers;
```

The output should look similar to this example and return between 2 to 6 nodes with private IPv4 addresses when connecting from an IPv4 network, depending on your VPC setup and AWS Region.

```
peer
---------------
 192.0.2.0.15
 192.0.2.0.24
 192.0.2.0.13
 192.0.2.0.7
 192.0.2.0.8

(5 rows)
```

I can't connect using `cassandra-stress`

You're trying to connect to Amazon Keyspaces using the `cassandra-stress` command, but you're receiving an SSL `context` error.

This happens if you try to connect to Amazon Keyspaces, but you don't have the trustStore setup correctly. Amazon Keyspaces requires the use of Transport Layer Security (TLS) to help secure connections with clients.

In this case, you see the following error.

```
Error creating the initializing the SSL Context
```

To resolve this issue, follow the instructions to set up a trustStore as shown in this topic the section called “Before you begin”.

Once the trustStore is setup, you should be able to connect with the following command.

```
./cassandra-stress user profile=./profile.yaml n=100 "ops(insert=1,select=1)"
 cl=LOCAL_QUORUM -node "cassandra.eu-north-1.amazonaws.com" -port native=9142
 -transport ssl-alg="PKIX" truststore="./cassandra_truststore.jks" truststore-
password="trustStore_pw" -mode native cql3 user="user_name" password="password"
```

I can't connect using IAM identities

You're trying to connect to an Amazon Keyspaces table using an IAM identity, but you're receiving an `Unauthorized` error.

This happens if you try to connect to an Amazon Keyspaces table using an IAM identity (for example, an IAM user) without implementing the policy and giving the user the required permissions first.

In this case, you see the following error.

```
Connection error: ('Unable to connect to any servers', {'3.234.248.202':
 AuthenticationFailed('Failed to authenticate to 3.234.248.202:
Error from server: code=2100 [Unauthorized] message="User
 arn:aws:iam::1234567890123:user/testuser has no permissions."',)})
```

To resolve this issue, verify the permissions of the IAM user. To connect with a standard driver, a user must have at least `SELECT` access to the system tables, because most drivers read the system keyspaces/tables when they establish the connection.

For example IAM policies that grant access to Amazon Keyspaces system and user tables, see the section called “Accessing Amazon Keyspaces tables”.

To review the troubleshooting section specific to IAM, see the section called “Troubleshooting”.

I'm trying to import data with cqlsh and the connection to my Amazon Keyspaces table is lost

You're trying to upload data to Amazon Keyspaces with cqlsh, but you're receiving connection errors.

The connection to Amazon Keyspaces fails after the cqlsh client receives three consecutive errors of any type from the server. The cqlsh client fails with the following message.

```
Failed to import 1 rows: NoHostAvailable - , will retry later, attempt 3 of 100
```

To resolve this error, you need to make sure that the data to be imported matches the table schema in Amazon Keyspaces. Review the import file for parsing errors. You can try using a single row of data by using an INSERT statement to isolate the error.

The client automatically attempts to reestablish the connection.

Troubleshooting capacity management errors in Amazon Keyspaces

Having trouble with serverless capacity? Here are some common issues and how to resolve them.

Serverless capacity errors

This section outlines how to recognize errors related to serverless capacity management and how to resolve them. For example, you might observe insufficient capacity events when your application exceeds your provisioned throughput capacity.

Because Apache Cassandra is cluster-based software that is designed to run on a fleet of nodes, it doesn't have exception messages related to serverless features such as throughput capacity. Most drivers only understand the error codes that are available in Apache Cassandra, so Amazon Keyspaces uses that same set of error codes to maintain compatibility.

To map Cassandra errors to the underlying capacity events, you can use Amazon CloudWatch to monitor the relevant Amazon Keyspaces metrics. Insufficient-capacity events that result in client-side errors can be categorized into these three groups based on the resource that is causing the event:

- **Table** – If you choose **Provisioned** capacity mode for a table, and your application exceeds your provisioned throughput, you might observe insufficient-capacity errors. For more information, see the section called "Configure read/write capacity modes".
- **Partition** – You might experience insufficient-capacity events if traffic against a given partition exceeds 3,000 RCUs or 1,000 WCUs. We recommend distributing traffic uniformly across partitions as a best practice. For more information, see the section called "Data modeling".
- **Connection** – You might experience insufficient throughput if you exceed the quota for the maximum number of operations per second, per connection. To increase throughput, you can increase the number of default connections when configuring the connection with the driver.

  To learn how to configure connections for Amazon Keyspaces, see the section called "How to configure connections". For more information about optimizing connections over VPC endpoints, see the section called "VPC endpoint connections".

To determine which resource is causing the insufficient-capacity event that is returning the client-side error, you can check the dashboard in the Amazon Keyspaces console. By default, the console

provides an aggregated view of the most common capacity and traffic related CloudWatch metrics in the **Capacity and related metrics** section on the **Capacity** tab for the table.

To create your own dashboard using Amazon CloudWatch, check the following Amazon Keyspaces metrics.

- `PerConnectionRequestRateExceeded` – Requests to Amazon Keyspaces that exceed the quota for the per-connection request rate. Each client connection to Amazon Keyspaces can support up to 3000 CQL requests per second. You can perform more than 3000 requests per second by creating multiple connections.
- `ReadThrottleEvents` – Requests to Amazon Keyspaces that exceed the read capacity for a table.
- `StoragePartitionThroughputCapacityExceeded` – Requests to an Amazon Keyspaces storage partition that exceed the throughput capacity of the partition. Amazon Keyspaces storage partitions can support up to 1000 WCU/WRU per second and 3000 RCU/RRU per second. To mitigate these exceptions, we recommend that you review your data model to distribute read/write traffic across more partitions.
- `WriteThrottleEvents` – Requests to Amazon Keyspaces that exceed the write capacity for a table.

To learn more about CloudWatch, see the section called “Monitoring with CloudWatch”. For a list of all available CloudWatch metrics for Amazon Keyspaces, see the section called “Metrics and dimensions”.

> **Note**
>
> To get started with a custom dashboard that shows all commonly observed metrics for Amazon Keyspaces, you can use a prebuilt CloudWatch template available on GitHub in the AWS samples repository.

Topics

- I'm receiving NoHostAvailable insufficient capacity errors from my client driver
- I'm receiving write timeout errors during data import
- I can't see the actual storage size of a keyspace or table

I'm receiving `NoHostAvailable` insufficient capacity errors from my client driver

You're seeing `Read_Timeout` or `Write_Timeout` exceptions for a table.

Repeatedly trying to write to or read from an Amazon Keyspaces table with insufficient capacity can result in client-side errors that are specific to the driver.

Use CloudWatch to monitor your provisioned and actual throughput metrics, and insufficient capacity events for the table. For example, a read request that doesn't have enough throughput capacity fails with a `Read_Timeout` exception and is posted to the `ReadThrottleEvents` metric. A write request that doesn't have enough throughput capacity fails with a `Write_Timeout` exception and is posted to the `WriteThrottleEvents` metric. For more information about these metrics, see the section called "Metrics and dimensions".

To resolve these issues, consider one of the following options.

- Increase the *provisioned throughput* for the table, which is the maximum amount of throughput capacity an application can consume. For more information, see the section called "Read capacity units and write capacity units".
- Let the service manage throughput capacity on your behalf with automatic scaling. For more information, see the section called "Manage throughput capacity with auto scaling".
- Chose **On-demand** capacity mode for the table. For more information, see the section called "Configure on-demand capacity mode".

If you need to increase the default capacity quota for your account, see *Quotas*.

You're seeing errors related to exceeded partition capacity.

When you're seeing the error `StoragePartitionThroughputCapacityExceeded` the partition capacity is temporarily exceeded. This might be automatically handled by adaptive capacity or on-demand capacity. We recommend reviewing your data model to distribute read/write traffic across more partitions to mitigate these errors. Amazon Keyspaces storage partitions can support up to 1000 WCU/WRU per second and 3000 RCU/RRU per second. To learn more about how to improve your data model to distribute read/write traffic across more partitions, see the section called "Data modeling".

`Write_Timeout` exceptions can also be caused by an elevated rate of concurrent write operations that include static and nonstatic data in the same logical partition. If traffic is expected to run multiple concurrent write operations that include static and nonstatic data within the same logical

partition, we recommend writing static and nonstatic data separately. Writing the data separately also helps to optimize the throughput costs.

You're seeing errors related to exceeded connection request rate.

You're seeing `PerConnectionRequestRateExceeded` due to one of the following causes.

- You might not have enough connections configured per session.
- You might be getting fewer connections than available peers, because you don't have the VPC endpoint permissions configured correctly. For more information about VPC endpoint policies, see the section called “Using interface VPC endpoints for Amazon Keyspaces”.
- If you're using a 4.x driver, check to see if you have hostname validation enabled. The driver enables TLS hostname verification by default. This configuration leads to Amazon Keyspaces appearing as a single-node cluster to the driver. We recommend that you turn hostname verification off.

We recommend that you follow these best practices to ensure that your connections and throughput are optimized:

- **Configure CQL query throughput tuning.**

  Amazon Keyspaces supports up to 3,000 CQL queries per TCP connection per second, but there is no limit on the number of connections a driver can establish.

  Most open-source Cassandra drivers establish a connection pool to Cassandra and load balance queries over that pool of connections. Amazon Keyspaces exposes 9 peer IP addresses to drivers. The default behavior of most drivers is to establish a single connection to each peer IP address. Therefore, the maximum CQL query throughput of a driver using the default settings will be 27,000 CQL queries per second.

  To increase this number, we recommend that you increase the number of connections per IP address that your driver is maintaining in its connection pool. For example, setting the maximum connections per IP address to 2 will double the maximum throughput of your driver to 54,000 CQL queries per second.

- **Optimize your single-node connections.**

  By default, most open-source Cassandra drivers establish one or more connections to every IP address advertised in the `system.peers` table when establishing a session. However, certain

configurations can lead to a driver connecting to a single Amazon Keyspaces IP address. This can happen if the driver is attempting SSL hostname validation of the peer nodes (for example, DataStax Java drivers), or when it's connecting through a VPC endpoint.

To get the same availability and performance as a driver with connections to multiple IP addresses, we recommend that you do the following:

- Increase the number of connections per IP to 9 or higher depending on the desired client throughput.
- Create a custom retry policy that ensures that retries are run against the same node. For more information, see

  the section called “How to configure retry policies”.
- If you use VPC endpoints, grant the IAM entity that is used to connect to Amazon Keyspaces access permissions to query your VPC for the endpoint and network interface information. This improves load balancing and increases read/write throughput. For more information, see ???.

I'm receiving write timeout errors during data import

You're receiving a timeout error when uploading data using the `cqlsh COPY` command.

```
Failed to import 1 rows: WriteTimeout - Error from server: code=1100 [Coordinator node
 timed out waiting for replica nodes' responses]
 message="Operation timed out - received only 0 responses." info={'received_responses':
 0, 'required_responses': 2, 'write_type': 'SIMPLE', 'consistency':
 'LOCAL_QUORUM'}, will retry later, attempt 1 of 100
```

Amazon Keyspaces uses the `ReadTimeout` and `WriteTimeout` exceptions to indicate when a write request fails due to insufficient throughput capacity. To help diagnose insufficient capacity exceptions, Amazon Keyspaces publishes the following metrics in Amazon CloudWatch.

- `WriteThrottleEvents`
- `ReadThrottledEvents`
- `StoragePartitionThroughputCapacityExceeded`

To resolve insufficient-capacity errors during a data load, lower the write rate per worker or the total ingest rate, and then retry to upload the rows. For more information, see the section called “Step 4: Configure `cqlsh COPY FROM` settings”. For a more robust data upload option, consider

using DSBulk, which is available from the GitHub repository. For step-by-step instructions, see the section called “Loading data using DSBulk”.

I can't see the actual storage size of a keyspace or table

You can't see the actual storage size of the keyspace or table.

To learn more about the storage size of your table, see the section called “Evaluate your costs at the table level”. You can also estimate storage size by starting to calculate the row size in a table. Detailed instructions for calculating the row size are available at the section called “Estimate row size”.

Troubleshooting data definition language errors in Amazon Keyspaces

Having trouble creating resources? Here are some common issues and how to resolve them.

Data definition language errors

Amazon Keyspaces performs data definition language (DDL) operations asynchronously—for example, creating and deleting keyspaces and tables. If an application is trying to use the resource before it's ready, the operation fails.

You can monitor the creation status of new keyspaces and tables in the AWS Management Console, which indicates when a keyspace or table is pending or active. You can also monitor the creation status of a new keyspace or table programmatically by querying the system schema table. A keyspace or table becomes visible in the system schema when it's ready for use.

> **Note**
>
> To optimize the creation of keyspaces using CloudFormation, you can use this utility to convert CQL scripts into CloudFormation templates. The tool is available from the GitHub repository.

Topics

- I created a new keyspace, but I can't view or access it
- I created a new table, but I can't view or access it

- I'm trying to restore a table using Amazon Keyspaces point-in-time recovery (PITR), but the restore fails
- I'm trying to use INSERT/UPDATE to edit custom Time to Live (TTL) settings, but the operation fails
- I'm trying to upload data to my Amazon Keyspaces table and I get an error about exceeding the number of columns
- I'm trying to delete data in my Amazon Keyspaces table and the deletion fails for the range

I created a new keyspace, but I can't view or access it

You're receiving errors from your application that is trying to access a new keyspace.

If you try to access a newly created Amazon Keyspaces keyspace that is still being created asynchronously, you will get an error. The following error is an example.

```
InvalidRequest: Error from server: code=2200 [Invalid query] message="unconfigured
 keyspace mykeyspace"
```

The recommended design pattern to check when a new keyspace is ready for use is to poll the Amazon Keyspaces system schema tables (system_schema_mcs.*).

For more information, see the section called “Check keyspace creation status”.

I created a new table, but I can't view or access it

You're receiving errors from your application that is trying to access a new table.

If you try to access a newly created Amazon Keyspaces table that is still being created asynchronously, you will get an error. For example, trying to query a table that isn't available yet fails with an `unconfigured table` error.

```
InvalidRequest: Error from server: code=2200 [Invalid query] message="unconfigured
 table mykeyspace.mytable"
```

Trying to view the table with `sync_table()` fails with a `KeyError`.

```
KeyError: 'mytable'
```

The recommended design pattern to check when a new table is ready for use is to poll the Amazon Keyspaces system schema tables (system_schema_mcs.*).

This is the example output for a table that is being created.

```
user-at-123@cqlsh:system_schema_mcs> select table_name,status from
 system_schema_mcs.tables where keyspace_name='example_keyspace' and
 table_name='example_table';

table_name | status

------------+----------

example_table | CREATING

(1 rows)
```

This is the example output for a table that is active.

```
user-at-123@cqlsh:system_schema_mcs> select table_name,status from
 system_schema_mcs.tables where keyspace_name='example_keyspace' and
 table_name='example_table';

table_name | status

------------+----------

example_table | ACTIVE

(1 rows)
```

For more information, see the section called “Check table creation status”.

I'm trying to restore a table using Amazon Keyspaces point-in-time recovery (PITR), but the restore fails

If you're trying to restore an Amazon Keyspaces table with point-in-time recovery (PITR), and you see the restore process begin but not complete successfully, you might not have configured all of the required permissions that are needed by the restore process for this particular table.

In addition to user permissions, Amazon Keyspaces might require permissions to perform actions during the restore process on your principal's behalf. This is the case if the table is encrypted with a customer managed key, or if you're using IAM policies that restrict incoming traffic.

For example, if you're using condition keys in your IAM policy to restrict source traffic to specific endpoints or IP ranges, the restore operation fails. To allow Amazon Keyspaces to perform the table restore operation on your principal's behalf, you must add an `aws:ViaAWSService` global condition key in the IAM policy.

For more information about permissions to restore tables, see the section called “Configure IAM permissions for restore”.

I'm trying to use INSERT/UPDATE to edit custom Time to Live (TTL) settings, but the operation fails

If you're trying to insert or update a custom TTL value, the operation might fail with the following error.

```
TTL is not yet supported.
```

To specify custom TTL values for rows or columns by using `INSERT` or `UPDATE` operations, you must first enable TTL for the table. You can enable TTL for a table using the `ttl` custom property.

For more information about enabling custom TTL settings for tables, see the section called “Update table custom TTL”.

I'm trying to upload data to my Amazon Keyspaces table and I get an error about exceeding the number of columns

You're uploading data and have exceeded the number of columns that can be updated simultaneously.

This error occurs when your table schema exceeds the maximum size of 350 KB. For more information, see *Quotas*.

I'm trying to delete data in my Amazon Keyspaces table and the deletion fails for the range

You're trying to delete data by partition key and receive a range delete error.

This error occurs when you're trying to delete more than 1,000 rows in one delete operation.

```
Range delete requests are limited by the amount of items that can be deleted in a
 single range.
```

For more information, see the section called “Range delete”.

To delete more than 1,000 rows within a single partition, consider the following options.

- Delete by partition – If the majority of partitions are under 1,000 rows, you can attempt to delete data by partition. If the partitions contain more than 1,000 rows, attempt to delete by the clustering column instead.
- Delete by clustering column – If your model contains multiple clustering columns, you can use the column hierarchy to delete multiple rows. Clustering columns are a nested structure, and you can delete many rows by operating against the top-level column.
- Delete by individual row – You can iterate through the rows and delete each row by its full primary key (partition columns and clustering columns).
- As a best practice, consider splitting your rows across partitions – In Amazon Keyspaces, we recommend that you distribute your throughput across table partitions. This distributes data and access evenly across physical resources, which provides the best throughput. For more information, see the section called “Data modeling”.

Consider also the following recommendations when you're planning delete operations for heavy workloads.

- With Amazon Keyspaces, partitions can contain a virtually unbounded number of rows. This allows you to scale partitions “wider” than the traditional Cassandra guidance of 100 MB. It’s not uncommon for time series or ledgers to grow over a gigabyte of data over time.
- With Amazon Keyspaces, there are no compaction strategies or tombstones to consider when you have to perform delete operations for heavy workloads. You can delete as much data as you want without impacting read performance.

Monitoring Amazon Keyspaces (for Apache Cassandra)

Monitoring is an important part of maintaining the reliability, availability, and performance of Amazon Keyspaces and your other AWS solutions. AWS provides the following monitoring tools to watch Amazon Keyspaces, report when something is wrong, and take automatic actions when appropriate:

- *Amazon Keyspaces* offers a preconfigured dashboard in the AWS Management Console showing the latency and errors aggregated across all tables in the account.
- *Amazon CloudWatch* monitors your AWS resources and the applications you run on AWS in real time. You can collect and track metrics with customized dashboards. For example, you can create a baseline for normal Amazon Keyspaces performance in your environment by measuring performance at various times and under different load conditions. As you monitor Amazon Keyspaces, store historical monitoring data so that you can compare it with current performance data, identify normal performance patterns and performance anomalies, and devise methods to address issues. To establish a baseline, you should, at a minimum, monitor for system errors. For more information, see the Amazon CloudWatch User Guide.
- *Amazon CloudWatch alarms* monitor a single metric over a time period that you specify, and perform one or more actions based on the value of the metric relative to a given threshold over a number of time periods. For example if you use Amazon Keyspaces in provisioned mode with application auto scaling, the action is a notification sent by the Amazon Simple Notification Service (Amazon SNS) to evaluate an Application Auto Scaling policy.

  CloudWatch alarms do not invoke actions simply because they are in a particular state. The state must have changed and been maintained for a specified number of periods. For more information, see Monitoring Amazon Keyspaces with Amazon CloudWatch.
- *Amazon CloudWatch Logs* enables you to monitor, store, and access your log files from Amazon Keyspaces tables, CloudTrail, and other sources. CloudWatch Logs can monitor information in the log files and notify you when certain thresholds are met. You can also archive your log data in highly durable storage. For more information, see the Amazon CloudWatch Logs User Guide.
- *AWS CloudTrail* captures API calls and related events made by or on behalf of your AWS account and delivers the log files to an Amazon S3 bucket that you specify. You can identify which users and accounts called AWS, the source IP address from which the calls were made, and when the calls occurred. For more information, see the AWS CloudTrail User Guide.

Amazon EventBridge is a serverless event bus service that makes it easy to connect your applications with data from a variety of sources. EventBridge delivers a stream of real-time data from your own applications, Software-as-a-Service (SaaS) applications, and AWS services and routes that data to targets such as Lambda. This enables you to monitor events that happen in services, and build event-driven architectures. For more information, see the Amazon EventBridge User Guide.

Topics

- Monitoring Amazon Keyspaces with Amazon CloudWatch
- Logging Amazon Keyspaces API calls with AWS CloudTrail

Monitoring Amazon Keyspaces with Amazon CloudWatch

You can monitor Amazon Keyspaces using Amazon CloudWatch, which collects raw data and processes it into readable, near real-time metrics. These statistics are kept for 15 months, so that you can access historical information and gain a better perspective on how your web application or service is performing.

You can also set alarms that watch for certain thresholds, and send notifications or take actions when those thresholds are met. For more information, see the Amazon CloudWatch User Guide.

> **Note**
>
> To get started quickly with a preconfigured CloudWatch dashboard showing common metrics for Amazon Keyspaces, you can use an CloudFormation template available from https://github.com/aws-samples/amazon-keyspaces-cloudwatch-cloudformation-templates.

Topics

- How do I use Amazon Keyspaces metrics?
- Amazon Keyspaces metrics and dimensions
- Viewing Amazon Keyspaces metrics in CloudWatch
- Creating CloudWatch alarms to monitor Amazon Keyspaces

How do I use Amazon Keyspaces metrics?

The metrics reported by Amazon Keyspaces provide information that you can analyze in different ways. The following list shows some common uses for the metrics. These are suggestions to get you started, not a comprehensive list. For more information about metrics and retention, see Metrics.

How can I?	Relevant metrics
How can I determine if any system errors occurred?	You can monitor `SystemErrors` to determine whether any requests resulted in a server error code. Typically, this metric should be equal to zero. If it isn't, you might want to investiga te.
How can I compare average provisioned read to consumed read capacity?	To monitor average provisioned read capacity and consumed read capacity 1. Set the **Period** for `ConsumedReadCapacityUnits` and `ProvisionedReadCapacityUnits` to the interval you want to monitor. 2. Change the **Statistic** for `ConsumedReadCapacityUnits` from `Average` to `Sum`. 3. Create a new empty **Math expression**. 4. In the **Details** section of the new math expression, enter the **Id** of `ConsumedReadCapacityUnits` and divide the metric by the CloudWatch **PERIOD** function of the metric (metric_id/(**PERIOD**(metric_id)). 5. Unselect `ConsumedReadCapacityUnits` . You can now compare your average consumed read capacity to your provisioned capacity. For more information on basic arithmetic functions and how to create a time series see Using metric math.

How can I?	Relevant metrics
How can I compare average provisioned write to consumed write capacity?	To monitor average provisioned write capacity and consumed write capacity 1. Set the **Period** for `ConsumedWriteCapacityUnits` and `ProvisionedWriteCapacityUnits` to the interval you want to monitor. 2. Change the **Statistic** for `ConsumedWriteCapacityUnits` from `Average` to `Sum`. 3. Create a new empty **Math expression**. 4. In the **Details** section of the new math expression, enter the **Id** of `ConsumedWriteCapacityUnits` and divide the metric by the CloudWatch **PERIOD** function of the metric (metric_id/(**PERIOD**(metric_id)). 5. Unselect `ConsumedWriteCapacityUnits` . You can now compare your average consumed write capacity to your provisioned capacity. For more information on basic arithmetic functions and how to create a time series see Using metric math.

Amazon Keyspaces metrics and dimensions

When you interact with Amazon Keyspaces, it sends metrics and dimensions to Amazon CloudWatch. All metrics are aggregated and reported every minute. The following sections are an overview of all available metrics for Amazon Keyspaces.

Topics

- Amazon Keyspaces metrics
- Dimensions for Amazon Keyspaces metrics
- Metrics for Amazon Keyspaces change data capture (CDC)
- Dimensions for Amazon Keyspaces change data capture (CDC) metrics

Amazon Keyspaces metrics

Amazon CloudWatch aggregates Amazon Keyspaces metrics at one-minute intervals.

Not all statistics, such as `Average` or `Sum`, are applicable for every metric. However, all of these values are available through the Amazon Keyspaces console, or by using the CloudWatch console, AWS CLI, or AWS SDKs for all metrics. In the following table, each metric has a list of valid statistics that are applicable to that metric.

Metric	Description
`AccountMaxTableLevelReads`	The maximum number of read capacity units that can be used by a table of an account. For on-demand tables this limit caps the maximum read request units a table can use. Units: `Count` Valid Statistics: • `Maximum` – The maximum number of read capacity units that can be used by a table of the account.
`AccountMaxTableLevelWrites`	The maximum number of write capacity units that can be used by a table of an account. For on-demand tables this limit caps the maximum write request units a table can use. Units: `Count` Valid Statistics: • `Maximum` – The maximum number of write capacity units that can be used by a table of the account.
`AccountProvisionedReadCapacityUtilization`	The percentage of provisioned read capacity units utilized by an account. Units: `Percent` Valid Statistics:

Metric	Description
	• `Maximum` – The maximum percentage of provisioned read capacity units utilized by the account. • `Minimum` – The minimum percentage of provisioned read capacity units utilized by the account. • `Average` – The average percentage of provisioned read capacity units utilized by the account. The metric is published for five-minute intervals. Therefore, if you rapidly adjust the provisioned read capacity units, this statistic might not reflect the true average.
`AccountProvisionedWriteCapacityUtilization`	The percentage of provisioned write capacity units utilized by an account. Units: `Percent` Valid Statistics: • `Maximum` – The maximum percentage of provisioned write capacity units utilized by the account. • `Minimum` – The minimum percentage of provisioned write capacity units utilized by the account. • `Average` – The average percentage of provisioned write capacity units utilized by the account. The metric is published for five-minute intervals. Therefore, if you rapidly adjust the provisioned write capacity units, this statistic might not reflect the true average.

Metric	Description
`BillableTableSizeInBytes`	The billable size of the table in bytes. It is the sum of the encoded size of all rows in the table. This metric helps you track your table storage costs over time. Units: `Bytes` Dimensions: `Keyspace, TableName` Valid Statistics: • `Maximum` – The maximum storage size of the table. • `Minimum` – The minimum storage size of the table. • `Average` – The average storage size of the table. This metric is calculated over 4 - 6 hour intervals.

Metric	Description
ConditionalCheckFailedRequests	The number of failed lightweight transaction (LWT) write requests. The INSERT, UPDATE, and DELETE operations let you provide a logical condition that must evaluate to true before the operation can proceed. If this condition evaluates to false, ConditionalCheckFailedRequests is incremented by one. Condition checks that evaluate to false consume write capacity units based on the size of the row. For more information, see the section called "Estimate capacity consumption of LWT". Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Minimum • Maximum • Average • SampleCount • Sum

Metric	Description
ConsumedReadCapacityUnits	The number of read capacity units consumed over the specified time period. For more information, see Read/Write capacity mode. **Note** To understand your average throughput utilization per second, use the Sum statistic to calculate the consumed throughput for the one minute period. Then divide the sum by the number of seconds in a minute (60) to calculate the average ConsumedReadCapacityUnits per second (recognizing that this average does not highlight any large but brief spikes in read activity that occurred during that minute). For more information on comparing average consumed read capacity to provisioned read capacity, see the section called "Using metrics" Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Minimum – The minimum number of read capacity units consumed by any individual request to the table. • Maximum – The maximum number of read capacity units consumed by any individual request to the table. • Average – The average per-request read capacity consumed.

Metric	Description
	Note The `Average` value is influenced by periods of inactivity where the sample value will be zero. • Sum – The total read capacity units consumed. This is the most useful statistic for the `ConsumedReadCapacityUnits` metric. • `SampleCount` – The number of requests to Amazon Keyspaces, even if no read capacity was consumed. **Note** The `SampleCount` value is influenced by periods of inactivity where the sample value will be zero.

Metric	Description
`ConsumedWriteCapacityUnits`	The number of write capacity units consumed over the specified time period. You can retrieve the total consumed write capacity for a table. For more information, see Read/Write capacity mode. **Note** To understand your average throughput utilization per second, use the `Sum` statistic to calculate the consumed throughput for the one minute period. Then divide the sum by the number of seconds in a minute (60) to calculate the average `ConsumedWriteCapacityUnits` per second (recognizing that this average does not highlight any large but brief spikes in write activity that occurred during that minute). For more information on comparing average consumed write capacity to provisioned write capacity, see the section called "Using metrics" Units: `Count` Dimensions: `Keyspace, TableName` Valid Statistics: • `Minimum` – The minimum number of write capacity units consumed by any individual request to the table. • `Maximum` – The maximum number of write capacity units consumed by any individual request to the table. • `Average` – The average per-request write capacity consumed.

Metric	Description
	Note The `Average` value is influenced by periods of inactivity where the sample value will be zero. • Sum – The total write capacity units consumed. This is the most useful statistic for the `ConsumedWriteCapacityUnits` metric. • `SampleCount` – The number of requests to Amazon Keyspaces, even if no write capacity was consumed. **Note** The `SampleCount` value is influenced by periods of inactivity where the sample value will be zero.

Metric	Description
`MaxProvisionedTabl eReadCapacityUtilization`	The percentage of provisioned read capacity units utilized by the highest provisioned read table of an account. Units: `Percent` Valid Statistics: • `Maximum` – : The maximum percentage of provisioned read capacity units utilized by the highest provisioned read table of the account. • `Minimum` – The minimum percentage of provisioned read capacity units utilized by the highest provisioned read table of the account. • `Average` – The average percentage of provisioned read capacity units utilized by the highest provisioned read table of the account. The metric is published for five-minute intervals. Therefore, if you rapidly adjust the provisioned read capacity units, this statistic might not reflect the true average.

Metric	Description
`MaxProvisionedTableWriteCapacityUtilization`	The percentage of provisioned write capacity utilized by the highest provisioned write table of an account. Units: `Percent` Valid Statistics: • `Maximum` – The maximum percentage of provisioned write capacity units utilized by the highest provisioned write table of the account. • `Minimum` – The minimum percentage of provisioned write capacity units utilized by the highest provisioned write table of the account. • `Average` – The average percentage of provisioned write capacity units utilized by the highest provisioned write table of the account. The metric is published for five-minute intervals. Therefore, if you rapidly adjust the provisioned write capacity units, this statistic might not reflect the true average.

Metric	Description
PerConnectionRequestRateExceeded	Requests to Amazon Keyspaces that exceed the per-connection request rate quota. Each client connection to Amazon Keyspaces can support up to 3000 CQL requests per second. Clients can create multiple connections to increase throughput. When you're using multi-Region replication, each replicated write also contributes to this quota. As a best practice, we recommend to increase the number of connections to your tables to avoid PerConnectionRequestRateExceeded errors. There is no limit to the number of connections you can have in Amazon Keyspaces. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • SampleCount • Sum

Metric	Description
ProvisionedReadCapacityUnits	The number of provisioned read capacity units for a table. The TableName dimension returns the ProvisionedReadCapacityUnits for the table. Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Minimum – The lowest setting for provisioned read capacity. If you use ALTER TABLE to increase read capacity, this metric shows the lowest value of provisioned ReadCapacityUnits during this time period. • Maximum – The highest setting for provisioned read capacity. If you use ALTER TABLE to decrease read capacity, this metric shows the highest value of provisioned ReadCapacityUnits during this time period. • Average – The average provisioned read capacity. The ProvisionedReadCapacityUnits metric is published at five-minute intervals. Therefore, if you rapidly adjust the provisioned read capacity units, this statistic might not reflect the true average.

Metric	Description
ProvisionedWriteCapacityUnits	The number of provisioned write capacity units for a table. The TableName dimension returns the ProvisionedWriteCapacityUnits for the table. Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Minimum – The lowest setting for provisioned write capacity. If you use ALTER TABLE to increase write capacity, this metric shows the lowest value of provisioned WriteCapacityUnits during this time period. • Maximum – The highest setting for provisioned write capacity. If you use ALTER TABLE to decrease write capacity, this metric shows the highest value of provisioned WriteCapacityUnits during this time period. • Average – The average provisioned write capacity. The ProvisionedWriteCapacityUnits metric is published at five-minute intervals. Therefore, if you rapidly adjust the provisioned write capacity units, this statistic might not reflect the true average.

Metric	Description
ReadThrottleEvents	Requests to Amazon Keyspaces that exceed the provisioned read capacity for a table, or account level quotas, request per connection quotas, or partition level quotas. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • SampleCount • Sum
ReplicationLatency	This metric only applies to multi-Region keyspaces and measures the time it took to replicate updates, inserts, or deletes from one replica table to another replica table in a multi-Region keyspace. Units: Millisecond Dimensions: TableName, ReceivingRegion Valid Statistics: • Average • Maximum • Minimum

Metric	Description
ReturnedItemCountBySelect	The number of rows returned by multi-row SELECT queries during the specified time period. Multi-row SELECT queries are queries which do not contain the fully qualified primary key, such as full table scans and range queries. The number of rows *returned* is not necessarily the same as the number of rows that were evaluated. For example, suppose that you requested a SELECT * with ALLOW FILTERING on a table that had 100 rows, but specified a WHERE clause that narrowed the results so that only 15 rows were returned. In this case, the response from SELECT would contain a ScanCount of 100 and a Count of 15 returned rows. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • Minimum • Maximum • Average • SampleCount • Sum

Metric	Description
StoragePartitionThroughputCapacityExceeded	Requests to an Amazon Keyspaces storage partition that exceed the throughput capacity of the partition. Amazon Keyspaces storage partitions can support up to 1000 WCU/WRU per second and 3000 RCU/RRU per second. We recommend reviewing your data model to distribute read/write traffic across more partitions to mitigate these exceptions. **Note** Logical Amazon Keyspaces partitions can span multiple storage partitions and are virtually unbounded in size. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • SampleCount • Sum
SuccessfulRequestCount	The number of successful requests processed over the specified time period. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • SampleCount

Metric	Description
SuccessfulRequestLatency	The successful requests to Amazon Keyspaces during the specified time period. SuccessfulRequestLatency can provide two different kinds of information: • The elapsed time for successful requests (Minimum, Maximum, Sum, or Average). • The number of successful requests (SampleCount). SuccessfulRequestLatency reflects activity only within Amazon Keyspaces and doesn't take network latency or client-side activity into account. Units: Milliseconds Dimensions: Keyspace, TableName, Operation Valid Statistics: • Minimum • Maximum • Average • SampleCount
SystemErrors	The requests to Amazon Keyspaces that generate a ServerError during the specified time period. A ServerError usually indicates an internal service error. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • Sum • SampleCount

Metric	Description
SystemReconciliationDeletes	The units consumed to delete tombstoned data when client-side timestamps are enabled. Each SystemReconciliationDelete provides enough capacity to delete or update up to 1KB of data per row. For example, to update a row that stores 2.5 KB of data and to delete one or more columns within the row at the same time requires 3 SystemReconciliationDeletes. Or, to delete an entire row that contains 3.5 KB of data requires 4 SystemReconciliationDeletes. Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Sum – The total number of SystemReconciliationDeletes consumed in a time period.
TTLDeletes	The units consumed to delete or update data in a row by using Time to Live (TTL). Each TTLDelete provides enough capacity to delete or update up to 1KB of data per row. For example, to update a row that stores 2.5 KB of data and to delete one or more columns within the row at the same time requires 3 TTL deletes. Or, to delete an entire row that contains 3.5 KB of data requires 4 TTL deletes. Units: Count Dimensions: Keyspace, TableName Valid Statistics: • Sum – The total number of TTLDeletes consumed in a time period.

Metric	Description
UserErrors	Requests to Amazon Keyspaces that generate an InvalidRequest error during the specified time period. InvalidRequest errors usually represent a client-side error, for example an invalid combination of parameter s, an attempt to update a non-existent table, or an incorrect request signature. UserErrors represent the aggregate of invalid requests for the current AWS Region and the current AWS account. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • Sum • SampleCount
WriteThrottleEvents	Requests to Amazon Keyspaces that exceed the provisioned write capacity for a table, or account level quotas, request per connection quotas, or partition level quotas. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • SampleCount • Sum

Dimensions for Amazon Keyspaces metrics

The metrics for Amazon Keyspaces are qualified by the values for the account, table name, or operation. You can use the CloudWatch console to retrieve Amazon Keyspaces data along any of the dimensions in the following table.

Dimension	Description
`Keyspace`	This dimension limits the data to a specific keyspace. This value can be any keyspace in the current Region and the current AWS account.
`Operation`	This dimension limits the data to one of the Amazon Keyspaces CQL operations, such as `INSERT` or `SELECT` operations.
`TableName`	This dimension limits the data to a specific table. This value can be any table name in the current Region and the current AWS account. If the table name is not unique within the account, you must also specify `Keyspace`.

Metrics for Amazon Keyspaces change data capture (CDC)

The following metrics are available in your CloudWatch account that monitor API calls to the Amazon Keyspaces change data capture (CDC) endpoint.

Metric	Description
`ReturnedRecordsCount`	The number of stream records returned by `GetRecords` operations during the specified time period. Units: `Count` Dimensions: `Keyspace, TableName, Operation` Valid Statistics: • `Minimum` • `Maximum`

Metric	Description
	• Average • SampleCount • Sum
SuccessfulRequestLatency	The successful requests to Amazon Keyspaces during the specified time period. SuccessfulRequestLatency can provide two different kinds of information: • The elapsed time for successful requests (Minimum, Maximum, Sum, or Average). • The number of successful requests (SampleCount). SuccessfulRequestLatency reflects activity only within Amazon Keyspaces CDC APIs and doesn't take network latency or client-side activity into account. Units: Milliseconds Dimensions: Keyspace, TableName, Operation Valid Statistics: • Minimum • Maximum • Average • SampleCount

Metric	Description
SystemErrors	The requests to Amazon Keyspaces CDC that generate a HTTP 500 status code during the specified time period. A HTTP 500 status code usually indicates an internal service error. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • Sum • SampleCount
UserErrors	Requests to Amazon Keyspaces CDC that generate an HTTP 400 status code during the specified time period. UserErrors represents the aggregate of HTTP 400 errors for Amazon Keyspaces CDC in the current AWS Region and the current AWS account. Units: Count Dimensions: Keyspace, TableName, Operation Valid Statistics: • Sum • SampleCount

Dimensions for Amazon Keyspaces change data capture (CDC) metrics

The metrics for Amazon Keyspaces are qualified by the values for the account, table name, or operation. You can use the CloudWatch console to retrieve Amazon Keyspaces data along any of the dimensions in the following table.

Dimension	Description
StreamLabel	This dimension limits the data to a specific change data capture (CDC) stream when KeyspaceName and TableName are specified.
Keyspace	This dimension limits the data to a specific keyspace. This value can be any keyspace in the current Region and the current AWS account.
TableName	This dimension limits the data to a specific table. This value can be any table name in the current Region and the current AWS account. If the table name is not unique within the account, you must also specify Keyspace.
Operation	This dimension limits the data to one of the following Amazon Keyspaces Streams API operations: GetRecords , GetStream GetShardIterator , and ListStreams .

Viewing Amazon Keyspaces metrics in CloudWatch

When you interact with Amazon Keyspaces, it sends the following metrics and dimensions to Amazon CloudWatch. All metrics are aggregated and reported every minute. You can use the following procedures to view the metrics for Amazon Keyspaces.

To view metrics using the CloudWatch console

Metrics are grouped first by the service namespace, and then by the various dimension combinations within each namespace.

1. Open the CloudWatch console at https://console.aws.amazon.com/cloudwatch/.
2. If necessary, change the AWS Region. On the navigation bar, choose the Region where your AWS resources reside. For more information, see AWS service endpoints.
3. In the navigation pane, choose **Metrics**.
4. Under the **All metrics** tab, choose AWS/Cassandra.

To view metrics using the AWS CLI

- At a command prompt, use the following command.

```
aws cloudwatch list-metrics --namespace "AWS/Cassandra"
```

Creating CloudWatch alarms to monitor Amazon Keyspaces

You can create an Amazon CloudWatch alarm for Amazon Keyspaces that sends an Amazon Simple Notification Service (Amazon SNS) message when the alarm changes state. An alarm watches a single metric over a time period that you specify. It performs one or more actions based on the value of the metric relative to a given threshold over a number of time periods. The action is a notification sent to an Amazon SNS topic or an Application Auto Scaling policy.

When you use Amazon Keyspaces in provisioned mode with Application Auto Scaling, the service creates two pairs of CloudWatch alarms on your behalf. Each pair represents your upper and lower boundaries for provisioned and consumed throughput settings. These CloudWatch alarms are triggered when the table's actual utilization deviates from your target utilization for a sustained period of time. To learn more about CloudWatch alarms created by Application Auto Scaling, see the section called “How Amazon Keyspaces automatic scaling works”.

Alarms invoke actions for sustained state changes only. CloudWatch alarms do not invoke actions simply because they are in a particular state. The state must have changed and been maintained for a specified number of periods.

For more information about creating CloudWatch alarms, see Using Amazon CloudWatch alarms in the *Amazon CloudWatch User Guide*.

Logging Amazon Keyspaces API calls with AWS CloudTrail

Amazon Keyspaces is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Amazon Keyspaces. CloudTrail captures Data Definition Language (DDL) API calls and Data Manipulation Language (DML) API calls for Amazon Keyspaces as events. The calls that are captured include calls from the Amazon Keyspaces console and programmatic calls to the Amazon Keyspaces API operations.

If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon Simple Storage Service (Amazon S3) bucket, including events for Amazon Keyspaces.

If you don't configure a trail, you can still view the most recent supported events on the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to Amazon Keyspaces, 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.

Topics

- Configuring Amazon Keyspaces log file entries in CloudTrail
- Amazon Keyspaces Data Definition Language (DDL) information in CloudTrail
- Amazon Keyspaces Data Manipulation Language (DML) information in CloudTrail
- Understanding Amazon Keyspaces log file entries

Configuring Amazon Keyspaces log file entries in CloudTrail

Each Amazon Keyspaces API action logged in CloudTrail includes request parameters that are expressed in CQL query language. For more information, see the *CQL language reference*.

You can view, search, and download recent events in your AWS account. For more information, see Viewing events with CloudTrail event history.

For an ongoing record of events in your AWS account, including events for Amazon Keyspaces, 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 topics in the *AWS CloudTrail User Guide*:

- Overview for creating a trail
- CloudTrail supported services and integrations
- Configuring Amazon SNS notifications for CloudTrail
- Receiving CloudTrail log files from multiple Regions
- Receiving CloudTrail log files from multiple accounts

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.

Amazon Keyspaces Data Definition Language (DDL) information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When a DDL activity occurs in Amazon Keyspaces, that activity is automatically recorded as a CloudTrail event along with other AWS service events in **Event history**. The following table shows the DDL statements that are logged for Amazon Keyspaces.

CloudTrail `eventName`	Statement	CQL action	AWS SDK action
CreateKeyspace	DDL	`CREATE KEYSPACE`	`CreateKeyspace`
AlterKeyspace	DDL	`ALTER KEYSPACE`	`UpdateKeyspace`
DropKeyspace	DDL	`DROP KEYSPACE`	`DeleteKeyspace`
CreateTable	DDL	`CREATE TABLE`	`CreateTable`
DropTable	DDL	`DROP TABLE`	`DeleteTable`
AlterTable	DDL	`ALTER TABLE`	`UpdateTable` , `TagResource` , `UntagResource`
CreateUdt	DDL	`CREATE TYPE`	`CreateType`
DropUdt	DDL	`DROP TYPE`	`DeleteType`

CloudTrail eventName	Statement	CQL action	AWS SDK action
GetStream	DDL	no CQL action available	`GetStream`
ListStreams	DDL	no CQL action available	`ListStreams`

Amazon Keyspaces Data Manipulation Language (DML) information in CloudTrail

To enable logging of Amazon Keyspaces DML statements with CloudTrail, you have to first enable logging of data plane API activity in CloudTrail. You can start logging Amazon Keyspaces DML events in new or existing trails by choosing to log activity for the **data event type Cassandra table** using the CloudTrail console, or by setting the `resources.type` value to `AWS::Cassandra::Table` using the AWS CLI, or CloudTrail API operations. For more information, see Logging data events.

For more information and an example that shows how to create alarms for data events, see the following post on the AWS Database blog Using DML auditing for Amazon Keyspaces (for Apache Cassandra).

The following table shows the data events that are logged by CloudTrail for `Cassandra table`.

CloudTrail eventName	Statement	CQL action	AWS SDK actions
Select	DML	`SELECT`	`GetKeyspace , GetTable, GetType, ListKeyspaces ,ListTables ,ListTypes ,ListTagsForResource`

CloudTrail eventName	Statement	CQL action	AWS SDK actions
Insert	DML	INSERT	no AWS SDK actions available
Update	DML	UPDATE	no AWS SDK actions available
Delete	DML	DELETE	no AWS SDK actions available
GetShardIterator	DML	no CQL action available	GetShardIterator
GetRecords	DML	no CQL action available	GetRecords

Understanding Amazon Keyspaces log file entries

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 example shows a CloudTrail log entry that demonstrates the `CreateKeyspace`, `DropKeyspace`, `CreateTable`, and `DropTable` actions:

```
{
  "Records": [
    {
      "eventVersion": "1.05",
      "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AKIAIOSFODNN7EXAMPLE:alice",
        "arn": "arn:aws:sts::111122223333:assumed-role/users/alice",
        "accountId": "111122223333",
        "sessionContext": {
          "sessionIssuer": {
            "type": "Role",
```

```
            "principalId": "AKIAIOSFODNN7EXAMPLE",
            "arn": "arn:aws:iam::111122223333:role/Admin",
            "accountId": "111122223333",
            "userName": "Admin"
          },
          "webIdFederationData": {},
          "attributes": {
            "mfaAuthenticated": "false",
            "creationDate": "2020-01-15T18:47:56Z"
          }
        }
      },
      "eventTime": "2020-01-15T18:53:04Z",
      "eventSource": "cassandra.amazonaws.com",
      "eventName": "CreateKeyspace",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "10.24.34.01",
      "userAgent": "Cassandra Client/ProtocolV4",
      "requestParameters": {
        "rawQuery": "\n\tCREATE KEYSPACE \"mykeyspace\"\n\tWITH\n\t\tREPLICATION =
{'class': 'SingleRegionStrategy'}\n\t\t",
        "keyspaceName": "mykeyspace"
      },
      "responseElements": null,
      "requestID": "bfa3e75d-bf4d-4fc0-be5e-89d15850eb41",
      "eventID": "d25beae8-f611-4229-877a-921557a07bb9",
      "readOnly": false,
      "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Keyspace",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/"
        }
      ],
      "eventType": "AwsApiCall",
      "apiVersion": "3.4.4",
      "recipientAccountId": "111122223333",
      "managementEvent": true,
      "eventCategory": "Management",
      "tlsDetails": {
          "tlsVersion": "TLSv1.2",
          "cipherSuite": "ECDHE-RSA-AES128-GCM-SHA256",
          "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    },
```

```
    {
      "eventVersion": "1.05",
      "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AKIAIOSFODNN7EXAMPLE:alice",
        "arn": "arn:aws:sts::111122223333:assumed-role/users/alice",
        "accountId": "111122223333",
        "sessionContext": {
          "sessionIssuer": {
            "type": "Role",
            "principalId": "AKIAIOSFODNN7EXAMPLE",
            "arn": "arn:aws:iam::111122223333:role/Admin",
            "accountId": "111122223333",
            "userName": "Admin"
          },
          "webIdFederationData": {},
          "attributes": {
            "mfaAuthenticated": "false",
            "creationDate": "2020-01-15T18:47:56Z"
          }
        }
      },
      "eventTime": "2020-01-15T19:28:39Z",
      "eventSource": "cassandra.amazonaws.com",
      "eventName": "DropKeyspace",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "10.24.34.01",
      "userAgent": "Cassandra Client/ProtocolV4",
      "requestParameters": {
        "rawQuery": "DROP KEYSPACE \"mykeyspace\"",
        "keyspaceName": "mykeyspace"
      },
      "responseElements": null,
      "requestID": "66f3d86a-56ae-4c29-b46f-abcd489ed86b",
      "eventID": "e5aebeac-e1dd-41e3-a515-84fe6aaabd7b",
      "readOnly": false,
      "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Keyspace",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/"
        }
      ],
      "eventType": "AwsApiCall",
```

```
      "apiVersion": "3.4.4",
      "recipientAccountId": "111122223333",
      "managementEvent": true,
      "eventCategory": "Management",
      "tlsDetails": {
          "tlsVersion": "TLSv1.2",
          "cipherSuite": "ECDHE-RSA-AES128-GCM-SHA256",
          "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    },
    {
      "eventVersion": "1.05",
      "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AKIAIOSFODNN7EXAMPLE:alice",
        "arn": "arn:aws:sts::111122223333:assumed-role/users/alice",
        "accountId": "111122223333",
        "sessionContext": {
          "sessionIssuer": {
            "type": "Role",
            "principalId": "AKIAIOSFODNN7EXAMPLE",
            "arn": "arn:aws:iam::111122223333:role/Admin",
            "accountId": "111122223333",
            "userName": "Admin"
          },
          "webIdFederationData": {},
          "attributes": {
            "mfaAuthenticated": "false",
            "creationDate": "2020-01-15T18:47:56Z"
          }
        }
      },
      "eventTime": "2020-01-15T18:55:24Z",
      "eventSource": "cassandra.amazonaws.com",
      "eventName": "CreateTable",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "10.24.34.01",
      "userAgent": "Cassandra Client/ProtocolV4",
      "requestParameters": {
        "rawQuery": "\n\tCREATE TABLE \"mykeyspace\".\"mytable\"(\n\t\t\"ID\" int,
\n\t\t\"username\" text,\n\t\t\"email\" text,\n\t\t\"post_type\" text,\n\t\tPRIMARY
 KEY((\"ID\", \"username\", \"email\")))",
        "keyspaceName": "mykeyspace",
        "tableName": "mytable"
      },
```

```
      "responseElements": null,
      "requestID": "5f845963-70ea-4988-8a7a-2e66d061aacb",
      "eventID": "fe0dbd2b-7b34-4675-a30c-740f9d8d73f9",
      "readOnly": false,
      "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Table",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable"
        }
      ],
      "eventType": "AwsApiCall",
      "apiVersion": "3.4.4",
      "recipientAccountId": "111122223333",
      "managementEvent": true,
      "eventCategory": "Management",
      "tlsDetails": {
          "tlsVersion": "TLSv1.2",
          "cipherSuite": "ECDHE-RSA-AES128-GCM-SHA256",
          "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    },
    {
      "eventVersion": "1.05",
      "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AKIAIOSFODNN7EXAMPLE:alice",
        "arn": "arn:aws:sts::111122223333:assumed-role/users/alice",
        "accountId": "111122223333",
        "sessionContext": {
          "sessionIssuer": {
            "type": "Role",
            "principalId": "AKIAIOSFODNN7EXAMPLE",
            "arn": "arn:aws:iam::111122223333:role/Admin",
            "accountId": "111122223333",
            "userName": "Admin"
          },
          "webIdFederationData": {},
          "attributes": {
            "mfaAuthenticated": "false",
            "creationDate": "2020-01-15T18:47:56Z"
          }
        }
      },
```

```
      "eventTime": "2020-01-15T19:27:59Z",
      "eventSource": "cassandra.amazonaws.com",
      "eventName": "DropTable",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "10.24.34.01",
      "userAgent": "Cassandra Client/ProtocolV4",
      "requestParameters": {
        "rawQuery": "DROP TABLE \"mykeyspace\".\"mytable\"",
        "keyspaceName": "mykeyspace",
        "tableName": "mytable"
      },
      "responseElements": null,
      "requestID": "025501b0-3582-437e-9d18-8939e9ef262f",
      "eventID": "1a5cbedc-4e38-4889-8475-3eab98de0ffd",
      "readOnly": false,
      "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Table",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable"
        }
      ],
      "eventType": "AwsApiCall",
      "apiVersion": "3.4.4",
      "recipientAccountId": "111122223333",
      "managementEvent": true,
      "eventCategory": "Management",
      "tlsDetails": {
          "tlsVersion": "TLSv1.2",
          "cipherSuite": "ECDHE-RSA-AES128-GCM-SHA256",
          "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    }
  ]
}
```

The following log file shows an example of a SELECT statement.

```
{
    "eventVersion": "1.09",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AKIAIOSFODNN7EXAMPLE",
```

```
        "arn": "arn:aws:iam::111122223333:user/alice",
        "accountId": "111122223333",
        "userName": "alice"
    },
    "eventTime": "2023-11-17T10:38:04Z",
    "eventSource": "cassandra.amazonaws.com",
    "eventName": "Select",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "10.24.34.01",
    "userAgent": "Cassandra Client/ProtocolV4",
    "requestParameters": {
          "keyspaceName": "my_keyspace",
          "tableName": "my_table",
          "conditions": [
              "pk = **(Redacted)",
              "ck < 3**(Redacted)0",
              "region = 't**(Redacted)t'"
          ],
          "select": [
              "pk",
              "ck",
              "region"
          ],
          "allowFiltering": true
    },
    "responseElements": null,
    "requestID": "6d83bbf0-a3d0-4d49-b1d9-e31779a28628",
    "eventID": "e00552d3-34e9-4092-931a-912c4e08ba17",
    "readOnly": true,
    "resources": [
        {
            "accountId": "111122223333",
            "type": "AWS::Cassandra::Table",
            "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/
table/my_table"
        }
    ],
    "eventType": "AwsApiCall",
    "apiVersion": "3.4.4",
    "managementEvent": false,
    "recipientAccountId": "111122223333",
    "eventCategory": "Data",
    "tlsDetails": {
        "tlsVersion": "TLSv1.3",
```

```
        "cipherSuite": "TLS_AES_128_GCM_SHA256",
        "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    }
}
```

The following log file shows an example of an `INSERT` statement.

```
{
    "eventVersion": "1.09",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AKIAIOSFODNN7EXAMPLE",
        "arn": "arn:aws:iam::111122223333:user/alice",
        "accountId": "111122223333",
        "userName": "alice"
    },
    "eventTime": "2023-12-01T22:11:43Z",
    "eventSource": "cassandra.amazonaws.com",
    "eventName": "Insert",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "10.24.34.01",
    "userAgent": "Cassandra Client/ProtocolV4",
    "requestParameters": {
          "keyspaceName": "my_keyspace",
          "tableName": "my_table",
          "primaryKeys": {
              "pk": "**(Redacted)",
              "ck": "1**(Redacted)8"
          },
          "columnNames": [
              "pk",
              "ck",
              "region"
          ],
          "updateParameters": {
              "TTL": "2**(Redacted)0"
          }
      }
    },
    "responseElements": null,
    "requestID": "edf8af47-2f87-4432-864d-a960ac35e471",
    "eventID": "81b56a1c-9bdd-4c92-bb8e-92776b5a3bf1",
    "readOnly": false,
```

```
    "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Table",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/table/
my_table"
        }
    ],
    "eventType": "AwsApiCall",
    "apiVersion": "3.4.4",
    "managementEvent": false,
    "recipientAccountId": "111122223333",
    "eventCategory": "Data",
    "tlsDetails": {
        "tlsVersion": "TLSv1.3",
        "cipherSuite": "TLS_AES_128_GCM_SHA256",
        "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    }
}
```

The following log file shows an example of an UPDATE statement.

```
{
    "eventVersion": "1.09",
    "userIdentity": {
          "type": "IAMUser",
          "principalId": "AKIAIOSFODNN7EXAMPLE",
          "arn": "arn:aws:iam::111122223333:user/alice",
          "accountId": "111122223333",
          "userName": "alice"
    },
    "eventTime": "2023-12-01T22:11:43Z",
    "eventSource": "cassandra.amazonaws.com",
    "eventName": "Update",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "10.24.34.01",
    "userAgent": "Cassandra Client/ProtocolV4",
    "requestParameters": {
          "keyspaceName": "my_keyspace",
          "tableName": "my_table",
          "primaryKeys": {
              "pk": "'t**(Redacted)t'",
              "ck": "'s**(Redacted)g'"
```

```
          },
          "assignmentColumnNames": [
             "nonkey"
          ],
          "conditions": [
              "nonkey < 1**(Redacted)7"
          ]
    },
    "responseElements": null,
    "requestID": "edf8af47-2f87-4432-864d-a960ac35e471",
    "eventID": "81b56a1c-9bdd-4c92-bb8e-92776b5a3bf1",
    "readOnly": false,
    "resources": [
        {
          "accountId": "111122223333",
          "type": "AWS::Cassandra::Table",
          "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/table/
my_table"
        }
    ],
    "eventType": "AwsApiCall",
    "apiVersion": "3.4.4",
    "managementEvent": false,
    "recipientAccountId": "111122223333",
    "eventCategory": "Data",
    "tlsDetails": {
          "tlsVersion": "TLSv1.3",
          "cipherSuite": "TLS_AES_128_GCM_SHA256",
          "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    }
}
```

The following log file shows an example of a DELETE statement.

```
{
    "eventVersion": "1.09",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AKIAIOSFODNN7EXAMPLE",
        "arn": "arn:aws:iam::111122223333:user/alice",
        "accountId": "111122223333",
        "userName": "alice",
    },
```

```
    "eventTime": "2023-10-23T13:59:05Z",
    "eventSource": "cassandra.amazonaws.com",
    "eventName": "Delete",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "10.24.34.01",
    "userAgent": "Cassandra Client/ProtocolV4",
    "requestParameters": {
        "keyspaceName": "my_keyspace",
        "tableName": "my_table",
        "primaryKeys": {
            "pk": "**(Redacted)",
            "ck": "**(Redacted)"
        },
        "conditions": [],
        "deleteColumnNames": [
            "m",
            "s"
        ],
        "updateParameters": {}
    },
    "responseElements": null,
    "requestID": "3d45e63b-c0c8-48e2-bc64-31afc5b4f49d",
    "eventID": "499da055-c642-4762-8775-d91757f06512",
    "readOnly": false,
    "resources": [
      {
        "accountId": "111122223333",
        "type": "AWS::Cassandra::Table",
        "ARN": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/my_keyspace/table/
my_table"
      }
    ],
    "eventType": "AwsApiCall",
    "apiVersion": "3.4.4",
    "managementEvent": false,
    "recipientAccountId": "111122223333",
    "eventCategory": "Data",
    "tlsDetails": {
        "tlsVersion": "TLSv1.3",
        "cipherSuite": "TLS_AES_128_GCM_SHA256",
        "clientProvidedHostHeader": "cassandra.us-east-1.amazonaws.com"
    }
}
```

Security in Amazon Keyspaces (for Apache Cassandra)

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that is built to meet the requirements of the most security-sensitive organizations.

Security is a shared responsibility between AWS and you. The shared responsibility model describes this as security *of* the cloud and security *in* the cloud:

- **Security of the cloud** – AWS is responsible for protecting the infrastructure that runs AWS services in the AWS Cloud. AWS also provides you with services that you can use securely. The effectiveness of our security is regularly tested and verified by third-party auditors as part of the AWS compliance programs. To learn about the compliance programs that apply to Amazon Keyspaces, see AWS Services in scope by compliance program.
- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your organization's requirements, and applicable laws and regulations.

This documentation will help you understand how to apply the shared responsibility model when using Amazon Keyspaces. The following topics show you how to configure Amazon Keyspaces to meet your security and compliance objectives. You'll also learn how to use other AWS services that can help you to monitor and secure your Amazon Keyspaces resources.

Topics

- Data protection in Amazon Keyspaces
- AWS Identity and Access Management for Amazon Keyspaces
- Compliance validation for Amazon Keyspaces (for Apache Cassandra)
- Resilience and disaster recovery in Amazon Keyspaces
- Infrastructure security in Amazon Keyspaces
- Configuration and vulnerability analysis for Amazon Keyspaces
- Security best practices for Amazon Keyspaces

Data protection in Amazon Keyspaces

The AWS shared responsibility model applies to data protection in Amazon Keyspaces (for Apache Cassandra). As described in this model, AWS is responsible for protecting the global infrastructure that runs all of the AWS Cloud. You are responsible for maintaining control over your content that is hosted on this infrastructure. You are also responsible for the security configuration and management tasks for the AWS services that you use. For more information about data privacy, see Data Privacy FAQ. For information about data protection in Europe, see the General Data Protection Regulation (GDPR) Center.

For data protection purposes, we recommend that you protect AWS account credentials and set up individual users with AWS IAM Identity Center or AWS Identity and Access Management (IAM). That way, each user is given only the permissions necessary to fulfill their job duties. We also recommend that you secure your data in the following ways:

- Use multi-factor authentication (MFA) with each account.
- Use SSL/TLS to communicate with AWS resources. We require TLS 1.2 and recommend TLS 1.3.
- Set up API and user activity logging with AWS CloudTrail. For information about using CloudTrail trails to capture AWS activities, see Working with CloudTrail trails in the *AWS CloudTrail User Guide*.
- Use AWS encryption solutions, along with all default security controls within AWS services.
- Use advanced managed security services such as Amazon Macie, which assists in discovering and securing sensitive data that is stored in Amazon S3.
- If you require FIPS 140-3 validated cryptographic modules when accessing AWS through a command line interface or an API, use a FIPS endpoint. For more information about the available FIPS endpoints, see Federal Information Processing Standard (FIPS) 140-3.

We strongly recommend that you never put confidential or sensitive information, such as your customers' email addresses, into tags or free-form text fields such as a **Name** field. This includes when you work with Amazon Keyspaces or other AWS services using the console, API, AWS CLI, or AWS SDKs. Any data that you enter into tags or free-form text fields used for names may be used for billing or diagnostic logs. If you provide a URL to an external server, we strongly recommend that you do not include credentials information in the URL to validate your request to that server.

Topics

- Encryption at rest in Amazon Keyspaces

- Encryption in transit in Amazon Keyspaces
- Internetwork traffic privacy in Amazon Keyspaces

Encryption at rest in Amazon Keyspaces

Amazon Keyspaces (for Apache Cassandra) *encryption at rest* provides enhanced security by encrypting all your data at rest using encryption keys stored in AWS Key Management Service (AWS KMS). This functionality helps reduce the operational burden and complexity involved in protecting sensitive data. With encryption at rest, you can build security-sensitive applications that meet strict compliance and regulatory requirements for data protection.

Amazon Keyspaces encryption at rest encrypts your data using 256-bit Advanced Encryption Standard (AES-256). This helps secure your data from unauthorized access to the underlying storage.

Amazon Keyspaces encrypts and decrypts the data in tables and streams transparently. Amazon Keyspaces uses envelope encryption and a key hierarchy to protect data encryption keys. It integrates with AWS KMS for storing and managing the root encryption key. For more information about the encryption key hierarchy, see the section called “How it works”. For more information about AWS KMS concepts like envelope encryption, see AWS KMS management service concepts in the *AWS Key Management Service Developer Guide*.

When creating a new table, you can choose one of the following *AWS KMS keys (KMS keys)*:

- AWS owned key – This is the default encryption type. The key is owned by Amazon Keyspaces (no additional charge).
- Customer managed key – This key is stored in your account and is created, owned, and managed by you. You have full control over the customer managed key (AWS KMS charges apply).

Amazon Keyspaces automatically encrypts change data capture (CDC) streams with the same key as the underlying table. For more information about CDC, see the section called “Working with CDC streams”.

You can switch between the AWS owned key and the customer managed key at any given time. You can specify a customer managed key when you create a new table or change the KMS key of an existing table by using the console or programmatically using CQL statements. To learn how, see Encryption at rest: How to use customer managed keys to encrypt tables in Amazon Keyspaces.

Encryption at rest using the default option of AWS owned keys is offered at no additional charge. However, AWS KMS charges apply for customer managed keys. For more information about pricing, see AWS KMS pricing.

Amazon Keyspaces encryption at rest is available in all AWS Regions, including the AWS China (Beijing) and AWS China (Ningxia) Regions. For more information, see Encryption at rest: How it works in Amazon Keyspaces.

Topics

- Encryption at rest: How it works in Amazon Keyspaces
- Encryption at rest: How to use customer managed keys to encrypt tables in Amazon Keyspaces

Encryption at rest: How it works in Amazon Keyspaces

Amazon Keyspaces (for Apache Cassandra) *encryption at rest* encrypts your data using the 256-bit Advanced Encryption Standard (AES-256). This helps secure your data from unauthorized access to the underlying storage. All customer data in Amazon Keyspaces tables is encrypted at rest by default, and server-side encryption is transparent, which means that changes to applications aren't required.

Encryption at rest integrates with AWS Key Management Service (AWS KMS) for managing the encryption key that is used to encrypt your tables. When creating a new table or updating an existing table, you can choose one of the following *AWS KMS key* options:

- AWS owned key – This is the default encryption type. The key is owned by Amazon Keyspaces (no additional charge).
- Customer managed key – This key is stored in your account and is created, owned, and managed by you. You have full control over the customer managed key (AWS KMS charges apply).

AWS KMS key (KMS key)

Encryption at rest protects all your Amazon Keyspaces data with a AWS KMS key. By default, Amazon Keyspaces uses an AWS owned key, a multi-tenant encryption key that is created and managed in an Amazon Keyspaces service account.

However, you can encrypt your Amazon Keyspaces tables using a customer managed key in your AWS account. You can select a different KMS key for each table in a keyspace. The KMS key you select for a table is also used to encrypt all its metadata and restorable backups.

You select the KMS key for a table when you create or update the table. You can change the KMS key for a table at any time, either in the Amazon Keyspaces console or by using the ALTER TABLE statement. The process of switching KMS keys is seamless, and doesn't require downtime or cause service degradation.

Key hierarchy

Amazon Keyspaces uses a key hierarchy to encrypt data. In this key hierarchy, the KMS key is the root key. It's used to encrypt and decrypt the Amazon Keyspaces table encryption key. The table encryption key is used to encrypt the encryption keys used internally by Amazon Keyspaces to encrypt and decrypt data when performing read and write operations.

With the encryption key hierarchy, you can make changes to the KMS key without having to reencrypt data or impacting applications and ongoing data operations.

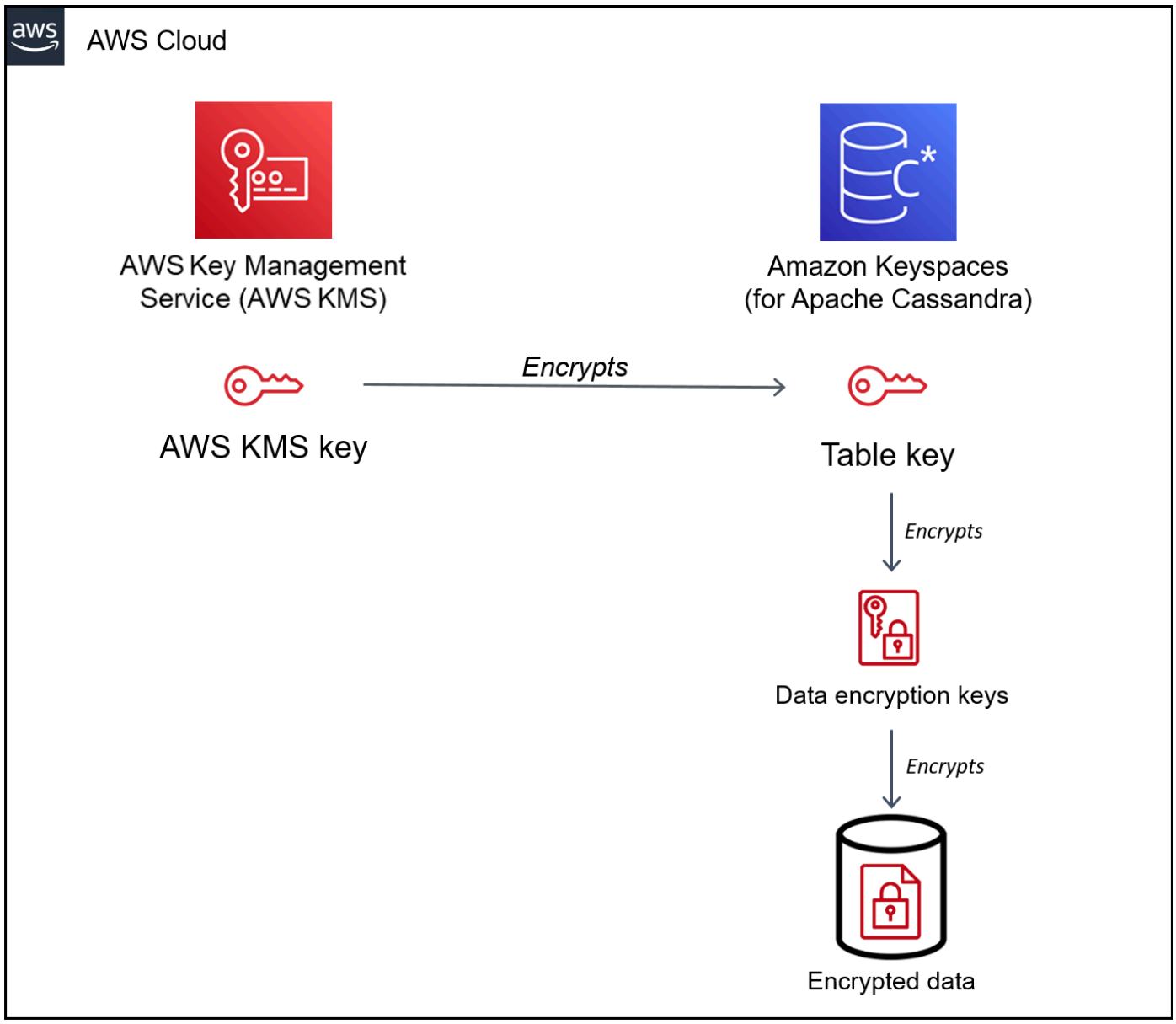


Table key

The Amazon Keyspaces table key is used as a key encryption key. Amazon Keyspaces uses the table key to protect the internal data encryption keys that are used to encrypt the data stored in tables, log files, and restorable backups. Amazon Keyspaces generates a unique data encryption key for each underlying structure in a table. However, multiple table rows might be protected by the same data encryption key.

When you first set the KMS key to a customer managed key, AWS KMS generates a *data key*. The AWS KMS data key refers to the table key in Amazon Keyspaces.

When you access an encrypted table, Amazon Keyspaces sends a request to AWS KMS to use the KMS key to decrypt the table key. Then, it uses the plaintext table key to decrypt the Amazon Keyspaces data encryption keys, and it uses the plaintext data encryption keys to decrypt table data.

Amazon Keyspaces uses and stores the table key and data encryption keys outside of AWS KMS. It protects all keys with Advanced Encryption Standard (AES) encryption and 256-bit encryption keys. Then, it stores the encrypted keys with the encrypted data so that they're available to decrypt the table data on demand.

Table key caching

To avoid calling AWS KMS for every Amazon Keyspaces operation, Amazon Keyspaces caches the plaintext table keys for each connection in memory. If Amazon Keyspaces gets a request for the cached table key after five minutes of inactivity, it sends a new request to AWS KMS to decrypt the table key. This call captures any changes made to the access policies of the KMS key in AWS KMS or AWS Identity and Access Management (IAM) since the last request to decrypt the table key.

Envelope encryption

If you change the customer managed key for your table, Amazon Keyspaces generates a new table key. Then, it uses the new table key to reencrypt the data encryption keys. It also uses the new table key to encrypt previous table keys that are used to protect restorable backups. This process is called envelope encryption. This ensures that you can access restorable backups even if you rotate the customer managed key. For more information about envelope encryption, see Envelope Encryption in the *AWS Key Management Service Developer Guide*.

Topics

- AWS owned keys
- Customer managed keys
- Encryption at rest usage notes

AWS owned keys

AWS owned keys aren't stored in your AWS account. They are part of a collection of KMS keys that AWS owns and manages for use in multiple AWS accounts. AWS services can use AWS owned keys to protect your data.

You can't view, manage, or use AWS owned keys, or audit their use. However, you don't need to do any work or change any programs to protect the keys that encrypt your data.

You aren't charged a monthly fee or a usage fee for use of AWS owned keys, and they don't count against AWS KMS quotas for your account.

Customer managed keys

Customer managed keys are keys in your AWS account that you create, own, and manage. You have full control over these KMS keys.

Use a customer managed key to get the following features:

- You create and manage the customer managed key, including setting and maintaining the key policies, IAM policies, and grants to control access to the customer managed key. You can enable and disable the customer managed key, enable and disable automatic key rotation, and schedule the customer managed key for deletion when it is no longer in use. You can create tags and aliases for the customer managed keys you manage.
- You can use a customer managed key with imported key material or a customer managed key in a custom key store that you own and manage.
- You can use AWS CloudTrail and Amazon CloudWatch Logs to track the requests that Amazon Keyspaces sends to AWS KMS on your behalf. For more information, see the section called “Step 6: Configure monitoring with AWS CloudTrail”.

Customer managed keys incur a charge for each API call, and AWS KMS quotas apply to these KMS keys. For more information, see AWS KMS resource or request quotas.

When you specify a customer managed key as the root encryption key for a table, restorable backups are encrypted with the same encryption key that is specified for the table at the time the backup is created. If the KMS key for the table is rotated, key enveloping ensures that the latest KMS key has access to all restorable backups.

Amazon Keyspaces must have access to your customer managed key to provide you access to your table data. If the state of the encryption key is set to disabled or it's scheduled for deletion, Amazon Keyspaces is unable to encrypt or decrypt data. As a result, you are not able to perform read and write operations on the table. As soon as the service detects that your encryption key is inaccessible, Amazon Keyspaces sends an email notification to alert you.

You must restore access to your encryption key within seven days or Amazon Keyspaces deletes your table automatically. As a precaution, Amazon Keyspaces creates a restorable backup of your table data before deleting the table. Amazon Keyspaces maintains the restorable backup for 35 days. After 35 days, you can no longer restore your table data. You aren't billed for the restorable backup, but standard restore charges apply.

You can use this restorable backup to restore your data to a new table. To initiate the restore, the last customer managed key used for the table must be enabled, and Amazon Keyspaces must have access to it.

> **Note**
>
> When you're creating a table that's encrypted using a customer managed key that's inaccessible or scheduled for deletion before the creation process completes, an error occurs. The create table operation fails, and you're sent an email notification.

Encryption at rest usage notes

Consider the following when you're using encryption at rest in Amazon Keyspaces.

- Server-side encryption at rest is enabled on all Amazon Keyspaces tables and can't be disabled. The entire table is encrypted at rest, you can't select specific columns or rows for encryption.
- By default, Amazon Keyspaces uses a single-service default key (AWS owned key) for encrypting all of your tables. If this key doesn’t exist, it's created for you. Service default keys can't be disabled.
- Encryption at rest only encrypts data while it's static (at rest) on a persistent storage media. If data security is a concern for data in transit or data in use, you must take additional measures:
  - Data in transit: All your data in Amazon Keyspaces is encrypted in transit. By default, communications to and from Amazon Keyspaces are protected by using Secure Sockets Layer (SSL)/Transport Layer Security (TLS) encryption.
  - Data in use: Protect your data before sending it to Amazon Keyspaces by using client-side encryption.
  - Customer managed keys: Data at rest in your tables is always encrypted using your customer managed keys. However operations that perform atomic updates of multiple rows encrypt data temporarily using AWS owned keys during processing. This includes range delete operations and operations that simultaneously access static and non-static data.

- A single customer managed key can have up to 50,000 grants. Every Amazon Keyspaces table associated with a customer managed key consumes 2 grants. One grant is released when the table is deleted. The second grant is used to create an automatic snapshot of the table to protect from data loss in case Amazon Keyspaces lost access to the customer managed key unintentionally. This grant is released 42 days after deletion of the table.

Encryption at rest: How to use customer managed keys to encrypt tables in Amazon Keyspaces

You can use the console or CQL statements to specify the AWS KMS key for new tables and update the encryption keys of existing tables in Amazon Keyspaces. The following topic outlines how to implement customer managed keys for new and existing tables.

Topics

- Prerequisites: Create a customer managed key using AWS KMS and grant permissions to Amazon Keyspaces
- Step 3: Specify a customer managed key for a new table
- Step 4: Update the encryption key of an existing table
- Step 5: Use the Amazon Keyspaces encryption context in logs
- Step 6: Configure monitoring with AWS CloudTrail

Prerequisites: Create a customer managed key using AWS KMS and grant permissions to Amazon Keyspaces

Before you can protect an Amazon Keyspaces table with a customer managed key, you must first create the key in AWS Key Management Service (AWS KMS) and then authorize Amazon Keyspaces to use that key.

Step 1: Create a customer managed key using AWS KMS

To create a customer managed key to be used to protect an Amazon Keyspaces table, you can follow the steps in Creating symmetric encryption KMS keys using the console or the AWS API.

Step 2: Authorize the use of your customer managed key

Before you can choose a customer managed key to protect an Amazon Keyspaces table, the policies on that customer managed key must give Amazon Keyspaces permission to use it on your behalf.

You have full control over the policies and grants on the customer managed key. You can provide these permissions in a key policy, an IAM policy, or a grant.

Amazon Keyspaces doesn't need additional authorization to use the default AWS owned key to protect the Amazon Keyspaces tables in your AWS account.

The following topics show how to configure the required permissions using IAM policies and grants that allow Amazon Keyspaces tables to use a customer managed key.

Topics

- Key policy for customer managed keys
- Example key policy
- Using grants to authorize Amazon Keyspaces

Key policy for customer managed keys

When you select a customer managed key to protect an Amazon Keyspaces table, Amazon Keyspaces gets permission to use the customer managed key on behalf of the principal who makes the selection. That principal, a user or role, must have the permissions on the customer managed key that Amazon Keyspaces requires.

At a minimum, Amazon Keyspaces requires the following permissions on a customer managed key:

- kms:Encrypt
- kms:Decrypt
- kms:ReEncrypt* (for kms:ReEncryptFrom and kms:ReEncryptTo)
- kms:GenerateDataKey* (for kms:GenerateDataKey and kms:GenerateDataKeyWithoutPlaintext)
- kms:DescribeKey
- kms:CreateGrant

Example key policy

For example, the following example key policy provides only the required permissions. The policy has the following effects:

- Allows Amazon Keyspaces to use the customer managed key in cryptographic operations and create grants—but only when it's acting on behalf of principals in the account who have

permission to use Amazon Keyspaces. If the principals specified in the policy statement don't have permission to use Amazon Keyspaces, the call fails, even when it comes from the Amazon Keyspaces service.

- The kms:ViaService condition key allows the permissions only when the request comes from Amazon Keyspaces on behalf of the principals listed in the policy statement. These principals can't call these operations directly. Note that the `kms:ViaService` value, `cassandra.*.amazonaws.com`, has an asterisk (*) in the Region position. Amazon Keyspaces requires the permission to be independent of any particular AWS Region.
- Gives the customer managed key administrators (users who can assume the `db-team` role) read-only access to the customer managed key and permission to revoke grants, including the grants that Amazon Keyspaces requires to protect the table.
- Gives Amazon Keyspaces read-only access to the customer managed key. In this case, Amazon Keyspaces can call these operations directly. It doesn't have to act on behalf of an account principal.

Before using an example key policy, replace the example principals with actual principals from your AWS account.

```
{
  "Id": "key-policy-cassandra",
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid" : "Allow access through Amazon Keyspaces for all principals in the account
 that are authorized to use Amazon Keyspaces",
      "Effect": "Allow",
      "Principal": {"AWS": "arn:aws:iam::111122223333:user/db-lead"},
      "Action": [
        "kms:Encrypt",
        "kms:Decrypt",
        "kms:ReEncrypt*",
        "kms:GenerateDataKey*",
        "kms:DescribeKey",
        "kms:CreateGrant"
      ],
      "Resource": "*",
      "Condition": {
         "StringLike": {
           "kms:ViaService" : "cassandra.*.amazonaws.com"
```

```
          }
        }
      },
      {
        "Sid":  "Allow administrators to view the customer managed key and revoke
 grants",
        "Effect": "Allow",
        "Principal": {
          "AWS": "arn:aws:iam::111122223333:role/db-team"
         },
        "Action": [
          "kms:Describe*",
          "kms:Get*",
          "kms:List*",
          "kms:RevokeGrant"
        ],
        "Resource": "*"
      }
    ]
}
```

Using grants to authorize Amazon Keyspaces

In addition to key policies, Amazon Keyspaces uses grants to set permissions on a customer managed key. To view the grants on a customer managed key in your account, use the ListGrants operation. Amazon Keyspaces doesn't need grants, or any additional permissions, to use the AWS owned key to protect your table.

Amazon Keyspaces uses the grant permissions when it performs background system maintenance and continuous data protection tasks. It also uses grants to generate table keys.

Each grant is specific to a table. If the account includes multiple tables encrypted under the same customer managed key, there is a grant of each type for each table. The grant is constrained by the Amazon Keyspaces encryption context, which includes the table name and the AWS account ID. The grant includes permission to retire the grant if it's no longer needed.

To create the grants, Amazon Keyspaces must have permission to call `CreateGrant` on behalf of the user who created the encrypted table.

The key policy can also allow the account to revoke the grant on the customer managed key. However, if you revoke the grant on an active encrypted table, Amazon Keyspaces will not be able to protect and maintain the table.

Step 3: Specify a customer managed key for a new table

Follow these steps to specify the customer managed key on a new table using the Amazon Keyspaces console or CQL.

Create an encrypted table using a customer managed key (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**, and then choose **Create table**.
3. On the **Create table** page in the **Table details** section, select a keyspace and provide a name for the new table.
4. In the **Schema** section, create the schema for your table.
5. In the **Table settings** section, choose **Customize settings**.
6. Continue to **Encryption settings**.

   In this step, you select the encryption settings for the table.

   In the **Encryption at rest** section under **Choose an AWS KMS key**, choose the option **Choose a different KMS key (advanced)**, and in the search field, choose an AWS KMS key or enter an Amazon Resource Name (ARN).

   > **Note**
   >
   > If the key you selected is not accessible or is missing the required permissions, see Troubleshooting key access in the AWS Key Management Service Developer Guide.

7. Choose **Create** to create the encrypted table.

Create a new table using a customer managed key for encryption at rest (CQL)

To create a new table that uses a customer managed key for encryption at rest, you can use the `CREATE TABLE` statement as shown in the following example. Make sure to replace the key ARN with an ARN for a valid key with permissions granted to Amazon Keyspaces.

```
CREATE TABLE my_keyspace.my_table(id bigint, name text, place text STATIC, PRIMARY
 KEY(id, name)) WITH CUSTOM_PROPERTIES = {
        'encryption_specification':{
```

```
                'encryption_type': 'CUSTOMER_MANAGED_KMS_KEY',
                'kms_key_identifier':'arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111'
            }
    };
```

If you receive an `Invalid Request Exception`, you need to confirm that the customer managed key is valid and Amazon Keyspaces has the required permissions. To confirm that the key has been configured correctly, see Troubleshooting key access in the AWS Key Management Service Developer Guide.

Step 4: Update the encryption key of an existing table

You can also use the Amazon Keyspaces console or CQL to change the encryption keys of an existing table between an AWS owned key and a customer managed KMS key at any time.

Update an existing table with the new customer managed key (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. In the navigation pane, choose **Tables**.
3. Choose the table that you want to update, and then choose the **Additional settings** tab.
4. In the **Encryption at rest** section, choose **Manage Encryption** to edit the encryption settings for the table.

   Under **Choose an AWS KMS key**, choose the option **Choose a different KMS key (advanced)**, and in the search field, choose an AWS KMS key or enter an Amazon Resource Name (ARN).

   > **Note**
   >
   > If the key you selected is not valid, see Troubleshooting key access in the AWS Key Management Service Developer Guide.

   Alternatively, you can choose an AWS owned key for a table that is encrypted with a customer managed key.
5. Choose **Save changes** to save your changes to the table.

Update the encryption key used for an existing table

To change the encryption key of an existing table, you use the `ALTER TABLE` statement to specify a customer managed key for encryption at rest. Make sure to replace the key ARN with an ARN for a valid key with permissions granted to Amazon Keyspaces.

```
ALTER TABLE my_keyspace.my_table WITH CUSTOM_PROPERTIES = {
              'encryption_specification':{
                     'encryption_type': 'CUSTOMER_MANAGED_KMS_KEY',
                     'kms_key_identifier':'arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111'
                   }
         };
```

If you receive an `Invalid Request Exception`, you need to confirm that the customer managed key is valid and Amazon Keyspaces has the required permissions. To confirm that the key has been configured correctly, see Troubleshooting key access in the AWS Key Management Service Developer Guide.

To change the encryption key back to the default encryption at rest option with AWS owned keys, you can use the `ALTER TABLE` statement as shown in the following example.

```
ALTER TABLE my_keyspace.my_table WITH CUSTOM_PROPERTIES = {
                'encryption_specification':{
                      'encryption_type' : 'AWS_OWNED_KMS_KEY'
                    }
         };
```

Step 5: Use the Amazon Keyspaces encryption context in logs

An encryption context is a set of key–value pairs that contain arbitrary nonsecret data. When you include an encryption context in a request to encrypt data, AWS KMS cryptographically binds the encryption context to the encrypted data. To decrypt the data, you must pass in the same encryption context.

Amazon Keyspaces uses the same encryption context in all AWS KMS cryptographic operations. If you use a customer managed key to protect your Amazon Keyspaces table, you can use the encryption context to identify the use of the customer managed key in audit records and logs. It also appears in plaintext in logs, such as in logs for AWS CloudTrail and Amazon CloudWatch Logs.

In its requests to AWS KMS, Amazon Keyspaces uses an encryption context with three key–value pairs.

```
"encryptionContextSubset": {
    "aws:cassandra:keyspaceName": "my_keyspace",
    "aws:cassandra:tableName": "mytable"
    "aws:cassandra:subscriberId": "111122223333"
}
```

- **Keyspace** – The first key–value pair identifies the keyspace that includes the table that Amazon Keyspaces is encrypting. The key is `aws:cassandra:keyspaceName`. The value is the name of the keyspace.

  ```
  "aws:cassandra:keyspaceName": "<keyspace-name>"
  ```

  For example:

  ```
  "aws:cassandra:keyspaceName": "my_keyspace"
  ```

- **Table** – The second key–value pair identifies the table that Amazon Keyspaces is encrypting. The key is `aws:cassandra:tableName`. The value is the name of the table.

  ```
  "aws:cassandra:tableName": "<table-name>"
  ```

  For example:

  ```
  "aws:cassandra:tableName": "my_table"
  ```

- **Account** – The third key–value pair identifies the AWS account. The key is `aws:cassandra:subscriberId`. The value is the account ID.

  ```
  "aws:cassandra:subscriberId": "<account-id>"
  ```

  For example:

  ```
  "aws:cassandra:subscriberId": "111122223333"
  ```

Step 6: Configure monitoring with AWS CloudTrail

If you use a customer managed key to protect your Amazon Keyspaces tables, you can use AWS CloudTrail logs to track the requests that Amazon Keyspaces sends to AWS KMS on your behalf.

The `GenerateDataKey`, `DescribeKey`, `Decrypt`, and `CreateGrant` requests are discussed in this section. In addition, Amazon Keyspaces uses a RetireGrant operation to remove a grant when you delete a table.

> **Note**
>
> When you work with Amazon Keyspaces, some operations may generate CloudTrail events with an `invokedBy` field of `dynamodb.amazonaws.com`. This is expected and occurs because Amazon Keyspaces integrates with Amazon DynamoDB to provide its service.

GenerateDataKey

Amazon Keyspaces creates a unique table key to encrypt data at rest. It sends a GenerateDataKey request to AWS KMS that specifies the KMS key for the table.

The event that records the `GenerateDataKey` operation is similar to the following example event. The user is the Amazon Keyspaces service account. The parameters include the Amazon Resource Name (ARN) of the customer managed key, a key specifier that requires a 256-bit key, and the encryption context that identifies the keyspace, the table, and the AWS account.

```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "AWSService",
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2021-04-16T04:56:05Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "GenerateDataKey",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "AWS Internal",
    "userAgent": "AWS Internal",
    "requestParameters": {
        "keySpec": "AES_256",
        "encryptionContext": {
            "aws:cassandra:keyspaceName": "my_keyspace",
```

```
            "aws:cassandra:tableName": "my_table",
            "aws:cassandra:subscriberId": "123SAMPLE012"
        },
        "keyId": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
    },
    "responseElements": null,
    "requestID": "5e8e9cb5-9194-4334-aacc-9dd7d50fe246",
    "eventID": "49fccab9-2448-4b97-a89d-7d5c39318d6f",
    "readOnly": true,
    "resources": [
        {
            "accountId": "123SAMPLE012",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "eventCategory": "Management",
    "recipientAccountId": "123SAMPLE012",
    "sharedEventID": "84fbaaf0-9641-4e32-9147-57d2cb08792e"
}
```

DescribeKey

Amazon Keyspaces uses a DescribeKey operation to determine whether the KMS key you selected exists in the account and Region.

The event that records the `DescribeKey` operation is similar to the following example event. The user is the Amazon Keyspaces service account. The parameters include the ARN of the customer managed key and a key specifier that requires a 256-bit key.

```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AIDAZ3FNIIVIZZ6H7CFQG",
        "arn": "arn:aws:iam::123SAMPLE012:user/admin",
        "accountId": "123SAMPLE012",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "userName": "admin",
```

```
        "sessionContext": {
            "sessionIssuer": {},
            "webIdFederationData": {},
            "attributes": {
                "mfaAuthenticated": "false",
                "creationDate": "2021-04-16T04:55:42Z"
            }
        },
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2021-04-16T04:55:58Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "DescribeKey",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "AWS Internal",
    "userAgent": "AWS Internal",
    "requestParameters": {
        "keyId": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
    },
    "responseElements": null,
    "requestID": "c25a8105-050b-4f52-8358-6e872fb03a6c",
    "eventID": "0d96420e-707e-41b9-9118-56585a669658",
    "readOnly": true,
    "resources": [
        {
            "accountId": "123SAMPLE012",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "eventCategory": "Management",
    "recipientAccountId": "123SAMPLE012"
}
```

Decrypt

When you access an Amazon Keyspaces table, Amazon Keyspaces needs to decrypt the table key so that it can decrypt the keys below it in the hierarchy. It then decrypts the data in the table.

To decrypt the table key, Amazon Keyspaces sends a Decrypt request to AWS KMS that specifies the KMS key for the table.

The event that records the `Decrypt` operation is similar to the following example event. The user is the principal in your AWS account who is accessing the table. The parameters include the encrypted table key (as a ciphertext blob) and the encryption context that identifies the table and the AWS account. AWS KMS derives the ID of the customer managed key from the ciphertext.

```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "AWSService",
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2021-04-16T05:29:44Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "Decrypt",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "AWS Internal",
    "userAgent": "AWS Internal",
    "requestParameters": {
        "encryptionContext": {
            "aws:cassandra:keyspaceName": "my_keyspace",
            "aws:cassandra:tableName": "my_table",
            "aws:cassandra:subscriberId": "123SAMPLE012"
        },
        "encryptionAlgorithm": "SYMMETRIC_DEFAULT"
    },
    "responseElements": null,
    "requestID": "50e80373-83c9-4034-8226-5439e1c9b259",
    "eventID": "8db9788f-04a5-4ae2-90c9-15c79c411b6b",
    "readOnly": true,
    "resources": [
        {
            "accountId": "123SAMPLE012",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
```

```
    "eventCategory": "Management",
    "recipientAccountId": "123SAMPLE012",
    "sharedEventID": "7ed99e2d-910a-4708-a4e3-0180d8dbb68e"
}
```

CreateGrant

When you use a customer managed key to protect your Amazon Keyspaces table, Amazon Keyspaces uses grants to allow the service to perform continuous data protection and maintenance and durability tasks. These grants aren't required on AWS owned keys.

The grants that Amazon Keyspaces creates are specific to a table. The principal in the CreateGrant request is the user who created the table.

The event that records the `CreateGrant` operation is similar to the following example event. The parameters include the ARN of the customer managed key for the table, the grantee principal and retiring principal (the Amazon Keyspaces service), and the operations that the grant covers. It also includes a constraint that requires all encryption operations use the specified encryption context.

```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AIDAZ3FNIIVIZZ6H7CFQG",
        "arn": "arn:aws:iam::arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111:user/admin",
        "accountId": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111",
        "accessKeyId": "AKIAI44QH8DHBEXAMPLE",
        "userName": "admin",
        "sessionContext": {
            "sessionIssuer": {},
            "webIdFederationData": {},
            "attributes": {
                "mfaAuthenticated": "false",
                "creationDate": "2021-04-16T04:55:42Z"
            }
        },
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2021-04-16T05:11:10Z",
    "eventSource": "kms.amazonaws.com",
```

```
    "eventName": "CreateGrant",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "AWS Internal",
    "userAgent": "AWS Internal",
    "requestParameters": {
        "keyId": "a7d328af-215e-4661-9a69-88c858909f20",
        "operations": [
            "DescribeKey",
            "GenerateDataKey",
            "Decrypt",
            "Encrypt",
            "ReEncryptFrom",
            "ReEncryptTo",
            "RetireGrant"
        ],
        "constraints": {
            "encryptionContextSubset": {
                "aws:cassandra:keyspaceName": "my_keyspace",
                "aws:cassandra:tableName": "my_table",
                "aws:cassandra:subscriberId": "123SAMPLE012"
            }
        },
        "retiringPrincipal": "cassandratest.us-east-1.amazonaws.com",
        "granteePrincipal": "cassandratest.us-east-1.amazonaws.com"
    },
    "responseElements": {
        "grantId":
 "18e4235f1b07f289762a31a1886cb5efd225f069280d4f76cd83b9b9b5501013"
    },
    "requestID": "b379a767-1f9b-48c3-b731-fb23e865e7f7",
    "eventID": "29ee1fd4-28f2-416f-a419-551910d20291",
    "readOnly": false,
    "resources": [
        {
            "accountId": "123SAMPLE012",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "eventCategory": "Management",
    "recipientAccountId": "123SAMPLE012"
```

```
}
```

Encryption in transit in Amazon Keyspaces

Amazon Keyspaces only accepts secure connections using Transport Layer Security (TLS). Encryption in transit provides an additional layer of data protection by encrypting your data as it travels to and from Amazon Keyspaces. Organizational policies, industry or government regulations, and compliance requirements often require the use of encryption in transit to increase the data security of your applications when they transmit data over the network.

To learn how to encrypt `cqlsh` connections to Amazon Keyspaces using TLS, see the section called "How to manually configure `cqlsh` connections for TLS". To learn how to use TLS encryption with client drivers, see the section called "Using a Cassandra client driver".

Internetwork traffic privacy in Amazon Keyspaces

This topic describes how Amazon Keyspaces (for Apache Cassandra) secures connections from on-premises applications to Amazon Keyspaces and between Amazon Keyspaces and other AWS resources within the same AWS Region.

Traffic between service and on-premises clients and applications

You have two connectivity options between your private network and AWS:

- An AWS Site-to-Site VPN connection. For more information, see What is AWS Site-to-Site VPN? in the *AWS Site-to-Site VPN User Guide*.
- An Direct Connect connection. For more information, see What is Direct Connect? in the *Direct Connect User Guide*.

As a managed service, Amazon Keyspaces (for Apache Cassandra) is protected by AWS global network security. For information about AWS security services and how AWS protects infrastructure, see AWS Cloud Security. To design your AWS environment using the best practices for infrastructure security, see Infrastructure Protection in *Security Pillar AWS Well-Architected Framework*.

You use AWS published API calls to access Amazon Keyspaces through the network. Clients must support the following:

- Transport Layer Security (TLS). We require TLS 1.2 and recommend TLS 1.3.
- Cipher suites with perfect forward secrecy (PFS) such as DHE (Ephemeral Diffie-Hellman) or ECDHE (Elliptic Curve Ephemeral Diffie-Hellman). Most modern systems such as Java 7 and later support these modes.

Amazon Keyspaces supports two methods of authenticating client requests. The first method uses service-specific credentials, which are password based credentials generated for a specific IAM user. You can create and manage the password using the IAM console, the AWS CLI, or the AWS API. For more information, see Using IAM with Amazon Keyspaces.

The second method uses an authentication plugin for the open-source DataStax Java Driver for Cassandra. This plugin enables IAM users, roles, and federated identities to add authentication information to Amazon Keyspaces (for Apache Cassandra) API requests using the AWS Signature Version 4 process (SigV4). For more information, see the section called “Create IAM credentials for AWS authentication”.

Traffic between AWS resources in the same Region

Interface VPC endpoints enable private communication between your virtual private cloud (VPC) running in Amazon VPC and Amazon Keyspaces. Interface VPC endpoints are powered by AWS PrivateLink, which is an AWS service that enables private communication between VPCs and AWS services. AWS PrivateLink enables this by using an elastic network interface with private IPs in your VPC so that network traffic does not leave the Amazon network. Interface VPC endpoints don't require an internet gateway, NAT device, VPN connection, or Direct Connect connection. For more information, see Amazon Virtual Private Cloud and Interface VPC endpoints (AWS PrivateLink). For example policies, see the section called “Using interface VPC endpoints for Amazon Keyspaces”.

AWS Identity and Access Management for Amazon Keyspaces

AWS Identity and Access Management (IAM) is an AWS service that helps an administrator securely control access to AWS resources. IAM administrators control who can be *authenticated* (signed in) and *authorized* (have permissions) to use Amazon Keyspaces resources. IAM is an AWS service that you can use with no additional charge.

Topics

- Audience
- Authenticating with identities

- Managing access using policies
- How Amazon Keyspaces works with IAM
- Amazon Keyspaces identity-based policy examples
- AWS managed policies for Amazon Keyspaces
- Troubleshooting Amazon Keyspaces identity and access
- Using service-linked roles for Amazon Keyspaces

Audience

How you use AWS Identity and Access Management (IAM) differs based on your role:

- **Service user** - request permissions from your administrator if you cannot access features (see Troubleshooting Amazon Keyspaces identity and access)
- **Service administrator** - determine user access and submit permission requests (see How Amazon Keyspaces works with IAM)
- **IAM administrator** - write policies to manage access (see Amazon Keyspaces identity-based policy examples)

Authenticating with identities

Authentication is how you sign in to AWS using your identity credentials. You must be authenticated as the AWS account root user, an IAM user, or by assuming an IAM role.

You can sign in as a federated identity using credentials from an identity source like AWS IAM Identity Center (IAM Identity Center), single sign-on authentication, or Google/Facebook credentials. For more information about signing in, see How to sign in to your AWS account in the *AWS Sign-In User Guide*.

For programmatic access, AWS provides an SDK and CLI to cryptographically sign requests. For more information, see AWS Signature Version 4 for API requests in the *IAM User Guide*.

AWS account root user

When you create an AWS account, you begin with one sign-in identity called the AWS account *root user* that has complete access to all AWS services and resources. We strongly recommend that you don't use the root user for everyday tasks. For tasks that require root user credentials, see Tasks that require root user credentials in the *IAM User Guide*.

IAM users and groups

An *IAM user* is an identity with specific permissions for a single person or application. We recommend using temporary credentials instead of IAM users with long-term credentials. For more information, see Require human users to use federation with an identity provider to access AWS using temporary credentials in the *IAM User Guide*.

An *IAM group* specifies a collection of IAM users and makes permissions easier to manage for large sets of users. For more information, see Use cases for IAM users in the *IAM User Guide*.

IAM roles

An *IAM role* is an identity with specific permissions that provides temporary credentials. You can assume a role by switching from a user to an IAM role (console) or by calling an AWS CLI or AWS API operation. For more information, see Methods to assume a role in the *IAM User Guide*.

IAM roles are useful for federated user access, temporary IAM user permissions, cross-account access, cross-service access, and applications running on Amazon EC2. For more information, see Cross account resource access in IAM in the *IAM User Guide*.

Managing access using policies

You control access in AWS by creating policies and attaching them to AWS identities or resources. A policy defines permissions when associated with an identity or resource. AWS evaluates these policies when a principal makes a request. Most policies are stored in AWS as JSON documents. For more information about JSON policy documents, see Overview of JSON policies in the *IAM User Guide*.

Using policies, administrators specify who has access to what by defining which **principal** can perform **actions** on what **resources**, and under what **conditions**.

By default, users and roles have no permissions. An IAM administrator creates IAM policies and adds them to roles, which users can then assume. IAM policies define permissions regardless of the method used to perform the operation.

Identity-based policies

Identity-based policies are JSON permissions policy documents that you attach to an identity (user, group, or role). These policies control what actions identities can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Define custom IAM permissions with customer managed policies in the *IAM User Guide*.

Identity-based policies can be *inline policies* (embedded directly into a single identity) or *managed policies* (standalone policies attached to multiple identities). To learn how to choose between managed and inline policies, see Choose between managed policies and inline policies in the *IAM User Guide*.

Resource-based policies

Resource-based policies are JSON policy documents that you attach to a resource. Examples include IAM *role trust policies* and Amazon S3 *bucket policies*. In services that support resource-based policies, service administrators can use them to control access to a specific resource. You must specify a principal in a resource-based policy.

Resource-based policies are inline policies that are located in that service. You can't use AWS managed policies from IAM in a resource-based policy.

Access control lists (ACLs)

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

Amazon S3, AWS WAF, and Amazon VPC are examples of services that support ACLs. To learn more about ACLs, see Access control list (ACL) overview in the *Amazon Simple Storage Service Developer Guide*.

Other policy types

AWS supports additional policy types that can set the maximum permissions granted by more common policy types:

- **Permissions boundaries** – Set the maximum permissions that an identity-based policy can grant to an IAM entity. For more information, see Permissions boundaries for IAM entities in the *IAM User Guide*.
- **Service control policies (SCPs)** – Specify the maximum permissions for an organization or organizational unit in AWS Organizations. For more information, see Service control policies in the *AWS Organizations User Guide*.
- **Resource control policies (RCPs)** – Set the maximum available permissions for resources in your accounts. For more information, see Resource control policies (RCPs) in the *AWS Organizations User Guide*.

- **Session policies** – Advanced policies passed as a parameter when creating a temporary session for a role or federated user. For more information, see Session policies in the *IAM User Guide*.

Multiple policy types

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy evaluation logic in the *IAM User Guide*.

How Amazon Keyspaces works with IAM

Before you use IAM to manage access to Amazon Keyspaces, you should understand what IAM features are available to use with Amazon Keyspaces. To get a high-level view of how Amazon Keyspaces and other AWS services work with IAM, see AWS services that work with IAM in the *IAM User Guide*.

Topics

- Amazon Keyspaces identity-based policies
- Amazon Keyspaces resource-based policies
- Authorization based on Amazon Keyspaces tags
- Amazon Keyspaces IAM roles

Amazon Keyspaces identity-based policies

With IAM identity-based policies, you can specify allowed or denied actions and resources as well as the conditions under which actions are allowed or denied. Amazon Keyspaces supports specific actions and resources, and condition keys. To learn about all of the elements that you use in a JSON policy, see IAM JSON policy elements reference in the *IAM User Guide*.

To see the Amazon Keyspaces service-specific resources and actions, and condition context keys that can be used for IAM permissions policies, see the Actions, resources, and condition keys for Amazon Keyspaces (for Apache Cassandra) in the *Service Authorization Reference*.

Actions

Administrators can use AWS JSON policies to specify who has access to what. That is, which **principal** can perform **actions** on what **resources**, and under what **conditions**.

The `Action` element of a JSON policy describes the actions that you can use to allow or deny access in a policy. Include actions in a policy to grant permissions to perform the associated operation.

Policy actions in Amazon Keyspaces use the following prefix before the action: `cassandra:`. For example, to grant someone permission to create an Amazon Keyspaces keyspace with the Amazon Keyspaces `CREATE` CQL statement, you include the `cassandra:Create` action in their policy. Policy statements must include either an `Action` or `NotAction` element. Amazon Keyspaces defines its own set of actions that describe tasks that you can perform with this service.

To specify multiple actions in a single statement, separate them with commas as follows:

```
"Action": [
      "cassandra:CREATE",
      "cassandra:MODIFY"
          ]
```

To see a list of Amazon Keyspaces actions, see Actions Defined by Amazon Keyspaces (for Apache Cassandra) in the *Service Authorization Reference*.

Resources

Administrators can use AWS JSON policies to specify who has access to what. That is, which **principal** can perform **actions** on what **resources**, and under what **conditions**.

The `Resource` JSON policy element specifies the object or objects to which the action applies. As a best practice, specify a resource using its Amazon Resource Name (ARN). For actions that don't support resource-level permissions, use a wildcard (*) to indicate that the statement applies to all resources.

```
"Resource": "*"
```

In Amazon Keyspaces, keyspaces, tables, and streams can be used in the `Resource` element of IAM permissions.

> **Note**
>
> To access user keyspaces and tables in Amazon Keyspaces, your IAM policy must include `cassandra:Select` permissions on system tables:

```
arn:${Partition}:cassandra:${Region}:${Account}:/keyspace/system*
```

This applies to the following scenarios:

- AWS Management Console access
- SDK resource operations, for example `GetKeyspace`, `GetTable`, `ListKeyspaces`, and `ListTables`
- Standard Apache Cassandra client driver connections, because drivers automatically read system tables during connection initialization

System tables are read-only and cannot be modified.

The Amazon Keyspaces keyspace resource has the following ARN:

```
arn:${Partition}:cassandra:${Region}:${Account}:/keyspace/${keyspaceName}/
```

The Amazon Keyspaces table resource has the following ARN:

```
arn:${Partition}:cassandra:${Region}:${Account}:/keyspace/${keyspaceName}/table/
${tableName}
```

The Amazon Keyspaces stream resource has the following ARN:

```
arn:${Partition}:cassandra:{Region}:${Account}:/keyspace/${keyspaceName}/table/
${tableName}/stream/${streamLabel}
```

For more information about the format of ARNs, see Amazon Resource Names (ARNs) and AWS service namespaces.

For example, to specify the `mykeyspace` keyspace in your statement, use the following ARN:

```
"Resource": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/"
```

To specify all keyspaces that belong to a specific account, use the wildcard (*):

```
"Resource": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/*"
```

Some Amazon Keyspaces actions, such as those for creating resources, cannot be performed on a specific resource. In those cases, you must use the wildcard (*).

```
"Resource": "*"
```

For example, to grant SELECT permissions to an IAM principal for `mytable` in `mykeyspace`, the principal must have permissions to read both, `mytable` and `keyspace/system*`. To specify multiple resources in a single statement, separate the ARNs with commas.

```
"Resource": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
```

To see a list of Amazon Keyspaces resource types and their ARNs, see Resources Defined by Amazon Keyspaces (for Apache Cassandra) in the *Service Authorization Reference*. To learn with which actions you can specify the ARN of each resource, see Actions Defined by Amazon Keyspaces (for Apache Cassandra).

Condition keys

Administrators can use AWS JSON policies to specify who has access to what. That is, which **principal** can perform **actions** on what **resources**, and under what **conditions**.

The `Condition` element specifies when statements execute based on defined criteria. You can create conditional expressions that use condition operators, such as equals or less than, to match the condition in the policy with values in the request. To see all AWS global condition keys, see AWS global condition context keys in the *IAM User Guide*.

Amazon Keyspaces defines its own set of condition keys and also supports using some global condition keys. To see all AWS global condition keys, see AWS global condition context keys in the *IAM User Guide*.

All Amazon Keyspaces actions support the `aws:RequestTag/${TagKey}`, the `aws:ResourceTag/${TagKey}`, and the `aws:TagKeys` condition keys. For more information, see the section called “Amazon Keyspaces resource access based on tags”.

To see a list of Amazon Keyspaces condition keys, see Condition Keys for Amazon Keyspaces (for Apache Cassandra) in the *Service Authorization Reference*. To learn with which actions and resources you can use a condition key, see Actions Defined by Amazon Keyspaces (for Apache Cassandra).

Examples

To view examples of Amazon Keyspaces identity-based policies, see Amazon Keyspaces identity-based policy examples.

Amazon Keyspaces resource-based policies

Amazon Keyspaces does not support resource-based policies. To view an example of a detailed resource-based policy page, see https://docs.aws.amazon.com/lambda/latest/dg/access-control-resource-based.html.

Authorization based on Amazon Keyspaces tags

You can manage access to your Amazon Keyspaces resources by using tags. To manage resource access based on tags, you provide tag information in the condition element of a policy using the `cassandra:ResourceTag/key-name`, `aws:RequestTag/key-name`, or `aws:TagKeys` condition keys. For more information about tagging Amazon Keyspaces resources, see the section called "Working with tags".

To view example identity-based policies for limiting access to a resource based on the tags on that resource, see Amazon Keyspaces resource access based on tags.

Amazon Keyspaces IAM roles

An IAM role is an entity within your AWS account that has specific permissions.

Using temporary credentials with Amazon Keyspaces

You can use temporary credentials to sign in with federation, to assume an IAM role, or to assume a cross-account role. You obtain temporary security credentials by calling AWS STS API operations such as AssumeRole or GetFederationToken.

Amazon Keyspaces supports using temporary credentials with the AWS Signature Version 4 (SigV4) authentication plugin available from the Github repo for the following languages:

- Java: https://github.com/aws/aws-sigv4-auth-cassandra-java-driver-plugin.
- Node.js: https://github.com/aws/aws-sigv4-auth-cassandra-nodejs-driver-plugin.
- Python: https://github.com/aws/aws-sigv4-auth-cassandra-python-driver-plugin.
- Go: https://github.com/aws/aws-sigv4-auth-cassandra-gocql-driver-plugin.

For examples and tutorials that implement the authentication plugin to access Amazon Keyspaces programmatically, see the section called “Using a Cassandra client driver”.

Service-linked roles

Service-linked roles allow AWS services to access resources in other services to complete an action on your behalf. Service-linked roles appear in your IAM account and are owned by the service. An IAM administrator can view but not edit the permissions for service-linked roles.

For details about creating or managing Amazon Keyspaces service-linked roles, see **the section called “Using service-linked roles”**.

Service roles

Amazon Keyspaces does not support service roles.

Amazon Keyspaces identity-based policy examples

By default, IAM users and roles don't have permission to create or modify Amazon Keyspaces resources. They also can't perform tasks using the console, CQLSH, AWS CLI, or AWS API. An IAM administrator must create IAM policies that grant users and roles permission to perform specific API operations on the specified resources they need. The administrator must then attach those policies to the IAM users or groups that require those permissions.

To learn how to create an IAM identity-based policy using these example JSON policy documents, see Creating policies on the JSON tab in the *IAM User Guide*.

Topics

- Policy best practices
- Using the Amazon Keyspaces console
- Allow users to view their own permissions
- Accessing Amazon Keyspaces tables
- Amazon Keyspaces resource access based on tags

Policy best practices

Identity-based policies determine whether someone can create, access, or delete Amazon Keyspaces resources in your account. These actions can incur costs for your AWS account. When you create or edit identity-based policies, follow these guidelines and recommendations:

- **Get started with AWS managed policies and move toward least-privilege permissions** – To get started granting permissions to your users and workloads, use the *AWS managed policies* that grant permissions for many common use cases. They are available in your AWS account. We recommend that you reduce permissions further by defining AWS customer managed policies that are specific to your use cases. For more information, see AWS managed policies or AWS managed policies for job functions in the *IAM User Guide*.
- **Apply least-privilege permissions** – When you set permissions with IAM policies, grant only the permissions required to perform a task. You do this by defining the actions that can be taken on specific resources under specific conditions, also known as *least-privilege permissions*. For more information about using IAM to apply permissions, see Policies and permissions in IAM in the *IAM User Guide*.
- **Use conditions in IAM policies to further restrict access** – You can add a condition to your policies to limit access to actions and resources. For example, you can write a policy condition to specify that all requests must be sent using SSL. You can also use conditions to grant access to service actions if they are used through a specific AWS service, such as CloudFormation. For more information, see IAM JSON policy elements: Condition in the *IAM User Guide*.
- **Use IAM Access Analyzer to validate your IAM policies to ensure secure and functional permissions** – IAM Access Analyzer validates new and existing policies so that the policies adhere to the IAM policy language (JSON) and IAM best practices. IAM Access Analyzer provides more than 100 policy checks and actionable recommendations to help you author secure and functional policies. For more information, see Validate policies with IAM Access Analyzer in the *IAM User Guide*.
- **Require multi-factor authentication (MFA)** – If you have a scenario that requires IAM users or a root user in your AWS account, turn on MFA for additional security. To require MFA when API operations are called, add MFA conditions to your policies. For more information, see Secure API access with MFA in the *IAM User Guide*.

For more information about best practices in IAM, see Security best practices in IAM in the *IAM User Guide*.

Using the Amazon Keyspaces console

Amazon Keyspaces doesn't require specific permissions to access the Amazon Keyspaces console. You need at least read-only permissions to list and view details about the Amazon Keyspaces resources in your AWS account. If you create an identity-based policy that is more restrictive than

the minimum required permissions, the console won't function as intended for entities (IAM users or roles) with that policy.

Two AWS managed policies are available to the entities for Amazon Keyspaces console access.

- AmazonKeyspacesReadOnlyAccess_v2 – This policy grants read-only access to Amazon Keyspaces.
- AmazonKeyspacesFullAccess – This policy grants permissions to use Amazon Keyspaces with full access to all features.

For more information about Amazon Keyspaces managed policies, see the section called “AWS managed policies”.

Allow users to view their own permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ViewOwnUserInfo",
            "Effect": "Allow",
            "Action": [
                "iam:GetUserPolicy",
                "iam:ListGroupsForUser",
                "iam:ListAttachedUserPolicies",
                "iam:ListUserPolicies",
                "iam:GetUser"
            ],
            "Resource": ["arn:aws:iam::*:user/${aws:username}"]
        },
        {
            "Sid": "NavigateInConsole",
            "Effect": "Allow",
            "Action": [
                "iam:GetGroupPolicy",
                "iam:GetPolicyVersion",
                "iam:GetPolicy",
```

```
                "iam:ListAttachedGroupPolicies",
                "iam:ListGroupPolicies",
                "iam:ListPolicyVersions",
                "iam:ListPolicies",
                "iam:ListUsers"
            ],
            "Resource": "*"
        }
    ]
}
```

Accessing Amazon Keyspaces tables

Note

To access user keyspaces and tables in Amazon Keyspaces, your IAM policy must include `cassandra:Select` permissions on system tables:

```
arn:${Partition}:cassandra:${Region}:${Account}:/keyspace/system*
```

This applies to the following scenarios:

- AWS Management Console access
- SDK resource operations, for example `GetKeyspace`, `GetTable`, `ListKeyspaces`, and `ListTables`
- Standard Apache Cassandra client driver connections, because drivers automatically read system tables during connection initialization

System tables are read-only and cannot be modified.

The following is a sample policy that grants read-only (SELECT) access to the Amazon Keyspaces system tables. For all samples, replace the Region and account ID in the Amazon Resource Name (ARN) with your own.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
```

```
         "Effect":"Allow",
         "Action":[
            "cassandra:Select"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

The following sample policy adds read-only access to the user table `mytable` in the keyspace `mykeyspace`.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

The following sample policy assigns read/write access to a user table and read access to the system tables.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Select",
            "cassandra:Modify"
```

```
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/
mytable",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

The following sample policy allows a user to create tables in keyspace `mykeyspace`.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "cassandra:Create",
            "cassandra:Select"
         ],
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/*",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ]
      }
   ]
}
```

The following sample policy assigns read access to the system tables, but restricts `SELECT` (read) and `MODIFY` (write) access to the user table `mytable`.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "cassandra:Select"
      ],
      "Resource": [
        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
      ]
```

```
    },
    {
      "Effect": "Deny",
      "Action": [
        "cassandra:Select",
        "cassandra:Modify"
      ],
      "Resource": [
        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/mytable"
      ]
    }
  ]
}
```

Amazon Keyspaces resource access based on tags

You can use conditions in your identity-based policy to control access to Amazon Keyspaces resources based on tags. These policies control visibility of the keyspaces and tables in the account. Note that tag-based permissions for system tables behave differently when requests are made using the AWS SDK compared to Cassandra Query Language (CQL) API calls via Cassandra drivers and developer tools.

- To make `List` and `Get` resource requests with the AWS SDK when using tag-based access, the caller needs to have read access to system tables. For example, `Select` action permissions are required to read data from system tables via the `GetTable` operation. If the caller has only tag-based access to a specific table, an operation that requires additional access to a system table will fail.
- For compatibility with established Cassandra driver behavior, tag-based authorization policies are not enforced when performing operations on system tables using Cassandra Query Language (CQL) API calls via Cassandra drivers and developer tools.

The following example shows how you can create a policy that grants permissions to a user to view a table if the table's `Owner` contains the value of that user's user name. In this example you also give read access to the system tables.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"ReadOnlyAccessTaggedTables",
```

```
         "Effect":"Allow",
         "Action":"cassandra:Select",
         "Resource":[
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/table/*",
            "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
         ],
         "Condition":{
            "StringEquals":{
               "aws:ResourceTag/Owner":"${aws:username}"
            }
         }
      }
   ]
}
```

You can attach this policy to the IAM users in your account. If a user named `richard-roe` attempts to view an Amazon Keyspaces table, the table must be tagged `Owner=richard-roe` or `owner=richard-roe`. Otherwise, he is denied access. The condition tag key `Owner` matches both `Owner` and `owner` because condition key names are not case-sensitive. For more information, see IAM JSON policy elements: Condition in the *IAM User Guide*.

The following policy grants permissions to a user to create tables with tags if the table's `Owner` contains the value of that user's user name.

```
{
    "Version": "2012-10-17",
    "Statement": [
       {
          "Sid": "CreateTagTableUser",
          "Effect": "Allow",
          "Action": [
              "cassandra:Create",
              "cassandra:TagResource"
          ],
          "Resource": "arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/*",
          "Condition":{
             "StringEquals":{
                "aws:RequestTag/Owner":"${aws:username}"
             }
          }
       }
```

```
    ]
}
```

AWS managed policies for Amazon Keyspaces

An AWS managed policy is a standalone policy that is created and administered by AWS. AWS managed policies are designed to provide permissions for many common use cases so that you can start assigning permissions to users, groups, and roles.

Keep in mind that AWS managed policies might not grant least-privilege permissions for your specific use cases because they're available for all AWS customers to use. We recommend that you reduce permissions further by defining customer managed policies that are specific to your use cases.

You cannot change the permissions defined in AWS managed policies. If AWS updates the permissions defined in an AWS managed policy, the update affects all principal identities (users, groups, and roles) that the policy is attached to. AWS is most likely to update an AWS managed policy when a new AWS service is launched or new API operations become available for existing services.

For more information, see AWS managed policies in the *IAM User Guide*.

AWS managed policy: AmazonKeyspacesReadOnlyAccess_v2

You can attach the `AmazonKeyspacesReadOnlyAccess_v2` policy to your IAM identities.

This policy grants read-only access to Amazon Keyspaces and includes the required permissions when connecting through private VPC endpoints.

Permissions details

This policy includes the following permissions.

- `Amazon Keyspaces` – Provides read-only access to Amazon Keyspaces.
- `Amazon Keyspaces CDC streams` – Allows principals to view Amazon Keyspaces CDC streams.
- `Application Auto Scaling` – Allows principals to view configurations from Application Auto Scaling. This is required so that users can view automatic scaling policies that are attached to a table.
- `CloudWatch` – Allows principals to view metric data and alarms configured in CloudWatch. This is required so users can view the billable table size and CloudWatch alarms that have been configured for a table.
- `AWS KMS` – Allows principals to view keys configured in AWS KMS. This is required so users can view AWS KMS keys that they create and manage in their account to confirm that the key assigned to Amazon Keyspaces is a symmetric encryption key that is enabled.
- `Amazon EC2` – Allows principals connecting to Amazon Keyspaces through VPC endpoints to query the VPC on your Amazon EC2 instance for endpoint and network interface information. This read-only access to the Amazon EC2 instance is required so Amazon Keyspaces can look up and store available interface VPC endpoints in the `system.peers` table used for connection load balancing.

To review the policy in `JSON` format, see AmazonKeyspacesReadOnlyAccess_v2.

AWS managed policy: AmazonKeyspacesReadOnlyAccess

You can attach the `AmazonKeyspacesReadOnlyAccess` policy to your IAM identities.

This policy grants read-only access to Amazon Keyspaces.

Permissions details

This policy includes the following permissions.

- `Amazon Keyspaces` – Provides read-only access to Amazon Keyspaces.
- `Amazon Keyspaces CDC streams` – Allows principals to view Amazon Keyspaces CDC streams.

- `Application Auto Scaling` – Allows principals to view configurations from Application Auto Scaling. This is required so that users can view automatic scaling policies that are attached to a table.
- `CloudWatch` – Allows principals to view metric data and alarms configured in CloudWatch. This is required so users can view the billable table size and CloudWatch alarms that have been configured for a table.
- `AWS KMS` – Allows principals to view keys configured in AWS KMS. This is required so users can view AWS KMS keys that they create and manage in their account to confirm that the key assigned to Amazon Keyspaces is a symmetric encryption key that is enabled.

To review the policy in `JSON` format, see AmazonKeyspacesReadOnlyAccess.

AWS managed policy: AmazonKeyspacesFullAccess

You can attach the `AmazonKeyspacesFullAccess` policy to your IAM identities.

This policy grants administrative permissions that allow your administrators unrestricted access to Amazon Keyspaces.

Permissions details

This policy includes the following permissions.

- `Amazon Keyspaces` – Allows principals to access any Amazon Keyspaces resource and perform all actions.
- `Application Auto Scaling` – Allows principals to create, view, and delete automatic scaling policies for Amazon Keyspaces tables. This is required so that administrators can manage automatic scaling policies for Amazon Keyspaces tables.
- `CloudWatch` – Allows principals to see the billable table size as well as create, view, and delete CloudWatch alarms for Amazon Keyspaces automatic scaling policies. This is required so that administrators can view the billable table size and create a CloudWatch dashboard.
- `IAM` – Allows Amazon Keyspaces to create service-linked roles with IAM automatically when the following features are turned on:

- `Amazon Keyspaces CDC streams` – When an administrator enables a stream for a table, Amazon Keyspaces creates the service-linked role AWSServiceRoleForAmazonKeyspacesCDC to publish CloudWatch metrics into your account on your behalf.
- `Application Auto Scaling` – When an administrator enables Application Auto Scaling for a table, Amazon Keyspaces creates the service-linked role AWSServiceRoleForApplicationAutoScaling_CassandraTable to perform automatic scaling actions on your behalf.
- `Amazon Keyspaces multi-Region replication` – When an administrator creates a new multi-Region keyspace, or adds a new AWS Region to an existing single-Region keyspace, Amazon Keyspaces creates the service-linked role AWSServiceRoleForAmazonKeyspacesReplication to perform replication of tables, data, and metadata to the selected Regions on your behalf.

- `AWS KMS` – Allows principals to view keys configured in AWS KMS. This is required so that users can view AWS KMS keys that they create and manage in their account to confirm that the key assigned to Amazon Keyspaces is a symmetric encryption key that is enabled.
- `Amazon EC2` – Allows principals connecting to Amazon Keyspaces through VPC endpoints to query the VPC on your Amazon EC2 instance for endpoint and network interface information. This read-only access to the Amazon EC2 instance is required so Amazon Keyspaces can look up and store available interface VPC endpoints in the `system.peers` table used for connection load balancing.

To review the policy in `JSON` format, see AmazonKeyspacesFullAccess.

AWS managed policy: KeyspacesCDCServiceRolePolicy

You can't attach `KeyspacesCDCServiceRolePolicy` to your IAM entities. This policy is attached to a service-linked role that allows Amazon Keyspaces to perform actions on your behalf. For more information, see the section called “CDC streams”.

This policy grants the required permissions to the service-linked role `AWSServiceRoleForAmazonKeyspacesCDC` to publish Amazon Keyspaces CDC stream metrics data to CloudWatch on your behalf.

Permissions details

This policy includes the following permissions.

- `CloudWatch` – Allows the service-linked-role AWSServiceRoleForAmazonKeyspacesCDC to publish metric data from Amazon Keyspaces CDC streams into the `"cloudwatch:namespace": "AWS/Cassandra"` in your CloudWatch account on your behalf.

To review the policy in `JSON` format, see KeyspacesCDCServiceRolePolicy.

Amazon Keyspaces updates to AWS managed policies

View details about updates to AWS managed policies for Amazon Keyspaces since this service began tracking these changes. For automatic alerts about changes to this page, subscribe to the RSS feed on the *Document history* page.

Change	Description	Date
KeyspacesCDCServiceRolePolicy – New policy	Amazon Keyspaces added a new managed policy `KeyspacesCDCServiceRolePolicy` which grants the required permissions to the service-linked role `AWSServiceRoleForAmazonKeyspacesCDC` to publish Amazon Keyspaces CDC stream metrics data to CloudWatch on your behalf. For more information, see the section called “CDC streams”.	July 02, 2025
AmazonKeyspacesReadOnlyAccess_v2 – Update to an existing policy	Amazon Keyspaces added new permissions to allow IAM principals to view Amazon	July 02, 2025

Change	Description	Date
	Keyspaces CDC streams. For more information, see the section called “View CDC streams”.	
AmazonKeyspacesReadOnlyAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow IAM principals to view Amazon Keyspaces CDC streams. For more information, see the section called “View CDC streams”.	July 02, 2025
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces created the `KeyspacesCDCServiceRolePolicy` managed policy for the service linked role AWSServiceRoleForAmazonKeyspacesCDC to add the permissions that are required when an administrator enables a stream for a table. Amazon Keyspaces uses the service-linked role `AWSServiceRoleForAmazonKeyspacesCDC` to publish CloudWatch metrics into your account on your behalf. For more information, see the section called “CDC streams”.	July 02, 2025

Change	Description	Date
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces updated the `KeyspacesReplicationServiceRolePolicy` of the service linked role AWSServiceRoleForAmazonKeyspacesReplication to add the permissions that are required when an administrator adds a new AWS Region to a single or multi-Region keyspace. Amazon Keyspaces uses the service-linked role `AWSServiceRoleForAmazonKeyspacesReplication` to replicate tables, their settings, and data on your behalf. For more information, see the section called “Multi-Region Replication”.	November 19, 2024

Change	Description	Date
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow Amazon Keyspaces to create a service-linked role when an administrator adds a new Region to a single or multi-Region keyspace. Amazon Keyspaces uses the service-linked role to perform data replication tasks on your behalf. For more information, see the section called "Multi-Region Replication".	October 3, 2023
AmazonKeyspacesReadOnlyAccess_v2 – New policy	Amazon Keyspaces created a new policy to add read-only permissions for clients connecting to Amazon Keyspaces through interface VPC endpoints to access the Amazon EC2 instance to look up network information. Amazon Keyspaces stores available interface VPC endpoints in the `system.peers` table for connection load balancing. For more information, see the section called "Using interface VPC endpoints".	September 12, 2023

Change	Description	Date
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow Amazon Keyspaces to create a service-linked role when an administrator creates a multi-Region keyspace. Amazon Keyspaces uses the service-linked role `AWSServiceRoleForAmazonKeyspacesReplication` to perform data replication tasks on your behalf. For more information, see the section called "Multi-Region Replication".	June 5, 2023
AmazonKeyspacesReadOnlyAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow users to view the billable size of a table using CloudWatch. Amazon Keyspaces integrates with Amazon CloudWatch to allow you to monitor the billable table size. For more information, see the section called "Amazon Keyspaces metrics".	July 7, 2022

Change	Description	Date
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow users to view the billable size of a table using CloudWatch. Amazon Keyspaces integrates with Amazon CloudWatch to allow you to monitor the billable table size. For more information, see the section called "Amazon Keyspaces metrics".	July 7, 2022
AmazonKeyspacesReadOnlyAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow users to view AWS KMS keys that have been configured for Amazon Keyspaces encryption at rest. Amazon Keyspaces encryption at rest integrates with AWS KMS for protecting and managing the encryption keys used to encrypt data at rest. To view the AWS KMS key configured for Amazon Keyspaces, read-only permissions have been added.	June 1, 2021

Change	Description	Date
AmazonKeyspacesFullAccess – Update to an existing policy	Amazon Keyspaces added new permissions to allow users to view AWS KMS keys that have been configured for Amazon Keyspaces encryption at rest. Amazon Keyspaces encryption at rest integrates with AWS KMS for protecting and managing the encryption keys used to encrypt data at rest. To view the AWS KMS key configured for Amazon Keyspaces, read-only permissions have been added.	June 1, 2021
Amazon Keyspaces started tracking changes	Amazon Keyspaces started tracking changes for its AWS managed policies.	June 1, 2021

Troubleshooting Amazon Keyspaces identity and access

Use the following information to help you diagnose and fix common issues that you might encounter when working with Amazon Keyspaces and IAM.

Topics

- I'm not authorized to perform an action in Amazon Keyspaces
- I modified an IAM user or role and the changes did not take effect immediately
- I can't restore a table using Amazon Keyspaces point-in-time recovery (PITR)
- I'm not authorized to perform iam:PassRole
- I'm an administrator and want to allow others to access Amazon Keyspaces
- I want to allow people outside of my AWS account to access my Amazon Keyspaces resources

I'm not authorized to perform an action in Amazon Keyspaces

If the AWS Management Console tells you that you're not authorized to perform an action, then you must contact your administrator for assistance. Your administrator is the person that provided you with your user name and password.

The following example error occurs when the `mateojackson` IAM user tries to use the console to view details about a *`table`* but does not have `cassandra:`*`Select`* permissions for the table.

```
User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform:
 cassandra:Select on resource: mytable
```

In this case, Mateo asks his administrator to update his policies to allow him to access the *`mytable`* resource using the `cassandra:`*`Select`* action.

I modified an IAM user or role and the changes did not take effect immediately

IAM policy changes may take up to 10 minutes to take effect for applications with existing, established connections to Amazon Keyspaces. IAM policy changes take effect immediately when applications establish a new connection. If you have made modifications to an existing IAM user or role, and it has not taken immediate effect, either wait for 10 minutes or disconnect and reconnect to Amazon Keyspaces.

I can't restore a table using Amazon Keyspaces point-in-time recovery (PITR)

If you are trying to restore an Amazon Keyspaces table with point-in-time recovery (PITR), and you see the restore process begin, but not complete successfully, you might not have configured all of the required permissions that are needed by the restore process. You must contact your administrator for assistance and ask that person to update your policies to allow you to restore a table in Amazon Keyspaces.

In addition to user permissions, Amazon Keyspaces may require permissions to perform actions during the restore process on your principal's behalf. This is the case if the table is encrypted with a customer-managed key, or if you are using IAM policies that restrict incoming traffic. For example, if you are using condition keys in your IAM policy to restrict source traffic to specific endpoints or IP ranges, the restore operation fails. To allow Amazon Keyspaces to perform the table restore operation on your principal's behalf, you must add an `aws:ViaAWSService` global condition key in the IAM policy.

For more information about permissions to restore tables, see the section called “Configure IAM permissions for restore”.

I'm not authorized to perform iam:PassRole

If you receive an error that you're not authorized to perform the `iam:PassRole` action, your policies must be updated to allow you to pass a role to Amazon Keyspaces.

Some AWS services allow you to pass an existing role to that service instead of creating a new service role or service-linked role. To do this, you must have permissions to pass the role to the service.

The following example error occurs when an IAM user named `marymajor` tries to use the console to perform an action in Amazon Keyspaces. However, the action requires the service to have permissions that are granted by a service role. Mary does not have permissions to pass the role to the service.

```
User: arn:aws:iam::123456789012:user/marymajor is not authorized to perform:
 iam:PassRole
```

In this case, Mary's policies must be updated to allow her to perform the `iam:PassRole` action.

If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

I'm an administrator and want to allow others to access Amazon Keyspaces

To allow others to access Amazon Keyspaces, you must grant permission to the people or applications that need access. If you are using AWS IAM Identity Center to manage people and applications, you assign permission sets to users or groups to define their level of access. Permission sets automatically create and assign IAM policies to IAM roles that are associated with the person or application. For more information, see Permission sets in the *AWS IAM Identity Center User Guide*.

If you are not using IAM Identity Center, you must create IAM entities (users or roles) for the people or applications that need access. You must then attach a policy to the entity that grants them the correct permissions in Amazon Keyspaces. After the permissions are granted, provide the credentials to the user or application developer. They will use those credentials to access AWS. To learn more about creating IAM users, groups, policies, and permissions, see IAM Identities and Policies and permissions in IAM in the *IAM User Guide*.

I want to allow people outside of my AWS account to access my Amazon Keyspaces resources

You can create a role that users in other accounts or people outside of your organization can use to access your resources. You can specify who is trusted to assume the role. For services that support resource-based policies or access control lists (ACLs), you can use those policies to grant people access to your resources.

To learn more, consult the following:

- To learn whether Amazon Keyspaces supports these features, see How Amazon Keyspaces works with IAM.
- To learn how to provide access to your resources across AWS accounts that you own, see Providing access to an IAM user in another AWS account that you own in the *IAM User Guide*.
- To learn how to provide access to your resources to third-party AWS accounts, see Providing access to AWS accounts owned by third parties in the *IAM User Guide*.
- To learn how to provide access through identity federation, see Providing access to externally authenticated users (identity federation) in the *IAM User Guide*.
- To learn the difference between using roles and resource-based policies for cross-account access, see Cross account resource access in IAM in the *IAM User Guide*.

Using service-linked roles for Amazon Keyspaces

Amazon Keyspaces (for Apache Cassandra) uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to Amazon Keyspaces. Service-linked roles are predefined by Amazon Keyspaces and include all the permissions that the service requires to call other AWS services on your behalf.

For information about other services that support service-linked roles, see AWS services that work with IAM and look for the services that have **Yes** in the **Service-linked roles** column. Choose a **Yes** with a link to view the service-linked role documentation for that service.

Topics

- Using roles for Amazon Keyspaces application auto scaling
- Using roles for Amazon Keyspaces Multi-Region Replication
- Using roles for Amazon Keyspaces CDC streams

Using roles for Amazon Keyspaces application auto scaling

Amazon Keyspaces (for Apache Cassandra) uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to Amazon Keyspaces. Service-linked roles are predefined by Amazon Keyspaces and include all the permissions that the service requires to call other AWS services on your behalf.

A service-linked role makes setting up Amazon Keyspaces easier because you don't have to manually add the necessary permissions. Amazon Keyspaces defines the permissions of its service-linked roles, and unless defined otherwise, only Amazon Keyspaces can assume its roles. The defined permissions include the trust policy and the permissions policy, and that permissions policy cannot be attached to any other IAM entity.

You can delete a service-linked role only after first deleting its related resources. This protects your Amazon Keyspaces resources because you can't inadvertently remove permission to access the resources.

Service-linked role permissions for Amazon Keyspaces

Amazon Keyspaces uses the service-linked role named **AWSServiceRoleForApplicationAutoScaling_CassandraTable** to allow Application Auto Scaling to call Amazon Keyspaces and Amazon CloudWatch on your behalf.

The AWSServiceRoleForApplicationAutoScaling_CassandraTable service-linked role trusts the following services to assume the role:

- `cassandra.application-autoscaling.amazonaws.com`

The role permissions policy allows Application Auto Scaling to complete the following actions on the specified Amazon Keyspaces resources:

- Action: `cassandra:Select` on `arn:*:cassandra:*:*:/keyspace/system/table/*`
- Action: `cassandra:Select` on the resource `arn:*:cassandra:*:*:/keyspace/system_schema/table/*`
- Action: `cassandra:Select` on the resource `arn:*:cassandra:*:*:/keyspace/system_schema_mcs/table/*`
- Action: `cassandra:Alter` on the resource `arn:*:cassandra:*:*:"*"`

Creating a service-linked role for Amazon Keyspaces

You don't need to manually create a service-linked role for Amazon Keyspaces automatic scaling. When you enable Amazon Keyspaces auto scaling on a table with the AWS Management Console, CQL, the AWS CLI, or the AWS API, Application Auto Scaling creates the service-linked role for you.

If you delete this service-linked role, and then need to create it again, you can use the same process to recreate the role in your account. When you enable Amazon Keyspaces auto scaling for a table, Application Auto Scaling creates the service-linked role for you again.

> **Important**
>
> This service-linked role can appear in your account if you completed an action in another service that uses the features supported by this role. To learn more, see A new role appeared in my AWS account.

Editing a service-linked role for Amazon Keyspaces

Amazon Keyspaces does not allow you to edit the AWSServiceRoleForApplicationAutoScaling_CassandraTable service-linked role. After you create a service-linked role, you cannot change the name of the role because various entities might reference the role. However, you can edit the description of the role using IAM. For more information, see Editing a service-linked role in the *IAM User Guide*.

Deleting a service-linked role for Amazon Keyspaces

If you no longer need to use a feature or service that requires a service-linked role, we recommend that you delete that role. That way you don’t have an unused entity that isn't actively monitored or maintained. However, you must first disable automatic scaling on all tables in the account across all AWS Regions before you can delete the service-linked role manually. To disable automatic scaling on Amazon Keyspaces tables, see the section called “Turn off Amazon Keyspaces auto scaling for a table”.

> **Note**
>
> If Amazon Keyspaces automatic scaling is using the role when you try to modify the resources, then the deregistration might fail. If that happens, wait for a few minutes and try the operation again.

To manually delete the service-linked role using IAM

Use the IAM console, the AWS CLI, or the AWS API to delete the AWSServiceRoleForApplicationAutoScaling_CassandraTable service-linked role. For more information, see Deleting a Service-Linked Role in the *IAM User Guide*.

> **Note**
>
> To delete the service-linked role used by Amazon Keyspaces automatic scaling, you must first disable automatic scaling on all tables in the account.

Supported Regions for Amazon Keyspaces service-linked roles

Amazon Keyspaces supports using service-linked roles in all of the Regions where the service is available. For more information, see Service endpoints for Amazon Keyspaces.

Using roles for Amazon Keyspaces Multi-Region Replication

Amazon Keyspaces (for Apache Cassandra) uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to Amazon Keyspaces. Service-linked roles are predefined by Amazon Keyspaces and include all the permissions that the service requires to call other AWS services on your behalf.

A service-linked role makes setting up Amazon Keyspaces easier because you don’t have to manually add the necessary permissions. Amazon Keyspaces defines the permissions of its service-linked roles, and unless defined otherwise, only Amazon Keyspaces can assume its roles. The defined permissions include the trust policy and the permissions policy, and that permissions policy cannot be attached to any other IAM entity.

You can delete a service-linked role only after first deleting its related resources. This protects your Amazon Keyspaces resources because you can't inadvertently remove permission to access the resources.

Service-linked role permissions for Amazon Keyspaces

Amazon Keyspaces uses the service-linked role named **AWSServiceRoleForAmazonKeyspacesReplication** to allow Amazon Keyspaces to add new AWS Regions to a keyspace on your behalf, and replicate tables and all their data and settings to the new Region. The role also allows Amazon Keyspaces to replicate writes to tables in all Regions on your behalf.

The AWSServiceRoleForAmazonKeyspacesReplication service-linked role trusts the following services to assume the role:

- `replication.cassandra.amazonaws.com`

The role permissions policy named KeyspacesReplicationServiceRolePolicy allows Amazon Keyspaces to complete the following actions:

- Action: `cassandra:Select`
- Action: `cassandra:SelectMultiRegionResource`
- Action: `cassandra:Modify`
- Action: `cassandra:ModifyMultiRegionResource`
- Action: `cassandra:AlterMultiRegionResource`
- Action: `application-autoscaling:RegisterScalableTarget` – Amazon Keyspaces uses the application auto scaling permissions when you add a replica to a single Region table in provisioned mode with auto scaling enabled.
- Action: `application-autoscaling:DeregisterScalableTarget`
- Action: `application-autoscaling:DescribeScalableTargets`
- Action: `application-autoscaling:PutScalingPolicy`
- Action: `application-autoscaling:DescribeScalingPolicies`
- Action: `cassandra:Alter`
- Action: `cloudwatch:DeleteAlarms`
- Action: `cloudwatch:DescribeAlarms`
- Action: `cloudwatch:PutMetricAlarm`

Although the Amazon Keyspaces service-linked role AWSServiceRoleForAmazonKeyspacesReplication provides the permissions: "Action:" for the specified Amazon Resource Name (ARN) "arn:*" in the policy, Amazon Keyspaces supplies the ARN of your account.

Permissions to create the service-linked role AWSServiceRoleForAmazonKeyspacesReplication are included in the `AmazonKeyspacesFullAccess` managed policy. For more information, see the section called “AmazonKeyspacesFullAccess”.

You must configure permissions to allow your users, groups, or roles to create, edit, or delete a service-linked role. For more information, see Service-linked role permissions in the *IAM User Guide*.

Creating a service-linked role for Amazon Keyspaces

You can't manually create a service-linked role. When you create a multi-Region keyspace in the AWS Management Console, the AWS CLI, or the AWS API, Amazon Keyspaces creates the service-linked role for you.

If you delete this service-linked role, and then need to create it again, you can use the same process to recreate the role in your account. When you create a multi-Region keyspace, Amazon Keyspaces creates the service-linked role for you again.

Editing a service-linked role for Amazon Keyspaces

Amazon Keyspaces does not allow you to edit the AWSServiceRoleForAmazonKeyspacesReplication service-linked role. After you create a service-linked role, you cannot change the name of the role because various entities might reference the role. However, you can edit the description of the role using IAM. For more information, see Editing a service-linked role in the *IAM User Guide*.

Deleting a service-linked role for Amazon Keyspaces

If you no longer need to use a feature or service that requires a service-linked role, we recommend that you delete that role. That way you don’t have an unused entity that is not actively monitored or maintained. However, you must first delete all multi-Region keyspaces in the account across all AWS Regions before you can delete the service-linked role manually.

Cleaning up a service-linked role

Before you can use IAM to delete a service-linked role, you must first delete any multi-Region keyspaces and tables used by the role.

> **Note**
>
> If the Amazon Keyspaces service is using the role when you try to delete the resources, then the deletion might fail. If that happens, wait for a few minutes and try the operation again.

To delete Amazon Keyspaces resources used by the AWSServiceRoleForAmazonKeyspacesReplication (console)

1. Sign in to the AWS Management Console, and open the Amazon Keyspaces console at https://console.aws.amazon.com/keyspaces/home.
2. Choose **Keyspaces** from the left-side panel.
3. Select all multi-Region keyspaces from the list.
4. Choose **Delete** confirm the deletion and choose **Delete keyspaces**.

You can also delete multi-Region keyspaces programmatically using any of the following methods.

- The Cassandra Query Language (CQL) ??? statement.
- The delete-keyspace operation of the AWS CLI.
- The DeleteKeyspace operation of the Amazon Keyspaces API.

Manually delete the service-linked role

Use the IAM console, the AWS CLI, or the AWS API to delete the AWSServiceRoleForAmazonKeyspacesReplication service-linked role. For more information, see Deleting a service-linked role in the *IAM User Guide*.

Supported Regions for Amazon Keyspaces service-linked roles

Amazon Keyspaces does not support using service-linked roles in every Region where the service is available. You can use the AWSServiceRoleForAmazonKeyspacesReplication role in the following Regions.

Region name	Region identity	Support in Amazon Keyspaces
US East (N. Virginia)	us-east-1	Yes
US East (Ohio)	us-east-2	Yes
US West (N. California)	us-west-1	Yes
US West (Oregon)	us-west-2	Yes

Region name	Region identity	Support in Amazon Keyspaces
Asia Pacific (Mumbai)	ap-south-1	Yes
Asia Pacific (Osaka)	ap-northeast-3	Yes
Asia Pacific (Seoul)	ap-northeast-2	Yes
Asia Pacific (Singapore)	ap-southeast-1	Yes
Asia Pacific (Sydney)	ap-southeast-2	Yes
Asia Pacific (Tokyo)	ap-northeast-1	Yes
Canada (Central)	ca-central-1	Yes
Europe (Frankfurt)	eu-central-1	Yes
Europe (Ireland)	eu-west-1	Yes
Europe (London)	eu-west-2	Yes
Europe (Paris)	eu-west-3	Yes
Africa (Cape Town)	af-south-1	Yes
South America (São Paulo)	sa-east-1	Yes
AWS GovCloud (US-East)	us-gov-east-1	No
AWS GovCloud (US-West)	us-gov-west-1	No

Using roles for Amazon Keyspaces CDC streams

Amazon Keyspaces (for Apache Cassandra) uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to Amazon Keyspaces. Service-linked roles are predefined by Amazon Keyspaces and include all the permissions that the service requires to call other AWS services on your behalf.

A service-linked role makes setting up Amazon Keyspaces easier because you don't have to manually add the necessary permissions. Amazon Keyspaces defines the permissions of its service-linked roles, and unless defined otherwise, only Amazon Keyspaces can assume its roles. The defined permissions include the trust policy and the permissions policy, and that permissions policy cannot be attached to any other IAM entity.

You can't delete the service-linked role.

Service-linked role permissions for Amazon Keyspaces

Amazon Keyspaces uses the service-linked role named **AWSServiceRoleForAmazonKeyspacesCDC** to allow Amazon Keyspaces CDC streams to publish CloudWatch metrics into your account on your behalf.

The AWSServiceRoleForAmazonKeyspacesCDC service-linked role trusts the following service to assume the role:

- `cassandra-streams.amazonaws.com`

The role permissions policy named KeyspacesCDCServiceRolePolicy allows Amazon Keyspaces to complete the following action on resources in the CloudWatch namespace `AWS/Cassandra`:

- Action: `cloudwatch:PutMetricData` on `*`

  The AWSServiceRoleForAmazonKeyspacesCDC provides the permissions: Action: cloudwatch:PutMetricData on all resources that match the following condition: `"cloudwatch:namespace": "AWS/Cassandra"`.

For more information about KeyspacesCDCServiceRolePolicy, see the section called "KeyspacesCDCServiceRolePolicy".

To enable CDC streams for a table, which automatically creates the service-linked role AWSServiceRoleForAmazonKeyspacesCDC, the IAM principal needs the following permissions.

```
{
    "Sid": "KeyspacesCDCServiceLinkedRole",
    "Effect": "Allow",
    "Action": "iam:CreateServiceLinkedRole",
    "Resource": "arn:aws:iam::*:role/aws-service-role/cassandra-streams.amazonaws.com/
AWSServiceRoleForAmazonKeyspacesCDC",
```

```
    "Condition": {
    "StringLike": {
        "iam:AWSServiceName": "cassandra-streams.amazonaws.com"
    }
}
```

Permissions to create the service-linked role AWSServiceRoleForAmazonKeyspacesCDC are included in the `AmazonKeyspacesFullAccess` managed policy. For more information, see the section called “AmazonKeyspacesFullAccess”.

Creating a service-linked role for Amazon Keyspaces

You don't need to manually create a service-linked role for Amazon Keyspaces CDC streams. When you enable Amazon Keyspaces CDC streams on a table with the AWS Management Console, CQL, the AWS CLI, or the AWS API, Amazon Keyspaces creates the service-linked role for you.

If you delete this service-linked role, and then need to create it again, you can use the same process to recreate the role in your account. When you enable Amazon Keyspaces CDC streams for a table, Amazon Keyspaces creates the service-linked role for you again.

Editing a service-linked role for Amazon Keyspaces

Amazon Keyspaces doesn’t allow you to edit the AWSServiceRoleForAmazonKeyspacesCDC service-linked role. After you create a service-linked role, you cannot change the name of the role because various entities might reference the role. However, you can edit the description of the role using IAM. For more information, see Editing a service-linked role in the *IAM User Guide*.

Supported Regions for Amazon Keyspaces service-linked roles

Amazon Keyspaces supports using service-linked roles in all of the Regions where the service is available. For more information, see AWS Regions and endpoints.

Compliance validation for Amazon Keyspaces (for Apache Cassandra)

Third-party auditors assess the security and compliance of Amazon Keyspaces (for Apache Cassandra) as part of multiple AWS compliance programs. These include:

- ISO/IEC 27001:2013, 27017:2015, 27018:2019, and ISO/IEC 9001:2015. For more information, see AWS ISO and CSA STAR certifications and services.

- System and Organization Controls (SOC)
- Payment Card Industry (PCI)
- Federal Risk and Authorization Management Program (FedRAMP) High
- Health Insurance Portability and Accountability Act (HIPAA)

Our new AWS sign-up experience is not designed for regulated workloads. If you're using our new AWS sign-up experience, but you want to use AWS for regulated workloads, you can sign up for AWS (advanced) or activate advanced features for your AWS environment.

To learn whether an AWS service is within the scope of specific compliance programs, see AWS services in Scope by Compliance Program and choose the compliance program that you are interested in. For general information, see AWS Compliance Programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading Reports in AWS Artifact.

Your compliance responsibility when using AWS services is determined by the sensitivity of your data, your company's compliance objectives, and applicable laws and regulations. For more information about your compliance responsibility when using AWS services, see AWS Security Documentation.

Resilience and disaster recovery in Amazon Keyspaces

The AWS global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency, high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between Availability Zones without interruption. Availability Zones are more highly available, fault tolerant, and scalable than traditional single or multiple data center infrastructures.

Amazon Keyspaces replicates data automatically three times in multiple AWS Availability Zones within the same AWS Region for durability and high availability.

For more information about AWS Regions and Availability Zones, see AWS global infrastructure.

In addition to the AWS global infrastructure, Amazon Keyspaces offers several features to help support your data resiliency and backup needs.

multi-Region replication

Amazon Keyspaces provides multi-Region replication if you need to replicate your data or applications over greater geographic distances. You can replicate your Amazon Keyspaces tables across different AWS Regions of your choice. For more information, see the section called "Multi-Region replication".

Point-in-time recovery (PITR)

PITR helps protect your Amazon Keyspaces tables from accidental write or delete operations by providing you continuous backups of your table data. For more information, see Point-in-time recovery for Amazon Keyspaces.

Infrastructure security in Amazon Keyspaces

As a managed service, Amazon Keyspaces (for Apache Cassandra) is protected by AWS global network security. For information about AWS security services and how AWS protects infrastructure, see AWS Cloud Security. To design your AWS environment using the best practices for infrastructure security, see Infrastructure Protection in *Security Pillar AWS Well-Architected Framework*.

You use AWS published API calls to access Amazon Keyspaces through the network. Clients must support the following:

- Transport Layer Security (TLS). We require TLS 1.2 and recommend TLS 1.3.
- Cipher suites with perfect forward secrecy (PFS) such as DHE (Ephemeral Diffie-Hellman) or ECDHE (Elliptic Curve Ephemeral Diffie-Hellman). Most modern systems such as Java 7 and later support these modes.

Amazon Keyspaces supports two methods of authenticating client requests. The first method uses service-specific credentials, which are password based credentials generated for a specific IAM user. You can create and manage the password using the IAM console, the AWS CLI, or the AWS API. For more information, see Using IAM with Amazon Keyspaces.

The second method uses an authentication plugin for the open-source DataStax Java Driver for Cassandra. This plugin enables IAM users, roles, and federated identities to add authentication information to Amazon Keyspaces (for Apache Cassandra) API requests using the AWS Signature Version 4 process (SigV4). For more information, see the section called "Create IAM credentials for AWS authentication".

You can call these API operations from any network location, but Amazon Keyspaces does support resource-based access policies, which can include restrictions based on the source IP address. You can also use Amazon Keyspaces policies to control access from specific Amazon Virtual Private Cloud (Amazon VPC) endpoints or specific VPCs. Effectively, this isolates network access to a given Amazon Keyspaces resource from only the specific VPC within the AWS network.

You can use an interface VPC endpoint to keep traffic between your Amazon VPC and Amazon Keyspaces from leaving the Amazon network. Interface VPC endpoints are powered by AWS PrivateLink, an AWS technology that enables private communication between AWS services using an elastic network interface with private IPs in your Amazon VPC. For more information, see the section called “Using interface VPC endpoints”.

Using Amazon Keyspaces with interface VPC endpoints

Interface VPC endpoints enable private communication between your virtual private cloud (VPC) running in Amazon VPC and Amazon Keyspaces. Interface VPC endpoints are powered by AWS PrivateLink, which is an AWS service that enables private communication between VPCs and AWS services.

AWS PrivateLink enables this by using an elastic network interface with private IP addresses in your VPC so that network traffic does not leave the Amazon network. Interface VPC endpoints don't require an internet gateway, NAT device, VPN connection, or Direct Connect connection. For more information, see Amazon Virtual Private Cloud and Interface VPC endpoints (AWS PrivateLink).

Topics

- Using interface VPC endpoints for Amazon Keyspaces
- Populating system.peers table entries with interface VPC endpoint information
- Controlling access to interface VPC endpoints for Amazon Keyspaces
- Availability
- VPC endpoint policies and Amazon Keyspaces point-in-time recovery (PITR)
- Common errors and warnings

Using interface VPC endpoints for Amazon Keyspaces

You can create an interface VPC endpoint so that traffic between Amazon Keyspaces and your Amazon VPC resources starts flowing through the interface VPC endpoint. To get started, follow the steps to create an interface endpoint. Next, edit the security group associated with the

endpoint that you created in the previous step, and configure an inbound rule for port 9142. For more information, see Adding, removing, and updating rules.

For a step-by-step tutorial to configure a connection to Amazon Keyspaces through a VPC endpoint, see the section called "Connecting with VPC endpoints". To learn how to configure cross-account access for Amazon Keyspaces resources separated from applications in different AWS accounts in a VPC, see the section called "Configure cross-account access".

Populating `system.peers` table entries with interface VPC endpoint information

Apache Cassandra drivers use the `system.peers` table to query for node information about the cluster. Cassandra drivers use the node information to load balance connections and retry operations. Amazon Keyspaces populates nine entries in the `system.peers` table automatically for clients connecting through the public endpoint.

To provide clients connecting through interface VPC endpoints with similar functionality, Amazon Keyspaces populates the `system.peers` table in your account with an entry for each Availability Zone where a VPC endpoint is available. To look up and store available interface VPC endpoints in the `system.peers` table, Amazon Keyspaces requires that you grant the IAM entity used to connect to Amazon Keyspaces access permissions to query your VPC for the endpoint and network interface information.

> **Important**
>
> Populating the `system.peers` table with your available interface VPC endpoints improves load balancing and increases read/write throughput. It is recommended for all clients accessing Amazon Keyspaces using interface VPC endpoints and is required for Apache Spark.

To grant the IAM entity used to connect to Amazon Keyspaces permissions to look up the necessary interface VPC endpoint information, you can update your existing IAM role or user policy, or create a new IAM policy as shown in the following example.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"ListVPCEndpoints",
```

```
            "Effect":"Allow",
            "Action":[
               "ec2:DescribeNetworkInterfaces",
               "ec2:DescribeVpcEndpoints"
            ],
            "Resource":"*"
         }
      ]
}
```

> **Note**
>
> The managed policies `AmazonKeyspacesReadOnlyAccess_v2` and `AmazonKeyspacesFullAccess` include the required permissions to let Amazon Keyspaces access the Amazon EC2 instance to read information about available interface VPC endpoints.

To confirm that the policy has been set up correctly, query the `system.peers` table to see networking information. If the `system.peers` table is empty, it could indicate that the policy hasn't been configured successfully or that you have exceeded the request rate quota for `DescribeNetworkInterfaces` and `DescribeVPCEndpoints` API actions. `DescribeVPCEndpoints` falls into the `Describe*` category and is considered a *non-mutating action*. `DescribeNetworkInterfaces` falls into the subset of *unfiltered and unpaginated non-mutating actions*, and different quotas apply. For more information, see Request token bucket sizes and refill rates in the Amazon EC2 API Reference.

If you do see an empty table, try again a few minutes later to rule out request rate quota issues. To verify that you have configured the VPC endpoints correctly, see the section called “VPC endpoint connection errors”. If your query returns results from the table, your policy has been configured correctly.

Controlling access to interface VPC endpoints for Amazon Keyspaces

With VPC endpoint policies, you can control access to resources in two ways:

- **IAM policy** – You can control the requests, users, or groups that are allowed to access Amazon Keyspaces through a specific VPC endpoint. You can do this by using a condition key in the policy that is attached to an IAM user, group, or role.

- **VPC policy** – You can control which VPC endpoints have access to your Amazon Keyspaces resources by attaching policies to them. To restrict access to a specific keyspace or table to only allow traffic coming through a specific VPC endpoint, edit the existing IAM policy that restricts resource access and add that VPC endpoint.

The following are example endpoint policies for accessing Amazon Keyspaces resources.

- **IAM policy example: Restrict all access to a specific Amazon Keyspaces table unless traffic comes from the specified VPC endpoint** – This sample policy can be attached to an IAM user, role, or group. It restricts access to a specified Amazon Keyspaces table unless incoming traffic originates from a specified VPC endpoint.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "UserOrRolePolicyToDenyAccess",
         "Action": "cassandra:*",
         "Effect": "Deny",
         "Resource": [
                        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable",
                        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
           ],
         "Condition": { "StringNotEquals" : { "aws:sourceVpce": "vpce-abc123" } }
      }
   ]
}
```

> **Note**
>
> To restrict access to a specific table, you must also include access to the system tables. System tables are read-only.

- **VPC policy example: Read-only access** – This sample policy can be attached to a VPC endpoint. (For more information, see Controlling access to Amazon VPC resources). It restricts actions to read-only access to Amazon Keyspaces resources through the VPC endpoint that it's attached to.

```
{
```

```
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "ReadOnly",
      "Principal": "*",
      "Action": [
        "cassandra:Select"
      ],
      "Effect": "Allow",
      "Resource": "*"
    }
  ]
}
```

- **VPC policy example: Restrict access to a specific Amazon Keyspaces table** – This sample policy can be attached to a VPC endpoint. It restricts access to a specific table through the VPC endpoint that it's attached to.

```
{
   "Version": "2012-10-17",
   "Statement": [
        {
            "Sid": "RestrictAccessToTable",
            "Principal": "*",
            "Action": "cassandra:*",
            "Effect": "Allow",
            "Resource": [
                        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/
mykeyspace/table/mytable",
                        "arn:aws:cassandra:us-east-1:111122223333:/keyspace/system*"
           ]
        }
   ]
}
```

> **Note**
>
> To restrict access to a specific table, you must also include access to the system tables. System tables are read-only.

Availability

Amazon Keyspaces supports using interface VPC endpoints in all of the AWS Regions where the service is available. For more information, see ???.

VPC endpoint policies and Amazon Keyspaces point-in-time recovery (PITR)

If you are using IAM policies with condition keys to restrict incoming traffic, the table restore operation may fail. For example, if you restrict source traffic to specific VPC endpoints using `aws:SourceVpce` condition keys, the table restore operation fails. To allow Amazon Keyspaces to perform a restore operation on your principal's behalf, you must add an `aws:ViaAWSService` condition key to your IAM policy. The `aws:ViaAWSService` condition key allows access when any AWS service makes a request using the principal's credentials. For more information, see IAM JSON policy elements: Condition key in the *IAM User Guide*. The following policy is an example of this.

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Sid":"CassandraAccessForVPCE",
         "Effect":"Allow",
         "Action":"cassandra:*",
         "Resource":"*",
         "Condition":{
            "Bool":{
               "aws:ViaAWSService":"false"
            },
            "StringEquals":{
               "aws:SourceVpce":[
                  "vpce-12345678901234567"
               ]
            }
         }
      },
      {
         "Sid":"CassandraAccessForAwsService",
         "Effect":"Allow",
         "Action":"cassandra:*",
         "Resource":"*",
         "Condition":{
            "Bool":{
               "aws:ViaAWSService":"true"
```

```
            }
         }
      }
   ]
}
```

Common errors and warnings

If you're using Amazon Virtual Private Cloud and you connect to Amazon Keyspaces, you might see the following warning.

```
Control node cassandra.us-east-1.amazonaws.com/1.111.111.111:9142 has an entry
 for itself in system.peers: this entry will be ignored. This is likely due to a
 misconfiguration;
please verify your rpc_address configuration in cassandra.yaml on all nodes in your
 cluster.
```

This warning occurs because the `system.peers` table contains entries for all of the Amazon VPC endpoints that Amazon Keyspaces has permissions to view, including the Amazon VPC endpoint that you're connected through. You can safely ignore this warning.

For other errors, see the section called “VPC endpoint connection errors”.

Using Amazon Keyspaces CDC streams with interface VPC endpoints

Interface VPC endpoints enable private communication between your virtual private cloud (VPC) running in Amazon VPC and Amazon Keyspaces. Interface VPC endpoints are powered by AWS PrivateLink, which is an AWS service that enables private communication between VPCs and AWS services.

AWS PrivateLink enables this by using an elastic network interface with private IP addresses in your VPC so that network traffic does not leave the Amazon network. Interface VPC endpoints don't require an internet gateway, NAT device, VPN connection, or Direct Connect connection. For more information, see Amazon Virtual Private Cloud and Interface VPC endpoints (AWS PrivateLink).

Topics

- Using interface VPC endpoints for Amazon Keyspaces CDC streams
- Amazon Keyspaces CDC streams interface VPC endpoints
- Create Amazon Keyspaces CDC streams interface VPC endpoint
- Update an Amazon Keyspaces CDC streams interface VPC endpoint

- List streams using an Amazon Keyspaces CDC streams interface VPC endpoint
- Create a policy for an Amazon Keyspaces CDC streams interface VPC endpoint

Using interface VPC endpoints for Amazon Keyspaces CDC streams

You can use an interface VPC endpoint so that traffic between Amazon Keyspaces CDC streams and your Amazon VPC resources starts flowing through the interface VPC endpoint. You can use VPC endpoint policies to restrict access to your CDC streams.

For more information about Amazon Keyspaces CDC streams, see the section called "Working with CDC streams".

Amazon Keyspaces CDC streams interface VPC endpoints

When you create an interface endpoint, Amazon Keyspaces CDC streams generates two types of endpoint-specific DNS name for the stream: *Regional* and *Zonal*.

Regional

The Regional DNS name includes the following information:

- a unique Amazon VPC endpoint ID
- a service identifier
- the AWS Region
- the `vpce.amazonaws.com` suffix

For an Amazon VPC endpoint with the ID `vpce-1a2b3c4d`, the generated DNS name might be look similar to the following example: `vpce-1a2b3c4d-5e6f.cassandra-streams.us-east-1.vpce.amazonaws.com`.

Zonal

The Zonal DNS name includes the Availability Zone in addition to the information in the Regional DNS name. The generated DNS name for the Amazon VPC endpoint with the ID `vpce-1a2b3c4d` would look like in the following example, note that the AWS Region now includes the Availability Zone: `vpce-1a2b3c4d-5e6f-us-east-1a.cassandra-streams.us-east-1.vpce.amazonaws.com`

You can use this option if your architecture isolates Availability Zones. For example, you could use it for fault containment or to reduce Regional data transfer costs.

> **Note**
>
> To achieve optimal reliability, we recommend deploying your service across a minimum of three Availability Zones.

Create Amazon Keyspaces CDC streams interface VPC endpoint

You can use the AWS CLI or the AWS SDK to access Amazon Keyspaces CDC Streams API operations through Amazon Keyspaces CDC Streams interface endpoints. For a complete listing of all available API operations, see *Amazon Keyspaces Streams API Reference*.

For more information about how to create VPC endpoints, see create an interface endpoint in the Amazon VPC User Guide.

To create a VPC endpoint, you can use the syntax in the following example.

```
aws ec2 create-vpc-endpoint \
  --region us-east-1 \
  --service-name api.aws.us-east-1.cassandra-streams \
  --vpc-id client-vpc-id \
  --subnet-ids client-subnet-id \
  --vpc-endpoint-type Interface \
  --security-group-ids client-sg-id
```

Update an Amazon Keyspaces CDC streams interface VPC endpoint

To update a VPC endpoint, you can use the syntax in the following example.

```
aws ec2 modify-vpc-endpoint \
  --region us-east-1 \
  --vpc-endpoint-id client-vpc-id \
  --policy-document policy-document \ #example optional parameter
  --add-security-group-ids security-group-ids \ #example optional parameter
```

List streams using an Amazon Keyspaces CDC streams interface VPC endpoint

To list the streams that are using a VPC endpoint, you can use the syntax in the following example. Make sure to replace the Region and the DNS name of the VPC endpoint ID with your own information.

```
aws keyspacesstreams \
  --endpoint https://vpce-1a2b3c4d-5e6f.cassandra-streams.us-east-1.vpce.amazonaws.com
 \
  --region us-east-1 \
  list-streams
```

Create a policy for an Amazon Keyspaces CDC streams interface VPC endpoint

You can attach an endpoint policy to your Amazon VPC endpoint that controls access to Amazon Keyspaces CDC streams. The policy specifies the following information:

- The AWS Identity and Access Management (IAM) principal that can perform actions
- The actions that can be performed
- The resources on which actions can be performed

To restrict access to specific Amazon Keyspaces CDC streams to only allow specific AWS services in your Amazon VPC access, you can use the following example.

The following stream policy grants access to any IAM principal for the actions `cassandra:GetStream` and `cassandra:GetRecords` for the specified stream `2025-02-20T11:22:33.444` attached to the resource `/keyspace/mykeyspace/table/mytable/` belonging to account `123456788901`. To use this endpoint policy, make sure to replace the Region, account ID, and resource with stream label.

```
{
"Version": "2012-10-17",
  "Id": "Policy1216114807515",
  "Statement": [
    { "Sid": "Access-to-specific-stream-only",
      "Principal": "*",
      "Action": [
        "cassandra:GetStream",
        "cassandra:GetRecords"
      ],
      "Effect": "Allow",
      "Resource": ["arn:aws:cassandra:us-east-1:111122223333:/keyspace/mykeyspace/
table/mytable/stream/2025-02-20T11:22:33.444"]
    }
  ]
```

```
}
```

> **Note**
>
> Amazon Keyspaces doesn't support Gateway endpoints for CDC streams.

Configuration and vulnerability analysis for Amazon Keyspaces

AWS handles basic security tasks like guest operating system (OS) and database patching, firewall configuration, and disaster recovery. These procedures have been reviewed and certified by the appropriate third parties. For more details, see the following resources:

- Shared responsibility model
- Amazon Web Services: Overview of security processes(whitepaper)

Security best practices for Amazon Keyspaces

Amazon Keyspaces (for Apache Cassandra) provides a number of security features to consider as you develop and implement your own security policies. The following best practices are general guidelines and don’t represent a complete security solution. Because these best practices might not be appropriate or sufficient for your environment, treat them as helpful considerations rather than prescriptions.

Topics

- Preventative security best practices for Amazon Keyspaces
- Detective security best practices for Amazon Keyspaces

Preventative security best practices for Amazon Keyspaces

The following security best practices are considered preventative because they can help you anticipate and prevent security incidents in Amazon Keyspaces.

Use encryption at rest

Amazon Keyspaces encrypts at rest all user data that's stored in tables by using encryption keys stored in AWS Key Management Service (AWS KMS). This provides an additional layer of data protection by securing your data from unauthorized access to the underlying storage.

By default, Amazon Keyspaces uses an AWS owned key for encrypting all of your tables. If this key doesn't exist, it's created for you. Service default keys can't be disabled.

Alternatively, you can use a customer managed key for encryption at rest. For more information, see Amazon Keyspaces Encryption at Rest.

Use IAM roles to authenticate access to Amazon Keyspaces

For users, applications, and other AWS services to access Amazon Keyspaces, they must include valid AWS credentials in their AWS API requests. You should not store AWS credentials directly in the application or EC2 instance. These are long-term credentials that are not automatically rotated, and therefore could have significant business impact if they are compromised. An IAM role enables you to obtain temporary access keys that can be used to access AWS services and resources.

For more information, see IAM Roles.

Use IAM policies for Amazon Keyspaces base authorization

When granting permissions, you decide who is getting them, which Amazon Keyspaces APIs they are getting permissions for, and the specific actions you want to allow on those resources. Implementing least privilege is key in reducing security risks and the impact that can result from errors or malicious intent.

Attach permissions policies to IAM identities (that is, users, groups, and roles) and thereby grant permissions to perform operations on Amazon Keyspaces resources.

You can do this by using the following:

- AWS managed (predefined) policies
- Customer managed policies

Use IAM policy conditions for fine-grained access control

When you grant permissions in Amazon Keyspaces, you can specify conditions that determine how a permissions policy takes effect. Implementing least privilege is key in reducing security risks and the impact that can result from errors or malicious intent.

You can specify conditions when granting permissions using an IAM policy. For example, you can do the following:

- Grant permissions to allow users read-only access to specific keyspaces or tables.
- Grant permissions to allow a user write access to a certain table, based upon the identity of that user.

For more information, see Identity-Based Policy Examples.

Consider client-side encryption

If you store sensitive or confidential data in Amazon Keyspaces, you might want to encrypt that data as close as possible to its origin so that your data is protected throughout its lifecycle. Encrypting your sensitive data in transit and at rest helps ensure that your plaintext data isn't available to any third party.

Detective security best practices for Amazon Keyspaces

The following security best practices are considered detective because they can help you detect potential security weaknesses and incidents.

Use AWS CloudTrail to monitor AWS Key Management Service (AWS KMS) AWS KMS key usage

If you're using a customer managed AWS KMS key for encryption at rest, usage of this key is logged into AWS CloudTrail. CloudTrail provides visibility into user activity by recording actions taken on your account. CloudTrail records important information about each action, including who made the request, the services used, the actions performed, parameters for the actions, and the response elements returned by the AWS service. This information helps you track changes made to your AWS resources and troubleshoot operational issues. CloudTrail makes it easier to ensure compliance with internal policies and regulatory standards.

You can use CloudTrail to audit key usage. CloudTrail creates log files that contain a history of AWS API calls and related events for your account. These log files include all AWS KMS API requests that were made using the console, AWS SDKs, and command line tools, in addition to those made through integrated AWS services. You can use these log files to get information about when the AWS KMS key was used, the operation that was requested, the identity of the requester, the IP address that the request came from, and so on. For more information, see Logging AWS Key Management Service API Calls with AWS CloudTrail and the AWS CloudTrail User Guide.

Use CloudTrail to monitor Amazon Keyspaces data definition language (DDL) operations

CloudTrail provides visibility into user activity by recording actions taken on your account. CloudTrail records important information about each action, including who made the request, the services used, the actions performed, parameters for the actions, and the response elements returned by the AWS service. This information helps you to track changes made to your AWS resources and to troubleshoot operational issues. CloudTrail makes it easier to ensure compliance with internal policies and regulatory standards.

All Amazon Keyspaces DDL operations are logged in CloudTrail automatically. DDL operations let you create and manage Amazon Keyspaces keyspaces and tables.

When activity occurs in Amazon Keyspaces, that activity is recorded in a CloudTrail event along with other AWS service events in the event history. For more information, see Logging Amazon Keyspaces operations by using AWS CloudTrail. You can view, search, and download recent events in your AWS account. For more information, see Viewing events with CloudTrail event history in the *AWS CloudTrail User Guide*.

For an ongoing record of events in your AWS account, including events for Amazon Keyspaces, create a trail. A trail enables CloudTrail to deliver log files to an Amazon Simple Storage Service (Amazon S3) bucket. By default, when you create a trail on 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 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.

Tag your Amazon Keyspaces resources for identification and automation

You can assign metadata to your AWS resources in the form of tags. Each tag is a simple label that consists of a customer-defined key and an optional value that can make it easier to manage, search for, and filter resources.

Tagging allows for grouped controls to be implemented. Although there are no inherent types of tags, they enable you to categorize resources by purpose, owner, environment, or other criteria. The following are some examples:

- Access – Used to control access to Amazon Keyspaces resources based on tags. For more information, see the section called “Authorization based on Amazon Keyspaces tags”.
- Security – Used to determine requirements such as data protection settings.
- Confidentiality – An identifier for the specific data-confidentiality level that a resource supports.

- Environment – Used to distinguish between development, test, and production infrastructure.

For more information, see AWS tagging strategies and Adding tags and labels to resources.

CQL language reference for Amazon Keyspaces (for Apache Cassandra)

After you connect to an Amazon Keyspaces endpoint, you use Cassandra Query Language (CQL) to work with your database. CQL is similar in many ways to Structured Query Language (SQL).

- **CQL elements** – This section covers the fundamental elements of CQL supported in Amazon Keyspaces, including identifiers, constants, terms, and data types. It explains concepts like string types, numeric types, collection types, and more.
- **Data Definition Language (DDL)** – DDL statements are used to manage data structures like keyspaces and tables in Amazon Keyspaces. This section covers statements for creating, altering, and dropping keyspaces and tables, as well as restoring tables from a point-in-time backup.
- **Data Manipulation Language (DML)** – DML statements are used to manage data within tables. This section covers statements for selecting, inserting, updating, and deleting data. It also explains advanced querying capabilities like using the `IN` operator, ordering results, and pagination.
- **Built-in functions** – Amazon Keyspaces supports a variety of built-in scalar functions that you can use in CQL statements. This section provides an overview of these functions, including examples of their usage.

Throughout this topic, you'll find detailed syntax, examples, and best practices for using CQL effectively in Amazon Keyspaces.

Topics

- Cassandra Query Language (CQL) elements in Amazon Keyspaces
- DDL statements (data definition language) in Amazon Keyspaces
- DML statements (data manipulation language) in Amazon Keyspaces
- Built-in functions in Amazon Keyspaces

Cassandra Query Language (CQL) elements in Amazon Keyspaces

Learn about the Cassandra Query Language (CQL) elements that are supported by Amazon Keyspaces, including identifiers, constants, terms, and data types.

Topics

- Identifiers
- Constants
- Terms
- Data types
- JSON encoding of Amazon Keyspaces data types

Identifiers

Identifiers (or names) are used to identify tables, columns, and other objects. An identifier can be quoted or not quoted. The following applies.

```
identifier          ::=  unquoted_identifier | quoted_identifier
unquoted_identifier ::=  re('[a-zA-Z][a-zA-Z0-9_]*')
quoted_identifier   ::=  '"' (any character where " can appear if doubled)+ '"'
```

Constants

The following constants are defined.

```
constant ::=  string | integer | float | boolean | uuid | blob | NULL
string   ::=  '\'' (any character where ' can appear if doubled)+ '\''
              '$$' (any character other than '$$') '$$'
integer  ::=  re('-?[0-9]+')
float    ::=  re('-?[0-9]+(\.[0-9]*)?([eE][+-]?[0-9+])?') | NAN | INFINITY
boolean  ::=  TRUE | FALSE
uuid     ::=  hex{8}-hex{4}-hex{4}-hex{4}-hex{12}
hex      ::=  re("[0-9a-fA-F]")
blob     ::=  '0' ('x' | 'X') hex+
```

Terms

A term denotes the kind of values that are supported. Terms are defined by the following.

```
term                ::=  constant | literal | function_call | arithmetic_operation |
 type_hint | bind_marker
literal             ::=  collection_literal | tuple_literal
function_call       ::=  identifier '(' [ term (',' term)* ] ')'
arithmetic_operation ::=  '-' term | term ('+' | '-' | '*' | '/' | '%') term
```

Data types

Amazon Keyspaces supports the following data types:

String types

Data type	Description
`ascii`	Represents an ASCII character string.
`text`	Represents a UTF-8 encoded string.
`varchar`	Represents a UTF-8 encoded string (`varchar` is an alias for `text`).

Numeric types

Data type	Description
`bigint`	Represents a 64-bit signed long.
`counter`	Represents a 64-bit signed integer counter. For more information, see the section called "Counters".
`decimal`	Represents a variable-precision decimal.
`double`	Represents a 64-bit IEEE 754 floating point.

Data type	Description
`float`	Represents a 32-bit IEEE 754 floating point.
`int`	Represents a 32-bit signed int.
`varint`	Represents an integer value within the +/-10^38 range.

Counters

A `counter` column contains a 64-bit signed integer. The counter value is incremented or decremented using the the section called "UPDATE" statement, and it cannot be set directly. This makes `counter` columns useful for tracking counts. For example, you can use counters to track the number of entries in a log file or the number of times a post has been viewed on a social network. The following restrictions apply to `counter` columns:

- A column of type `counter` cannot be part of the `primary key` of a table.
- In a table that contains one or more columns of type `counter`, all columns in that table must be of type `counter`.

In cases where a counter update fails (for example, because of timeouts or loss of connection with Amazon Keyspaces), the client doesn't know whether the counter value was updated. If the update is retried, the update to the counter value might get applied a second time.

Blob type

Data type	Description
`blob`	Represents arbitrary bytes.

Boolean type

Data type	Description
`boolean`	Represents `true` or `false`.

Time-related types

Data type	Description
`date`	A string in the format `<yyyy>-<mm>-<dd>` .
`timestamp`	64-bit signed integer representing the date and time since epoch (January 1 1970 at 00:00:00 GMT) in milliseconds.
`timeuuid`	Represents a version 1 UUID.

Collection types

Data type	Description
`list`	Represents an ordered collection of literal elements.
`map`	Represents an unordered collection of key-value pairs.
`set`	Represents an unordered collection of one or more literal elements.

You declare a collection column by using the collection type followed by another data type (for example, `TEXT` or `INT`) in angled brackets. You can create a column with a `SET` of `TEXT`, or you can create a `MAP` of `TEXT` and `INT` key-value pairs, as shown in the following example.

```
SET <TEXT>
MAP <TEXT, INT>
```

A *non-frozen* collection allows you to make updates to each individual collection element. Client-side timestamps and Time to Live (TTL) settings are stored for individual elements.

When you use the `FROZEN` keyword on a collection type, the values of the collection are serialized into a single immutable value, and Amazon Keyspaces treats them like a `BLOB`. This is a *frozen*

collection. An INSERT or UPDATE statement overwrites the entire frozen collection. You can't make updates to individual elements inside a frozen collection.

Client-side timestamps and Time to Live (TTL) settings apply to the entire frozen collection, not to individual elements. Frozen collection columns can be part of the PRIMARY KEY of a table.

You can nest frozen collections. For example, you can define a MAP within a SET if the MAP is using the FROZEN keyword, as shown in the following example.

```
SET <FROZEN> <MAP <TEXT, INT>>>
```

Amazon Keyspaces supports nesting of up to 8 levels of frozen collections by default. For more information, see the section called "Amazon Keyspaces service quotas". For more information about functional differences with Apache Cassandra, see the section called "FROZEN collections". For more information about CQL syntax, see the section called "CREATE TABLE" and the section called "ALTER TABLE".

Tuple type

The tuple data type represents a bounded group of literal elements. You can use a tuple as an alternative to a user defined type. You don't need to use the FROZEN keyword for tuples. This is because a tuple is always frozen and you can't update elements individually.

Other types

Data type	Description
inet	A string representing an IP address, in either IPv4 or IPv6 format.

Static

In an Amazon Keyspaces table with clustering columns, you can use the STATIC keyword to create a static column of any type.

The following statement is an example of this.

```
my_column INT STATIC
```

For more information about working with static columns, see the section called "Estimate capacity consumption of static columns".

User-defined types (UDTs)

Amazon Keyspaces supports user-defined types (UDTs). You can use any valid Amazon Keyspaces data type to create a UDT, including collections and other existing UDTs. You create UDTs in a keyspace and can use them to define columns in any table in the keyspace.

For more information about CQL syntax, see the section called "Types". For more information about working with UDTs, see the section called "User-defined types (UDTs)".

To review how many UDTs are supported per keyspace, supported levels of nesting, and other default values and quotas related to UDTs, see the section called "Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces".

JSON encoding of Amazon Keyspaces data types

Amazon Keyspaces offers the same JSON data type mappings as Apache Cassandra. The following table describes the data types Amazon Keyspaces accepts in `INSERT JSON` statements and the data types Amazon Keyspaces uses when returning data with the `SELECT JSON` statement.

For single-field data types such as `float`, `int`, `UUID`, and `date`, you also can insert data as a `string`. For compound data types and collections, such as `tuple`, `map`, and `list`, you can also insert data as JSON or as an encoded `JSON string`.

JSON data type	Data types accepted in `INSERT JSON` statements	Data types returned in `SELECT JSON` statements	Notes
`ascii`	`string`	`string`	Uses JSON character escape `\u`.
`bigint`	`integer, string`	`integer`	String must be a valid 64-bit integer.
`blob`	`string`	`string`	String should begin with `0x` followed by an even number of hex digits.

JSON data type	Data types accepted in `INSERT JSON` statements	Data types returned in `SELECT JSON` statements	Notes
`boolean`	`boolean, string`	`boolean`	String must be either `true` or `false`.
`date`	`string`	`string`	Date in format `YYYY-MM-DD` , timezone UTC.
`decimal`	`integer, float, string`	`float`	Can exceed 32-bit or 64-bit IEEE-754 floating point precision in client-si de decoder.
`double`	`integer, float, string`	`float`	String must be a valid integer or float.
`float`	`integer, float, string`	`float`	String must be a valid integer or float.
`inet`	`string`	`string`	IPv4 or IPv6 address.
`int`	`integer, string`	`integer`	String must be a valid 32-bit integer.
`list`	`list, string`	`list`	Uses the native JSON list representation.
`map`	`map, string`	`map`	Uses the native JSON map representation.
`smallint`	`integer, string`	`integer`	String must be a valid 16-bit integer.
`set`	`list, string`	`list`	Uses the native JSON list representation.

JSON data type	Data types accepted in `INSERT JSON` statements	Data types returned in `SELECT JSON` statements	Notes
`text`	`string`	`string`	Uses JSON character escape `\u`.
`time`	`string`	`string`	Time of day in format `HH-MM-SS[.fffffffff]` .
`timestamp`	`integer, string`	`string`	A timestamp. String constants allow you to store timestamps as dates. Date stamps with format `YYYY-MM-DD HH:MM:SS.SSS` are returned.
`timeuuid`	`string`	`string`	Type 1 UUID. See constants for the UUID format.
`tinyint`	`integer, string`	`integer`	String must be a valid 8-bit integer.
`tuple`	`list, string`	`list`	Uses the native JSON list representation.
UDT	`map, string`	`map`	Uses the native JSON map representation with field names as keys.
`uuid`	`string`	`string`	See constants for the UUID format.

JSON data type	Data types accepted in `INSERT JSON` statements	Data types returned in `SELECT JSON` statements	Notes
`varchar`	`string`	`string`	Uses JSON character escape \u.
`varint`	`integer, string`	`integer`	Variable length; might overflow 32-bit or 64-bit integers in client-side decoder.

DDL statements (data definition language) in Amazon Keyspaces

Data definition language (DDL) is the set of Cassandra Query Language (CQL) statements that you use to manage data structures in Amazon Keyspaces (for Apache Cassandra), such as keyspaces and tables. You use DDL to create these data structures, modify them after they are created, and remove them when they're no longer in use. Amazon Keyspaces performs DDL operations asynchronously. For more information about how to confirm that an asynchronous operation has completed, see the section called “Asynchronous creation and deletion of keyspaces and tables”.

The following DDL statements are supported:

- CREATE KEYSPACE
- ALTER KEYSPACE
- DROP KEYSPACE
- USE
- CREATE TABLE
- ALTER TABLE
- RESTORE TABLE
- DROP TABLE
- CREATE TYPE
- DROP TYPE

Topics

- Keyspaces
- Tables
- User-defined types (UDTs)

Keyspaces

A *keyspace* groups related tables that are relevant for one or more applications. In terms of a relational database management system (RDBMS), keyspaces are roughly similar to databases, tablespaces, or similar constructs.

> **Note**
>
> In Apache Cassandra, keyspaces determine how data is replicated among multiple storage nodes. However, Amazon Keyspaces is a fully managed service: The details of its storage layer are managed on your behalf. For this reason, keyspaces in Amazon Keyspaces are logical constructs only, and aren't related to the underlying physical storage.

For information about quota limits and constraints for Amazon Keyspaces keyspaces, see *Quotas*.

Statements for keyspaces

- CREATE KEYSPACE
- ALTER KEYSPACE
- DROP KEYSPACE
- USE

CREATE KEYSPACE

Use the `CREATE KEYSPACE` statement to create a new keyspace.

Syntax

```
create_keyspace_statement ::=
    CREATE KEYSPACE [ IF NOT EXISTS ] keyspace_name
    WITH options
```

Where:

- *keyspace_name* is the name of the keyspace to be created.
- *options* are one or more of the following:
  - REPLICATION – A map that indicates the replication strategy for the keyspace:
    - SingleRegionStrategy – For a single-Region keyspace. (Required)
    - NetworkTopologyStrategy – Specify at least two AWS Regions. The replication factor for each Region is three. (Optional)
  - DURABLE_WRITES – Writes to Amazon Keyspaces are always durable, so this option isn't required. However, if specified, the value must be true.
  - TAGS – A list of key-value pair tags to be attached to the resource when you create it. (Optional)

Example

Create a keyspace as follows.

```
CREATE KEYSPACE my_keyspace
    WITH REPLICATION = {'class': 'SingleRegionStrategy'} and TAGS ={'key1':'val1',
 'key2':'val2'} ;
```

To create a multi-Region keyspace, specify NetworkTopologyStrategy and include at least two AWS Regions. The replication factor for each Region is three.

```
CREATE KEYSPACE my_keyspace
    WITH REPLICATION = {'class':'NetworkTopologyStrategy', 'us-east-1':'3', 'ap-
southeast-1':'3','eu-west-1':'3'};
```

ALTER KEYSPACE

You can use the ALTER KEYSPACE WITH statement for the following *options*

- REPLICATION – Use this option to add a new AWS Region replica to a keyspace. You can add a new Region to a single-Region or to a multi-Region keyspace.
- TAGS – Use this option to add or remove tags from a keyspace.

Syntax

```
alter_keyspace_statement ::=
    ALTER KEYSPACE keyspace_name
    WITH options
```

Where:

- *keyspace_name* is the name of the keyspace to be altered.
- *options* are one of the following:
  - ADD | DROP TAGS – A list of key-value pair tags to be added or removed from the keyspace.
  - REPLICATION – A map that indicates the replication strategy for the keyspace;
    - class– NetworkTopologyStrategy defines the keyspace as a multi-Region keyspace.
    - region– Specify one additional AWS Region for this keyspace. The replication factor for each Region is three.
    - CLIENT_SIDE_TIMESTAMPS – The default is DISABLED. You can only change the status to ENABLED.

Examples

Alter a keyspace as shown in the following example to add tags.

```
ALTER KEYSPACE my_keyspace ADD TAGS {'key1':'val1', 'key2':'val2'};
```

To add a third Region to a multi-Region keyspace, you can use the following statement.

```
ALTER KEYSPACE my_keyspace
WITH REPLICATION = {
    'class': 'NetworkTopologyStrategy',
    'us-east-1': '3',
    'us-west-2': '3',
    'us-west-1': '3'
} AND CLIENT_SIDE_TIMESTAMPS = {'status': 'ENABLED'};
```

DROP KEYSPACE

Use the DROP KEYSPACE statement to remove a keyspace—including all of its contents, such as tables.

Syntax

```
drop_keyspace_statement ::=
    DROP KEYSPACE [ IF EXISTS ] keyspace_name
```

Where:

- *keyspace_name* is the name of the keyspace to be dropped.

Example

```
DROP KEYSPACE my_keyspace;
```

USE

Use the USE statement to define the current keyspace. This allows you to refer to objects bound to a specific keyspace, for example tables and types, without using the fully qualified name that includes the keyspace prefix.

Syntax

```
use_statement ::=
    USE keyspace_name
```

Where:

- *keyspace_name* is the name of the keyspace to be used.

Example

```
USE my_keyspace;
```

Tables

Tables are the primary data structures in Amazon Keyspaces. Data in a table is organized into rows and columns. A subset of those columns is used to determine partitioning (and ultimately data placement) through the specification of a partition key.

Another set of columns can be defined into clustering columns, which means that they can participate as predicates in query execution.

By default, new tables are created with *on-demand* throughput capacity. You can change the capacity mode for new and existing tables. For more information about read/write capacity throughput modes, see the section called "Configure read/write capacity modes".

For tables in provisioned mode, you can configure optional AUTOSCALING_SETTINGS. For more information about Amazon Keyspaces auto scaling and the available options, see the section called "Configure automatic scaling on an existing table".

For information about quota limits and constraints for Amazon Keyspaces tables, see *Quotas*.

Statements for tables

- CREATE TABLE
- ALTER TABLE
- RESTORE TABLE
- DROP TABLE

CREATE TABLE

Use the CREATE TABLE statement to create a new table.

Syntax

```
create_table_statement ::=  CREATE TABLE [ IF NOT EXISTS ] table_name
    '('
        column_definition
        ( ',' column_definition )*
        [ ',' PRIMARY KEY '(' primary_key ')' ]
    ')' [ WITH table_options ]

column_definition      ::=  column_name cql_type [ FROZEN ][ STATIC ][ PRIMARY KEY]

primary_key            ::=  partition_key [ ',' clustering_columns ]

partition_key          ::=  column_name
                              | '(' column_name ( ',' column_name )* ')'

clustering_columns     ::=  column_name ( ',' column_name )*

table_options          ::=  [table_options]
                              | CLUSTERING ORDER BY '(' clustering_order
 ')' [ AND table_options ]
```

```
                              | cdc
                              | CUSTOM_PROPERTIES
                              | AUTOSCALING_SETTINGS
                              | default_time_to_live
                              | TAGS

clustering_order       ::=  column_name (ASC | DESC) ( ',' column_name (ASC | DESC) )*
```

Where:

- *table_name* is the name of the table to be created. The fully qualified name includes the keyspace prefix. Alternatively, you can set the current keyspace with the USE keyspace statement.
- *column_definition* consists of the following:
  - *column_name* – The name of the column.
  - *cql_type* – An Amazon Keyspaces data type (see Data types).
  - *FROZEN* – Designates this column that is user-defined or of type `collection` (for example, `LIST`, `SET`, or `MAP`) as frozen. A *frozen* collection is serialized into a single immutable value and treated like a `BLOB`. For more information, see the section called “Collection types”.
  - *STATIC* – Designates this column as static. Static columns store values that are shared by all rows in the same partition.
  - *PRIMARY KEY* – Designates this column as the table's primary key.
- *primary_key* consists of the following:
  - `partition_key`
  - `clustering_columns`
- *partition_key*:
  - The partition key can be a single column, or it can be a compound value composed of two or more columns. The partition key portion of the primary key is required and determines how Amazon Keyspaces stores your data.
- *clustering_columns*:
  - The optional clustering column portion of your primary key determines how the data is clustered and sorted within each partition.
- *table_options* consist of the following:
  - *CLUSTERING ORDER BY* – The default CLUSTERING ORDER on a table is composed of your clustering keys in the ASC (ascending) sort direction. Specify it to override the default sort behavior.

- *cdc* – A boolean that specifies if Amazon Keyspaces creates a change data capture (CDC) stream for the table. The default is `false`. To specify the `view type` when enabling a stream, set the `cdc_specification` with `CUSTOM_PROPERTIES` .
- *CUSTOM_PROPERTIES* – A map of settings that are specific to Amazon Keyspaces.
  - `capacity_mode`: Specifies the read/write throughput capacity mode for the table. The options are `throughput_mode:PAY_PER_REQUEST` and `throughput_mode:PROVISIONED`. The provisioned capacity mode requires `read_capacity_units` and `write_capacity_units` as inputs. The default is `throughput_mode:PAY_PER_REQUEST`.
  - `cdc_specification`: Specifies the `view_type` of the CDC stream. The options are:
    - `NEW_AND_OLD_IMAGES` – both versions of the row, before and after the change. This is the default.
    - `NEW_IMAGE` – the version of the row after the change.
    - `OLD_IMAGE` – the version of the row before the change.
    - `KEYS_ONLY` – the partition and clustering keys of the row that was changed.

    For more information about CDC streams, see the section called "Working with CDC streams". For code examples, see the section called "Enable a CDC stream for a new table".
  - `client_side_timestamps`: Specifies if client-side timestamps are enabled or disabled for the table. The options are `{'status': 'enabled'}` and `{'status': 'disabled'}`. If it's not specified, the default is `status:disabled`. After client-side timestamps are enabled for a table, this setting cannot be disabled.
  - `encryption_specification`: Specifies the encryption options for encryption at rest. If it's not specified, the default is `encryption_type:AWS_OWNED_KMS_KEY`. The encryption option customer managed key requires the AWS KMS key in Amazon Resource Name (ARN) format as input: `kms_key_identifier:ARN`: `kms_key_identifier:ARN`.
  - `point_in_time_recovery`: Specifies if point-in-time restore is enabled or disabled for the table. The options are `status:enabled` and `status:disabled`. If it's not specified, the default is `status:disabled`.
  - `replica_updates`: Specifies the settings of a multi-Region table that are specific to an AWS Region. For a multi-Region table, you can configure the table's read capacity differently per AWS Region. You can do this by configuring the following parameters. For more information and examples, see the section called "Create a multi-Region table in provisioned mode".

    - `region` – The AWS Region of the table replica with the following settings:
      - `read_capacity_units`
  - TTL: Enables Time to Live custom settings for the table. To enable, use `status:enabled`. The default is `status:disabled`. After TTL is enabled, you can't disable it for the table.
- *`AUTOSCALING_SETTINGS`* includes the following optional settings for tables in provisioned mode. For more information and examples, see the section called “Create a new table with automatic scaling”.
  - `provisioned_write_capacity_autoscaling_update`:
    - `autoscaling_disabled` – To enable auto scaling for write capacity, set the value to `false`. The default is `true`. (Optional)
    - `minimum_units` – The minimum level of write throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
    - `maximum_units` – The maximum level of write throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
    - `scaling_policy` – Amazon Keyspaces supports the target tracking policy. The auto scaling target is the provisioned write capacity of the table.
      - `target_tracking_scaling_policy_configuration` – To define the target tracking policy, you must define the target value. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.
        - `target_value` – The target utilization rate of the table. Amazon Keyspaces auto scaling ensures that the ratio of consumed capacity to provisioned capacity stays at or near this value. You define `target_value` as a percentage. A double between 20 and 90. (Required)
        - `scale_in_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale in activity starts. If no value is provided, the default is 0. (Optional)
        - `scale_out_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale out activity starts. If no value is provided, the default is 0. (Optional)

        - `disable_scale_in`: A `boolean` that specifies if `scale-in` is disabled or enabled for the table. This parameter is disabled by default. To turn on `scale-in`, set the `boolean` value to `FALSE`. This means that capacity is automatically scaled down for a table on your behalf. (Optional)

- `provisioned_read_capacity_autoscaling_update`:
    - `autoscaling_disabled` – To enable auto scaling for read capacity, set the value to `false`. The default is `true`. (Optional)
    - `minimum_units` – The minimum level of throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
    - `maximum_units` – The maximum level of throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
    - `scaling_policy` – Amazon Keyspaces supports the target tracking policy. The auto scaling target is the provisioned read capacity of the table.
        - `target_tracking_scaling_policy_configuration` – To define the target tracking policy, you must define the target value. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.
            - `target_value` – The target utilization rate of the table. Amazon Keyspaces auto scaling ensures that the ratio of consumed capacity to provisioned capacity stays at or near this value. You define `target_value` as a percentage. A double between 20 and 90. (Required)
            - `scale_in_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale in activity starts. If no value is provided, the default is 0. (Optional)
            - `scale_out_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale out activity starts. If no value is provided, the default is 0. (Optional)
            - `disable_scale_in`: A `boolean` that specifies if `scale-in` is disabled or enabled for the table. This parameter is disabled by default. To turn on `scale-in`, set the `boolean` value to `FALSE`. This means that capacity is automatically scaled down for a table on your behalf. (Optional)

- `replica_updates`: Specifies the AWS Region specific auto scaling settings of a multi-Region table. For a multi-Region table, you can configure the table's read capacity differently per AWS Region. You can do this by configuring the following parameters. For more information and examples, see the section called “Update provisioned capacity and auto scaling settings for a multi-Region table”.
  - `region` – The AWS Region of the table replica with the following settings:
    - `provisioned_read_capacity_autoscaling_update`
      - `autoscaling_disabled` – To enable auto scaling for the table's read capacity, set the value to `false`. The default is `true`. (Optional)

        > **Note**
        >
        > Auto scaling for a multi-Region table has to be either enabled or disabled for all replicas of the table.

      - `minimum_units` – The minimum level of read throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
      - `maximum_units` – The maximum level of read throughput that the table should always be ready to support. The value must be between 1 and the max throughput per second quota for your account (40,000 by default).
      - `scaling_policy` – Amazon Keyspaces supports the target tracking policy. The auto scaling target is the provisioned read capacity of the table.
        - `target_tracking_scaling_policy_configuration` – To define the target tracking policy, you must define the target value. For more information about target tracking and cooldown periods, see Target Tracking Scaling Policies in the *Application Auto Scaling User Guide*.
          - `target_value` – The target utilization rate of the table. Amazon Keyspaces auto scaling ensures that the ratio of consumed read capacity to provisioned read capacity stays at or near this value. You define `target_value` as a percentage. A double between 20 and 90. (Required)
          - `scale_in_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale in activity starts. If no value is provided, the default is 0. (Optional)

- `scale_out_cooldown` – A cooldown period in seconds between scaling activities that lets the table stabilize before another scale out activity starts. If no value is provided, the default is 0. (Optional)
- `disable_scale_in`: A `boolean` that specifies if `scale-in` is disabled or enabled for the table. This parameter is disabled by default. To turn on `scale-in`, set the `boolean` value to `FALSE`. This means that read capacity is automatically scaled down for a table on your behalf. (Optional)

- `default_time_to_live` – The default Time to Live setting in seconds for the table.
- `TAGS` – A list of key-value pair tags to be attached to the resource when it's created.
- *`clustering_order`* consists of the following:
  - *`column_name`* – The name of the column.
  - *`ASC | DESC`* – Sets the ascendant (`ASC`) or descendant (`DESC`) order modifier. If it's not specified, the default order is ASC.

Example

```
CREATE TABLE IF NOT EXISTS my_keyspace.my_table (
                                            id text,
                                            name text,
                                            region text,
                                            division text,
                                            project text,
                                            role text,
                                            pay_scale int,
                                            vacation_hrs float,
                                            manager_id text,
                                            PRIMARY KEY (id,division))
                                            WITH CUSTOM_PROPERTIES={
                                                'capacity_mode':{
                                                        'throughput_mode':
 'PROVISIONED', 'read_capacity_units': 10, 'write_capacity_units': 20
                                                    },
                                                'point_in_time_recovery':{'status':
 'enabled'},
                                                'encryption_specification':{
                                                        'encryption_type':
 'CUSTOMER_MANAGED_KMS_KEY',
```

```
 'kms_key_identifier':'arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111'
                                                        }
                                                    }
                                                    AND CLUSTERING ORDER BY (division ASC)
                                                    AND TAGS={'key1':'val1', 'key2':'val2'}
                                                    AND default_time_to_live = 3024000;
```

In a table that uses clustering columns, non-clustering columns can be declared as static in the table definition. For more information about static columns, see the section called “Estimate capacity consumption of static columns”.

Example

```
CREATE TABLE my_keyspace.my_table (
                                                    id int,
                                                    name text,
                                                    region text,
                                                    division text,
                                                    project text STATIC,
                                                    PRIMARY KEY (id,division));
```

You can create a table with a column that uses a user-defined type (UDT). The first statement in the examples creates a type, the second statement creates a table with a column that uses the type.

Example

```
CREATE TYPE my_keyspace."udt""N@ME" (my_field int);
CREATE TABLE my_keyspace.my_table (my_col1 int pri key, my_col2 "udt""N@ME");
```

ALTER TABLE

Use the `ALTER TABLE` statement to add new columns, add tags, or change the table's custom properties.

Syntax

```
alter_table_statement ::=  ALTER TABLE table_name
```

```
        [ ADD ( column_definition | column_definition_list)  ]
        [[ADD | DROP] TAGS {'key1':'val1', 'key2':'val2'}]
        [ WITH table_options [ , ... ] ] ;

column_definition      ::=  column_name cql_type
```

Where:

- *table_name* is the name of the table to be altered.
- *column_definition* is the name of the column and data type to be added.
- *column_definition_list* is a comma-separated list of columns placed inside parentheses.
- *table_options* consist of the following:
  - *AUTOSCALING_SETTINGS* includes the optional auto scaling settings for provisioned tables. For syntax and detailed descriptions, see the section called “CREATE TABLE”. For examples, see the section called “Configure automatic scaling on an existing table”.
  - *cdc* – A boolean that specifies if Amazon Keyspaces creates a change data capture (CDC) stream for the table. The default is `false`. To specify the `view type` when enabling a stream, set the `cdc_specification` with `CUSTOM_PROPERTIES` .
  - *CUSTOM_PROPERTIES* – A map of settings specific to Amazon Keyspaces.
    - `capacity_mode`: Specifies the read/write throughput capacity mode for the table. The options are `throughput_mode:PAY_PER_REQUEST` and `throughput_mode:PROVISIONED`. The provisioned capacity mode requires `read_capacity_units` and `write_capacity_units` as inputs. The default is `throughput_mode:PAY_PER_REQUEST`.
    - `cdc_specification`: Specifies the `view_type` of the CDC stream. The options are:
      - `NEW_AND_OLD_IMAGES` – both versions of the row, before and after the change. This is the default.
      - `NEW_IMAGE` – the version of the row after the change.
      - `OLD_IMAGE` – the version of the row before the change.
      - `KEYS_ONLY` – the partition and clustering keys of the row that was changed.

      For more information about CDC streams, see the section called “Working with CDC streams”. For code examples, see the section called “Enable a CDC stream for an existing table”.

- `client_side_timestamps`: Specifies if client-side timestamps are enabled or disabled for the table. The options are `{'status': 'enabled'}` and `{'status': 'disabled'}`. If it's not specified, the default is `status:disabled`. After client-side timestamps are enabled for a table, this setting cannot be disabled.
- `encryption_specification`: Specifies the encryption option for encryption at rest. The options are `encryption_type:AWS_OWNED_KMS_KEY` and `encryption_type:CUSTOMER_MANAGED_KMS_KEY`. The encryption option customer managed key requires the AWS KMS key in Amazon Resource Name (ARN) format as input: `kms_key_identifier:ARN`.
- `point_in_time_recovery`: Specifies if point-in-time restore is enabled or disabled for the table. The options are `status:enabled` and `status:disabled`. The default is `status:disabled`.
- `replica_updates`: Specifies the AWS Region specific settings of a multi-Region table. For a multi-Region table, you can configure the table's read capacity differently per AWS Region. You can do this by configuring the following parameters. For more information and examples, see the section called “Update provisioned capacity and auto scaling settings for a multi-Region table”.
  - `region` – The AWS Region of the table replica with the following settings:
    - `read_capacity_units`
- `ttl`: Enables Time to Live custom settings for the table. To enable, use `status:enabled`. The default is `status:disabled`. After `ttl`is enabled, you can't disable it for the table.

- `default_time_to_live`: The default Time to Live setting in seconds for the table.
- *TAGS* is a list of key-value pair tags to be attached to the resource.

> **Note**
>
> With ALTER TABLE, you can only change a single custom property. You can't combine more than one ALTER TABLE command in the same statement.

Examples

The following statement shows how to add a column to an existing table.

```
ALTER TABLE mykeyspace.mytable ADD (ID int);
```

This statement shows how to add two collection columns to an existing table:

- A frozen collection column `col_frozen_list` that contains a nested frozen collection
- A non-frozen collection column `col_map` that contains a nested frozen collection

```
ALTER TABLE my_Table ADD(col_frozen_list FROZEN<LIST<FROZEN<SET<TEXT>>>>, col_map
 MAP<INT, FROZEN<SET<INT>>>);
```

The following example shows how to add a column that uses a user-defined type (UDT) to a table.

```
ALTER TABLE my_keyspace.my_table ADD (my_column, my_udt;);
```

To change a table's capacity mode and specify read and write capacity units, you can use the following statement.

```
ALTER TABLE mykeyspace.mytable WITH CUSTOM_PROPERTIES={'capacity_mode':
{'throughput_mode': 'PROVISIONED', 'read_capacity_units': 10, 'write_capacity_units':
 20}};
```

The following statement specifies a customer managed KMS key for the table.

```
ALTER TABLE mykeyspace.mytable WITH CUSTOM_PROPERTIES={
              'encryption_specification':{
                     'encryption_type': 'CUSTOMER_MANAGED_KMS_KEY',
                     'kms_key_identifier':'arn:aws:kms:eu-
west-1:5555555555555:key/11111111-1111-111-1111-111111111111'
                  }
         };
```

To enable point-in-time restore for a table, you can use the following statement.

```
ALTER TABLE mykeyspace.mytable WITH CUSTOM_PROPERTIES={'point_in_time_recovery':
 {'status': 'enabled'}};
```

To set a default Time to Live value in seconds for a table, you can use the following statement.

```
ALTER TABLE my_table WITH default_time_to_live = 2592000;
```

This statement enables custom Time to Live settings for a table.

```
ALTER TABLE mytable WITH CUSTOM_PROPERTIES={'ttl':{'status': 'enabled'}};
```

RESTORE TABLE

Use the RESTORE TABLE statement to restore a table to a point in time. This statement requires point-in-time recovery to be enabled on a table. For more information, see the section called "Backup and restore with point-in-time recovery".

Syntax

```
restore_table_statement ::=
    RESTORE TABLE restored_table_name FROM TABLE source_table_name
                    [ WITH table_options [ , ... ] ];
```

Where:

- *restored_table_name* is the name of the restored table.
- *source_table_name* is the name of the source table.
- *table_options* consists of the following:
  - *restore_timestamp* is the restore point time in ISO 8601 format. If it's not specified, the current timestamp is used.
  - *CUSTOM_PROPERTIES* – A map of settings specific to Amazon Keyspaces.
    - capacity_mode: Specifies the read/write throughput capacity mode for the table. The options are throughput_mode:PAY_PER_REQUEST and throughput_mode:PROVISIONED. The provisioned capacity mode requires read_capacity_units and write_capacity_units as inputs. The default is the current setting from the source table.
    - encryption_specification: Specifies the encryption option for encryption at rest. The options are encryption_type:AWS_OWNED_KMS_KEY and encryption_type:CUSTOMER_MANAGED_KMS_KEY. The encryption option customer managed key requires the AWS KMS key in Amazon Resource Name (ARN) format as input: kms_key_identifier:ARN. To restore a table encrypted with a customer managed key to a table encrypted with an AWS owned key, Amazon Keyspaces requires access to the AWS KMS key of the source table.
    - point_in_time_recovery: Specifies if point-in-time restore is enabled or disabled for the table. The options are status:enabled and status:disabled. Unlike when you

create new tables, the default status for restored tables is `status:enabled` because the setting is inherited from the source table. To disable PITR for restored tables, you must set `status:disabled` explicitly.

- `replica_updates`: Specifies the AWS Region specific settings of a multi-Region table. For a multi-Region table, you can configure the table's read capacity differently per AWS Region. You can do this by configuring the following parameters.
  - `region` – The AWS Region of the table replica with the following settings:
    - `read_capacity_units`
- *`AUTOSCALING_SETTINGS`* includes the optional auto scaling settings for provisioned tables. For detailed syntax and descriptions, see the section called “CREATE TABLE”.
- *`TAGS`* is a list of key-value pair tags to be attached to the resource.

> **Note**
>
> Deleted tables can only be restored to the time of deletion.

Example

```
RESTORE TABLE mykeyspace.mytable_restored from table mykeyspace.my_table
WITH restore_timestamp = '2020-06-30T04:05:00+0000'
AND custom_properties = {'point_in_time_recovery':{'status':'disabled'},
 'capacity_mode':{'throughput_mode': 'PROVISIONED', 'read_capacity_units': 10,
 'write_capacity_units': 20}}
AND TAGS={'key1':'val1', 'key2':'val2'};
```

DROP TABLE

Use the `DROP TABLE` statement to remove a table from the keyspace.

Syntax

```
drop_table_statement ::=
    DROP TABLE [ IF EXISTS ] table_name
```

Where:

- `IF EXISTS` prevents `DROP TABLE` from failing if the table doesn't exist. (Optional)

- *table_name* is the name of the table to be dropped.

Example

```
DROP TABLE my_keyspace.my_table;
```

User-defined types (UDTs)

UDT – A grouping of fields and data types that you can use to define a single column in Amazon Keyspaces. Valid data types for UDTs are all supported Cassandra data types, including collections and other UDTs that you've already created in the same keyspace. For more information about supported Cassandra data types, see the section called “Cassandra data type support”.

```
user_defined_type::= udt_name
udt_name::= [ keyspace_name '.' ] identifier
```

Statements for types

- CREATE TYPE
- DROP TYPE

CREATE TYPE

Use the CREATE TYPE statement to create a new type.

Syntax

```
create_type_statement ::=  CREATE TYPE [ IF NOT EXISTS ] udt_name
    '('field_definition ( ',' field_definition)* ')'
            field_definition::= identifier cql_type
```

Where:

- IF NOT EXISTS prevents CREATE TYPE from failing if the type already exists. (Optional)
- *udt_name* is the fully-qualified name of the UDT in type format, for example my_keyspace.my_type. If you define the current keyspace with the USE statement, you don't need to specify the keyspace name.
- *field_definition* consists of a name and a type.

The following table shows examples of allowed UDT names. The first columns shows how to enter the name when you create the type, the second column shows how Amazon Keyspaces formats the name internally. Amazon Keyspaces expects the formatted name for operations like `GetType`.

Entered name	Formatted name	Note
`MY_UDT`	`my_udt`	Without double-quotes, Amazon Keyspaces converts all upper-case characters to lower-case.
`"MY_UDT"`	`MY_UDT`	With double-quotes, Amazon Keyspaces respects the upper-case characters, and removes the double-quotes from the formatted name.
`"1234"`	`1234`	With double-quotes, the name can begin with a number, and Amazon Keyspaces removes the double-quotes from the formatted name.
`"Special_Ch@r@cters<>!!"`	`Special_Ch@r@cters<>!!`	With double-quotes, the name can contain special characters, and Amazon Keyspaces removes the double-quotes from the formatted name.
`"nested""""quotes"`	`nested"""quotes`	Amazon Keyspaces removes the outer double-quotes and the escape double-quotes from the formatted name.

Examples

```
CREATE TYPE my_keyspace.phone (
    country_code int,
    number text
);
```

You can nest UDTs if the nested UDT is frozen. For more information about default values and quotas for types, see the section called “Amazon Keyspaces UDT quotas and default values”.

```
CREATE TYPE my_keyspace.user (
    first_name text,
```

```
    last_name text,
    phones FROZEN<phone>
);
```

For more code examples that show how to create UDTs, see the section called “User-defined types (UDTs)”.

DROP TYPE

Use the DROP TYPE statement to delete a UDT. You can only delete a type that's not in use by another type or table.

Syntax

```
drop_type_statement ::=  DROP TYPE [ IF EXISTS ] udt_name
```

Where:

- IF EXISTS prevents DROP TYPE from failing if the type doesn't exist. (Optional)
- *udt_name* is the fully-qualified name of the UDT in type format, for example my_keyspace.my_type. If you define the current keyspace with the USE statement, you don't need to specify the keyspace name.

Example

```
DROP TYPE udt_name;
```

DML statements (data manipulation language) in Amazon Keyspaces

Data manipulation language (DML) is the set of Cassandra Query Language (CQL) statements that you use to manage data in Amazon Keyspaces (for Apache Cassandra) tables. You use DML statements to add, modify, or delete data in a table.

You also use DML statements to query data in a table. (Note that CQL doesn't support joins or subqueries.)

Topics

- SELECT
- INSERT
- UPDATE
- DELETE

SELECT

Use a SELECT statement to query data.

Syntax

```
select_statement ::=  SELECT  [ JSON ] ( select_clause | '*' )
                      FROM table_name
                      [ WHERE 'where_clause' ]
                      [ ORDER BY 'ordering_clause' ]
                      [ LIMIT (integer | bind_marker) ]
                      [ ALLOW FILTERING ]
select_clause    ::=  selector [ AS identifier ] ( ',' selector [ AS identifier ] )
selector         ::=  column_name
                      | term
                      | CAST '(' selector AS cql_type ')'
                      | function_name '(' [ selector ( ',' selector )* ] ')'
where_clause     ::=  relation ( AND relation )*
relation         ::=  column_name operator term
                      TOKEN
operator         ::=  '=' | '<' | '>' | '<=' | '>=' | IN | CONTAINS | CONTAINS KEY
ordering_clause  ::=  column_name [ ASC | DESC ] ( ',' column_name [ ASC | DESC ] )*
```

Examples

```
SELECT name, id, manager_id FROM "myGSGKeyspace".employees_tbl ;

SELECT JSON name, id, manager_id FROM "myGSGKeyspace".employees_tbl ;
```

For a table that maps JSON-encoded data types to Amazon Keyspaces data types, see the section called “JSON encoding of Amazon Keyspaces data types”.

Using the IN keyword

The IN keyword specifies equality for one or more values. It can be applied to the partition key and the clustering column. Results are returned in the order the keys are presented in the SELECT statement.

Examples

```
SELECT * from mykeyspace.mytable WHERE primary.key1 IN (1,2) and clustering.key1 = 2;
SELECT * from mykeyspace.mytable WHERE primary.key1 IN (1,2) and clustering.key1 <= 2;
SELECT * from mykeyspace.mytable WHERE primary.key1 = 1 and clustering.key1 IN (1, 2);
SELECT * from mykeyspace.mytable WHERE primary.key1 <= 2 and clustering.key1 IN (1, 2)
 ALLOW FILTERING;
```

For more information about the IN keyword and how Amazon Keyspaces processes the statement, see the section called “Use IN SELECT”.

Ordering results

The ORDER BY clause specifies the sort order of the returned results. It takes as arguments a list of column names along with the sort order for each column. You can only specify clustering columns in ordering clauses. Non-clustering columns are not allowed. The sort order options are ASC for ascending and DESC for descending sort order. If the sort order is omitted, the default ordering of the clustering column is used. For possible sort orders, see the section called “Order results”.

Example

```
SELECT name, id, division, manager_id FROM "myGSGKeyspace".employees_tbl WHERE id =
 '012-34-5678' ORDER BY division;
```

When using ORDER BY with the IN keyword, results are ordered within a page. Full re-ordering with disabled pagination is not supported.

TOKEN

You can apply the TOKEN function to the PARTITION KEY column in SELECT and WHERE clauses. With the TOKEN function, Amazon Keyspaces returns rows based on the mapped token value of the PARTITION_KEY rather than on the value of the PARTITION KEY.

TOKEN relations are not supported with the IN keyword.

Examples

```
SELECT TOKEN(id) from my_table;

SELECT TOKEN(id) from my_table WHERE TOKEN(id) > 100 and TOKEN(id) < 10000;
```

TTL function

You can use the TTL function with the SELECT statement to retrieve the expiration time in seconds that is stored for a column. If no TTL value is set, the function returns null.

Example

```
SELECT TTL(my_column) from my_table;
```

The TTL function can't be used on multi-cell columns such as collections.

WRITETIME function

You can use the WRITETIME function with the SELECT statement to retrieve the timestamp that is stored as metadata for the value of a column only if the table uses client-side timestamps. For more information, see the section called "Client-side timestamps".

```
SELECT WRITETIME(my_column) from my_table;
```

The WRITETIME function can't be used on multi-cell columns such as collections.

> **Note**
>
> For compatibility with established Cassandra driver behavior, tag-based authorization policies are not enforced when you perform operations on system tables by using Cassandra Query Language (CQL) API calls through Cassandra drivers and developer tools. For more information, see the section called "Amazon Keyspaces resource access based on tags".

INSERT

Use the INSERT statement to add a row to a table.

Syntax

```
insert_statement ::=  INSERT INTO table_name ( names_values | json_clause )
                      [ IF NOT EXISTS ]
                      [ USING update_parameter ( AND update_parameter )* ]
names_values     ::=  names VALUES tuple_literal
json_clause      ::=  JSON string [ DEFAULT ( NULL | UNSET ) ]
names            ::=  '(' column_name ( ',' column_name )* ')'
```

Example

```
INSERT INTO "myGSGKeyspace".employees_tbl (id, name, project, region, division, role,
 pay_scale, vacation_hrs, manager_id)
VALUES ('012-34-5678','Russ','NightFlight','US','Engineering','IC',3,12.5,
 '234-56-7890') ;
```

Update parameters

INSERT supports the following values as update_parameter:

- TTL – A time value in seconds. The maximum configurable value is 630,720,000 seconds, which is the equivalent of 20 years.
- TIMESTAMP – A bigint value representing the number of microseconds since the standard base time known as the epoch: January 1 1970 at 00:00:00 GMT. A timestamp in Amazon Keyspaces has to fall between the range of 2 days in the past and 5 minutes in the future.

Example

```
INSERT INTO my_table (userid, time, subject, body, user)
        VALUES (B79CB3BA-745E-5D9A-8903-4A02327A7E09, 96a29100-5e25-11ec-90d7-
b5d91eceda0a, 'Message', 'Hello','205.212.123.123')
        USING TTL 259200;
```

JSON support

For a table that maps JSON-encoded data types to Amazon Keyspaces data types, see the section called “JSON encoding of Amazon Keyspaces data types”.

You can use the JSON keyword to insert a JSON-encoded map as a single row. For columns that exist in the table but are omitted in the JSON insert statement, use DEFAULT UNSET to preserve

the existing values. Use DEFAULT NULL to write a NULL value into each row of omitted columns and overwrite the existing values (standard write charges apply). DEFAULT NULL is the default option.

Example

```
INSERT INTO "myGSGKeyspace".employees_tbl JSON '{"id":"012-34-5678",
                                                 "name": "Russ",
                                                 "project": "NightFlight",
                                                 "region": "US",
                                                 "division": "Engineering",
                                                 "role": "IC",
                                                 "pay_scale": 3,
                                                 "vacation_hrs": 12.5,
                                                 "manager_id": "234-56-7890"}';
```

If the JSON data contains duplicate keys, Amazon Keyspaces stores the last value for the key (similar to Apache Cassandra). In the following example, where the duplicate key is id, the value 234-56-7890 is used.

Example

```
INSERT INTO "myGSGKeyspace".employees_tbl JSON '{"id":"012-34-5678",
                                                 "name": "Russ",
                                                 "project": "NightFlight",
                                                 "region": "US",
                                                 "division": "Engineering",
                                                 "role": "IC",
                                                 "pay_scale": 3,
                                                 "vacation_hrs": 12.5,
                                                 "id": "234-56-7890"}';
```

UPDATE

Use the UPDATE statement to modify a row in a table.

Syntax

```
update_statement ::=  UPDATE table_name
                      [ USING update_parameter ( AND update_parameter )* ]
```

```
                    SET assignment ( ',' assignment )*
                    WHERE where_clause
                    [ IF ( EXISTS | condition ( AND condition )*) ]
update_parameter ::=  ( integer | bind_marker )
assignment       ::=  simple_selection '=' term
                    | column_name '=' column_name ( '+' | '-' ) term
                    | column_name '=' list_literal '+' column_name
simple_selection ::=  column_name
                    | column_name '[' term ']'
                    | column_name '.' `field_name
condition        ::=  simple_selection operator term
```

Example

```
UPDATE "myGSGKeyspace".employees_tbl SET pay_scale = 5 WHERE id = '567-89-0123' AND
 division = 'Marketing' ;
```

To increment a `counter`, use the following syntax. For more information, see the section called "Counters".

```
UPDATE ActiveUsers SET counter = counter + 1  WHERE user = A70FE1C0-5408-4AE3-
BE34-8733E5K09F14 AND action = 'click';
```

Update parameters

UPDATE supports the following values as `update_parameter`:

- TTL – A time value in seconds. The maximum configurable value is 630,720,000 seconds, which is the equivalent of 20 years.
- `TIMESTAMP` – A `bigint` value representing the number of microseconds since the standard base time known as the epoch: January 1 1970 at 00:00:00 GMT. A timestamp in Amazon Keyspaces has to fall between the range of 2 days in the past and 5 minutes in the future.

Example

```
UPDATE my_table (userid, time, subject, body, user)
        VALUES (B79CB3BA-745E-5D9A-8903-4A02327A7E09, 96a29100-5e25-11ec-90d7-
b5d91eceda0a, 'Message', 'Hello again','205.212.123.123')
```

```
        USING TIMESTAMP '2022-11-03 13:30:54+0400';
```

DELETE

Use the DELETE statement to remove a row from a table.

Syntax

```
delete_statement ::=  DELETE [ simple_selection ( ',' simple_selection ) ]
                      FROM table_name
                      [ USING update_parameter ( AND update_parameter )* ]
                      WHERE where_clause
                      [ IF ( EXISTS | condition ( AND condition )*) ]

simple_selection ::=  column_name
                     | column_name '[' term ']'
                     | column_name '.' `field_name

condition        ::=  simple_selection operator term
```

Where:

- *table_name* is the table that contains the row you want to delete.

Example

```
DELETE manager_id FROM "myGSGKeyspace".employees_tbl WHERE id='789-01-2345' AND
 division='Executive' ;
```

DELETE supports the following value as update_parameter:

- TIMESTAMP – A bigint value representing the number of microseconds since the standard base time known as the epoch: January 1 1970 at 00:00:00 GMT.

Built-in functions in Amazon Keyspaces

Amazon Keyspaces (for Apache Cassandra) supports a variety of built-in functions that you can use in Cassandra Query Language (CQL) statements.

Topics

- Scalar functions

Scalar functions

A *scalar function* performs a calculation on a single value and returns the result as a single value. Amazon Keyspaces supports the following scalar functions.

Function	Description
`blobAsType`	Returns a value of the specified data type.
`cast`	Converts one native data type into another native data type.
`currentDate`	Returns the current date/time as a date.
`currentTime`	Returns the current date/time as a time.
`currentTimestamp`	Returns the current date/time as a timestamp.
`currentTimeUUID`	Returns the current date/time as a `timeuuid`.
`fromJson`	Converts the JSON string into the selected column's data type.
`maxTimeuuid`	Returns the largest possible `timeuuid` for timestamp or date string.
`minTimeuuid`	Returns the smallest possible `timeuuid` for timestamp or date string.
`now`	Returns a new unique `timeuuid`.
`toDate`	Converts either a `timeuuid` or a timestamp to a date type.
`toJson`	Returns the column value of the selected column in JSON format.
`token`	Returns the hash value of the partition key.

Function	Description
`toTimestamp`	Converts either a `timeuuid` or a date to a timestamp.
`TTL`	Returns the expiration time in seconds for a column.
`typeAsBlob`	Converts the specified data type into a `blob`.
`toUnixTimestamp`	Converts either a `timeuuid` or a timestamp into a `bigInt`.
`uuid`	Returns a random version 4 UUID.
`writetime`	Returns the timestamp of the value of the specified column.
`dateOf`	*(Deprecated)* Extracts the timestamp of a `timeuuid`, and returns the value as a date.
`unixTimestampOf`	*(Deprecated)* Extracts the timestamp of a `timeuuid`, and returns the value as a raw, 64-bit integer timestamp.

Quotas for Amazon Keyspaces (for Apache Cassandra)

This section describes current quotas and default values for Amazon Keyspaces (for Apache Cassandra).

Topics

- Amazon Keyspaces service quotas
- Increasing or decreasing throughput (for provisioned tables)
- Amazon Keyspaces encryption at rest
- Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces

Amazon Keyspaces service quotas

The following table contains Amazon Keyspaces (for Apache Cassandra) quotas and the default values. Information about which quotas can be adjusted is available in the Service Quotas console, where you can also request quota increases. For more information on quotas, contact AWS Support.

Quota	Description	Amazon Keyspaces default
Max keyspaces per AWS Region	The maximum number of keyspaces for this subscriber per Region. You can adjust this default value in the Service Quotas console.	256
Max tables per AWS Region	The maximum number of tables across all keyspaces for this subscriber per Region. You can adjust this default value in the Service Quotas console.	256

Quota	Description	Amazon Keyspaces default
Max amount of data restored using `ADD REGION` operations	The maximum size of data that can be concurrently restored by `ADD REGION` operations. To increase the amount of data to be concurrently restored, contact Support.	10 TB
Max table schema size	The maximum size of a table schema.	350 KB
Max concurrent DDL operations	The maximum number of concurrent DDL operations allowed for this subscriber per Region.	50
Max queries per connection	The maximum number of CQL queries that can be processed by a single client TCP connection per second.	3000
Max row size	The maximum size of a row, excluding static column data. For details, see the section called “Estimate row size”.	1 MB

Quota	Description	Amazon Keyspaces default
Max number of columns in `INSERT` and `UPDATE` statements	The maximum number of columns allowed in CQL `INSERT` or `UPDATE` statements. An `INSERT` or `UPDATE` statement supports up to 225 regular columns when Time to Live (TTL) is turned off. If TTL is turned on, up to 166 regular columns can be modified in a single operation.	225/166
Max static data per logical partition	The maximum aggregate size of static data in a logical partition. For details, see the section called "Calculate static column size per logical partition".	1 MB
Max subqueries per `IN` `SELECT` statement	The maximum number of subqueries you can use for the `IN` keyword in a `SELECT` statement. You can adjust this default value in the Service Quotas console.	100

Quota	Description	Amazon Keyspaces default
Max number of nested frozen collections per AWS Region	The maximum number of nested collections supported when you're using the FROZEN keyword for a column with a collection data type. For more informati on about frozen collectio ns, see the section called "Collection types". To increase the nesting level, contact Support.	8
Max number of statements in a logged batch	The maximum number of CQL statements supported when you're using a logged batch statment. For more informati on about batch statements, see the section called "Use batch statements".	100
Max number of statements in a logged batch using static columns	The maximum number of CQL statements supported when you're using static columns in a logged batch statment. For more information about batch statements, see the section called "Use batch statements".	50
Max size of logged batch statement	The maximum size of a logged batch statment. For more information about batch statements, see the section called "Use batch statements".	4MB

Quota	Description	Amazon Keyspaces default
Max number of statements in an unlogged batch	The maximum number of CQL statements supported when you're using an unlogged batch statment. For more information about batch statements, see the section called “Use batch statements”.	30
Max read throughput per second	The maximum read throughput per second—read request units (RRUs) or read capacity units (RCUs)—that can be allocated to a table per Region. You can adjust this default value in the Service Quotas console.	40,000
Max write throughput per second	The maximum write throughput per second—write request units (WRUs) or write capacity units (WCUs)—that can be allocated to a table per Region. You can adjust this default value in the Service Quotas console.	40,000
Max write throughput for a table using change-data-capture (CDC)	The maximum write capacity for an Amazon Keyspaces table with CDC enabled. This default quota only applies to tables in provisioned read/write capacity mode. You can adjust this default value in the Service Quotas console.	40,000

Quota	Description	Amazon Keyspaces default
Account-level read throughput (provisioned)	The maximum number of aggregate read capacity units (RCUs) allocated for the account per Region. This is applicable only for tables in provisioned read/write capacity mode. You can adjust this default value in the Service Quotas console.	80,000
Account-level write throughput (provisioned)	The maximum number of aggregate write capacity units (WCU) allocated for the account per Region. This is applicable only for tables in provisioned read/write capacity mode. You can adjust this default value in the Service Quotas console.	80,000
Max number of scalable targets per Region per account	The maximum number of scalable targets for the account per Region. An Amazon Keyspaces table counts as one scalable target if auto scaling is enabled for read capacity, and as another scalable target if auto scaling is enabled for write capacity. You can adjust this default value in the Service Quotas console for Application Auto Scaling by choosing **Scalable targets for Amazon Keyspaces**.	1,500

Quota	Description	Amazon Keyspaces default
Max partition key size	The maximum size of the compound partition key. Up to 3 bytes of additiona l storage are added to the raw size of each column included in the partition key for metadata.	2048 bytes
Max clustering key size	The maximum combined size of all clustering columns. Up to 4 bytes of additional storage are added to the raw size of each clustering column for metadata.	850 bytes
Max concurrent table restores using Point-in-time Recovery (PITR)	The maximum number of concurrent table restores using PITR per subscriber is 4. You can adjust this default value in the Service Quotas console.	4
Max amount of data restored using point-in-time recovery (PITR)	The maximum size of data that can be restored using PITR within 24 hours. You can adjust this default value in the Service Quotas console.	5 TB

Increasing or decreasing throughput (for provisioned tables)

Increasing provisioned throughput

You can increase `ReadCapacityUnits` or `WriteCapacityUnits` as often as necessary by using the console or the `ALTER TABLE` statement. The new settings don't take effect until the `ALTER TABLE` operation is complete.

You can't exceed your per-account quotas when you add provisioned capacity. And you can increase the provisioned capacity for your tables as much as you need. For more information about per-account quotas, see the preceding section, the section called “Amazon Keyspaces service quotas”.

Decreasing provisioned throughput

For every table in an `ALTER TABLE` statement, you can decrease `ReadCapacityUnits` or `WriteCapacityUnits` (or both). The new settings don't take effect until the `ALTER TABLE` operation is complete.

A decrease is allowed up to four times, anytime per day. A day is defined according to Universal Coordinated Time (UTC). Additionally, if there was no decrease in the past hour, an additional decrease is allowed. This effectively brings the maximum number of decreases in a day to 27 (4 decreases in the first hour, and 1 decrease for each of the subsequent 1-hour windows in a day).

Amazon Keyspaces encryption at rest

You can change encryption options between an AWS owned AWS KMS key and a customer managed AWS KMS key up to four times within a 24-hour window, on a per table basis, starting from when the table was created. If there was no change in the past six hours, an additional change is allowed. This effectively brings the maximum number of changes in a day to eight (four changes in the first six hours, and one change for each of the subsequent six-hour windows in a day).

You can change the encryption option to use an AWS owned AWS KMS key as often as necessary, even if the earlier quota has been exhausted.

These are the quotas unless you request a higher amount. To request a service quota increase, see Support.

Quotas and default values for user-defined types (UDTs) in Amazon Keyspaces

Amazon Keyspaces UDT quotas and default values

The following table contains quotas and default values related to UDTs in Amazon Keyspaces. Information about which quotas can be adjusted is available in the Service Quotas console, where you can also request quota increases. For more information about these quotas, contact AWS Support.

Quota	Description	Amazon Keyspaces default
Max number of UDTs per AWS Region	The maximum number of UDTs across all keyspaces for this subscriber per Region.	256
Max number of tables per UDT	The maximum number of tables that can reference the same UDT.	100
Max number of UDTs per table	The maximum number of UDTs that a table can reference.	50
Max level of nesting of UDTs	The maximum nesting depth supported for UDTs.	8
Max amount of direct child UDTs per UDT	The maximum number of child UDTs supported for a UDT.	10
Max amount of direct parent UDTs per UDT	The maximum number of parent UDTs supported for a UDT.	10
Max UDT schema size	The maximum size of the schema for a UDT.	25 KB
Max UDT name length	The maximum number of characters in the UDT name.	48
Max UDT field name length	The maximum number of characters in a UDT field name.	128

Document history for Amazon Keyspaces (for Apache Cassandra)

The following table describes the important changes to the documentation since the last release of Amazon Keyspaces (for Apache Cassandra). For notification about updates to this documentation, you can subscribe to an RSS feed.

- **Latest documentation update:** January 28, 2026

Change	Description	Date
GetRecords API now returns iterator description	The `GetRecords` API response now includes an `iteratorDescription` field that contains an `iteratorPosition` value indicating the current iterator's position within the shard, helping you optimize polling frequency.	June 2, 2026
You can now pre-warm new and existing tables in Amazon Keyspaces	You can now configure `warm-throughput` for new and existing tables in Amazon Keyspaces to pre-warm them for anticipated spikes in peak capacity.	January 28, 2026
Amazon Keyspaces now supports an integrated AWS CloudShell experience	You can now launch a pre-authenticated shell directly from the Amazon Keyspaces console.	January 26, 2026
Amazon Keyspaces now supports logged batches	You can now combine multiple statements into	November 11, 2025

	logged batches in Amazon Keyspaces.	
Changes to Amazon Keyspaces TLS certificates	Updated instructions to include certificates issued under the Amazon Trust Services (ATS) chain.	October 25, 2025
Amazon Keyspaces now supports IPv4 and IPv6 requests	Amazon Keyspaces dual-stack endpoints support IPv4 and IPv6 configurations.	September 30, 2025
`NOW` and `UUID` are now supported in all CQL statements in Amazon Keyspaces	You can now use the `NOW` and `UUID` functions in all CQL statements in Amazon Keyspaces.	September 8, 2025
The Amazon Keyspaces Streams Kinesis Adapter is now available	You can now process Amazon Keyspaces CDC streams with the Kinesis Client Library (KCL).	July 2, 2025
Amazon Keyspaces new managed policy	Amazon Keyspaces added a new managed policy `KeyspacesCDCServiceRolePolicy` which grants the required permissions to the service-linked role `AWSServiceRoleForAmazonKeyspacesCDC` to publish Amazon Keyspaces CDC stream metrics data to CloudWatch on your behalf. For more information, see Using roles for Amazon Keyspaces CDC streams.	July 2, 2025

Amazon Keyspaces managed policy update	Amazon Keyspaces added new permissions to the `AmazonKeyspacesReadOnlyAccess_v2` and the `AmazonKeyspacesReadOnlyAccess` managed policies to allow IAM principals to view streams. Amazon Keyspaces updated the `AmazonKeyspacesFullAccess` managed policy with permissions to create a service-linked role `AWSServiceRoleForAmazonKeyspacesCDC` that publishes CloudWatch metrics on the principals behalf.	July 2, 2025
Amazon Keyspaces change data capture (CDC) streams are now available	Enable CDC streams to record changes in your Amazon Keyspaces tables.	July 2, 2025
Amazon Keyspaces multi-Region replication now supports the Africa (Cape Town) Region.	You can now define the Africa (Cape Town) Region for multi-Region keyspaces.	March 31, 2025
Amazon Keyspaces multi-Region replication now supports unlimited AWS Regions.	You can now define as many Regions as you want for multi-Region keyspaces.	March 25, 2025
Amazon Keyspaces support for user-defined types (UDTs) in multi-Region keyspaces	You can now create and use UDTs in multi-Region keyspaces.	March 24, 2025

Amazon Keyspaces managed policy update	Amazon Keyspaces added new permissions to the `AmazonKeyspacesFullAccess` managed policy to allow IAM principals to add new Regions to an existing keyspace. This includes an update to the service-linked role AWSServiceRoleForAmazonKeyspacesReplication.	November 19, 2024
Add replicas to multi-Region tables in Amazon Keyspaces	You can now add new AWS Regions to existing single and multi-Region keyspaces.	November 19, 2024
Support for user-defined types (UDTs) in Amazon Keyspaces	With native support for UDTs in Amazon Keyspaces you can now define data structures in your applications that represent real-world data hierarchies.	October 30, 2024
`ADD COLUMN` support for Amazon Keyspaces multi-Region replication	Amazon Keyspaces now supports schema changes for multi-Region tables.	September 17, 2024
Updated migration guidance for Amazon Keyspaces	The updated migration guidance outlines how to create a migration plan to successfully migrate from Apache Cassandra to Amazon Keyspaces, including different strategies for offline and online migrations.	June 28, 2024

Connect to Amazon Keyspaces from Amazon Elastic Kubernetes Service	You can now follow a step-by-step tutorial to connect to Amazon Keyspaces from Amazon EKS.	February 7, 2024
Amazon Keyspaces multi-Region replication support for provisioned tables	Amazon Keyspaces now supports provisioned capacity mode for multi-Region tables.	January 23, 2024
Amazon Keyspaces auto scaling APIs for provisioned tables	Amazon Keyspaces now offers CQL and AWS API support for setting up auto scaling with provisioned capacity mode.	January 23, 2024
Amazon Keyspaces DML activity included in CloudTrail logs	You can now audit Amazon Keyspaces Data Manipulation Language (DML) API calls in AWS CloudTrail.	December 20, 2023
Amazon Keyspaces support for the FROZEN keyword	Amazon Keyspaces now supports the FROZEN keyword for collection data types.	November 15, 2023
Amazon Keyspaces managed policy update	Amazon Keyspaces added new permissions to the `AmazonKeyspacesFullAccess` managed policy to allow clients connecting to Amazon Keyspaces through interface VPC endpoints access to the Amazon EC2 instance to update the Amazon Keyspaces `system.peers` table with network information from the VPC.	October 3, 2023

Amazon Keyspaces managed policy update	Amazon Keyspaces created a new `AmazonKeyspacesReadOnlyAccess_v2` managed policy to allow clients connecting to Amazon Keyspaces through interface VPC endpoints access to the Amazon EC2 instance to update the Amazon Keyspaces `system.peers` table with network information from the VPC.	September 12, 2023
Best practices for creating connections in Amazon Keyspaces	Learn how to improve and optimize client driver configurations in Amazon Keyspaces.	June 30, 2023
System keyspaces are now documented for Amazon Keyspaces	Learn what is stored in system keyspaces and how to query them for useful information in Amazon Keyspaces.	June 21, 2023
Amazon Keyspaces now supports multi-Region replication	Amazon Keyspaces multi-Region replication helps you to maintain globally distributed applications by providing you with improved fault tolerance, stability, and resilience.	June 5, 2023

Amazon Keyspaces managed policy update	Amazon Keyspaces added new permissions to the `AmazonKeyspacesFullAccess` managed policy to allow Amazon Keyspaces to create a service-linked role when an administrator creates a multi-Region keyspace.	June 5, 2023
Amazon Keyspaces support for the `IN` keyword	Amazon Keyspaces now supports the `IN` keyword in `SELECT` statements.	April 25, 2023
Cross-account access for Amazon Keyspaces and interface VPC endpoints	Learn how to implement cross-account access for Amazon Keyspaces with VPC endpoints.	April 20, 2023
Amazon Keyspaces support for client-side timestamps	Amazon Keyspaces client-side timestamps are Cassandra-compatible cell-level timestamps that help distributed applications to determine the order of write operations when different clients make changes to the same data.	March 14, 2023
Getting started with Amazon Keyspaces and interface VPC endpoints	In this step-by-step tutorial, learn how to connect to Amazon Keyspaces from a VPC.	March 1, 2023

Optimizing costs of Amazon Keyspaces tables	Best practices and guidance are available to help you identify strategies for optimizing costs of your existing Amazon Keyspaces tables.	February 17, 2023
The `Murmur3Partitioner` is now the default	The `Murmur3Partitioner` is now the default partitioner in Amazon Keyspaces.	November 17, 2022
Amazon Keyspaces now supports `Murmur3Partitioner`	The `Murmur3Partitioner` is now available in Amazon Keyspaces.	November 9, 2022
Support update for empty strings and blob values	Amazon Keyspaces now also supports empty strings and blob values as clustering column values.	October 19, 2022
Amazon Keyspaces is now available in AWS GovCloud (US)	Amazon Keyspaces is now available in the AWS GovCloud (US) Region and is in scope for FedRAMP-High compliance. For information about available endpoints, see AWS GovCloud (US) Region FIPS endpoints.	August 4, 2022
Monitor Amazon Keyspaces table storage costs with Amazon CloudWatch	Amazon Keyspaces now helps you monitor and track table storage costs over time with the `BillableTableSizeInBytes` CloudWatch metric.	June 14, 2022

Amazon Keyspaces now supports Terraform	You can now use Terraform to perform data definition language (DDL) operations in Amazon Keyspaces.	June 9, 2022
Amazon Keyspaces `token` function support	Amazon Keyspaces now helps you optimize application queries by using the `token` function.	April 19, 2022
Amazon Keyspaces integration with Apache Spark	Amazon Keyspaces now helps you read and write data in Apache Spark more easily by using the open-source Spark Cassandra Connector.	April 19, 2022
Amazon Keyspaces API Reference	Amazon Keyspaces supports control plane operations to manage keyspaces and tables using the AWS SDK and AWS CLI. The API reference guide describes the supported control plane operations in detail.	March 2, 2022
How to troubleshoot common configuration issues when using Amazon Keyspaces.	Learn more about how to resolve common configuration issues you may encounter when using Amazon Keyspaces.	November 22, 2021
Amazon Keyspaces support for Time to Live (TTL).	Amazon Keyspaces Time to Live (TTL) helps you simplify your application logic and optimize the price of storage by expiring data from tables automatically.	October 18, 2021

Migrating data to Amazon Keyspaces using DSBulk.	Step-by-step tutorial for migrating data from Apache Cassandra to Amazon Keyspaces using the DataStax Bulk Loader (DSBulk).	August 9, 2021
Amazon Keyspaces support for VPC Endpoint entries in the `system.peers` table.	Amazon Keyspaces allows you to populate the `system.peers` table with available interface VPC endpoint information to improve load balancing and increase read/write throughput.	July 29, 2021
Update to IAM managed policies to support customer managed AWS KMS keys.	IAM managed policies for Amazon Keyspaces now include permissions to list and view available customer managed AWS KMS keys stored in AWS KMS.	June 1, 2021
Amazon Keyspaces support for customer managed AWS KMS keys.	Amazon Keyspaces allows you to take control of customer managed AWS KMS keys stored in AWS KMS for encryption at rest.	June 1, 2021
Amazon Keyspaces support for JSON syntax	Amazon Keyspaces helps you read and write JSON documents more easily by supporting JSON syntax for INSERT and SELECT operations.	January 21, 2021

Amazon Keyspaces support for static columns	Amazon Keyspaces now helps you update and store common data between multiple rows efficiently by using static columns.	November 9, 2020
GA release of NoSQL Workbench support for Amazon Keyspaces	NoSQL Workbench is a client-side application that helps you design and visualize nonrelational data models for Amazon Keyspaces more easily. NoSQL Workbench clients are available for Windows, macOS, and Linux.	October 28, 2020
Preview release of NoSQL Workbench support for Amazon Keyspaces	NoSQL Workbench is a client-side application that helps you design and visualize nonrelational data models for Amazon Keyspaces more easily. NoSQL Workbench clients are available for Windows, macOS, and Linux.	October 5, 2020
New code examples for programmatic access to Amazon Keyspaces	We continue to add code examples for programmatic access to Amazon Keyspaces . Samples are now available for Java, Python, Go, C#, and Perl Cassandra drivers that support Apache Cassandra version 3.11.2.	July 17, 2020

Amazon Keyspaces point-in-time recovery (PITR)	Amazon Keyspaces now offers point-in-time recovery (PITR) to help protect your tables from accidental write or delete operations by providing you continuous backups of your table data.	July 9, 2020
Amazon Keyspaces general availability	With Amazon Keyspaces , formerly known during preview as Amazon Managed Apache Cassandra Service (MCS), you can use the Cassandra Query Language (CQL) code, Apache 2.0–licensed Cassandra drivers, and developer tools that you already use today.	April 23, 2020
Amazon Keyspaces automatic scaling	Amazon Keyspaces (for Apache Cassandra) integrates with Application Auto Scaling to help you provision throughput capacity efficiently for variable workloads in response to actual application traffic by adjusting throughput capacity automatically.	April 23, 2020
Interface virtual private cloud (VPC) endpoints for Amazon Keyspaces	Amazon Keyspaces offers private communication between the service and your VPC so that network traffic doesn't leave the Amazon network.	April 16, 2020

Tag-based access policies	You can now use resource tags in IAM policies to manage access to Amazon Keyspaces.	April 8, 2020
Counter data type	Amazon Keyspaces now helps you coordinate increments and decrements to column values by using counters.	April 7, 2020
Tagging resources	Amazon Keyspaces now enables you to label and categorize resources by using tags.	March 31, 2020
CloudFormation support	Amazon Keyspaces now helps you automate the creation and management of resources by using CloudFormation.	March 25, 2020
Support for IAM roles and policies and SigV4 authentication	Added information on how you can use AWS Identity and Access Management (IAM) to manage access permissions and implement security policies for Amazon Keyspaces and how to use the authentication plugin for the DataStax Java Driver for Cassandra to programmatically access Amazon Keyspaces using IAM roles and federated identities.	March 17, 2020

Read/write capacity mode	Amazon Keyspaces now supports two read/write throughput capacity modes. The read/write capacity mode controls how you're charged for read and write throughput and how table throughput capacity is managed.	February 20, 2020
Initial release	This documentation covers the initial release of Amazon Keyspaces (for Apache Cassandra).	December 3, 2019