Microsoft SQL Server 2019 To Amazon Aurora with PostgreSQL Compatibility (12.4)

Migration Playbook

1.5 April 2021

Notices

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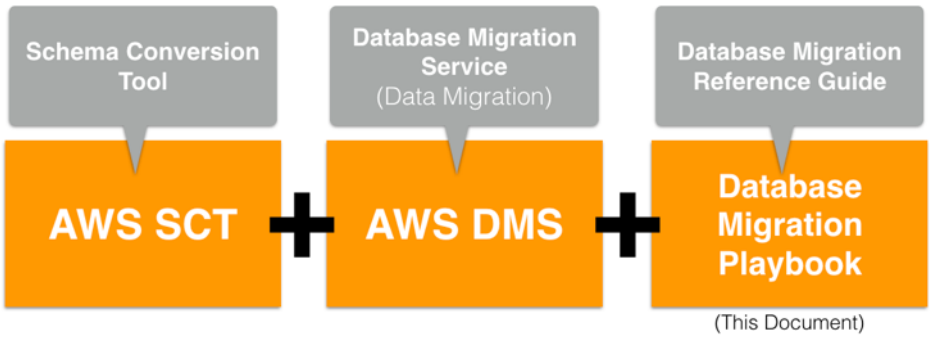
Table of Contents

Introduction

The migration process from a source database (Oracle or SQL Server) to Amazon Aurora (PostgreSQL or MySQL) typically involves several stages. The first stage is to use the AWS Schema Conversion Tool (SCT) and the AWS Database Migration Service (DMS) to convert and migrate the schema and data. While most of the migration work can be automated, some aspects require manual intervention and adjustments to both database schema objects and database code.



The purpose of this Playbook is to assist administrators tasked with migrating from source databases to Aurora with the aspects that can't be automatically migrated using the Amazon Web Services Schema Conversion Tool (AWS SCT). It focuses on the differences, incompatibilities, and similarities between the source database and Aurora in a wide range of topics including T-SQL, Configuration, High Availability and Disaster Recovery (HADR), Indexing, Management, Performance Tuning, Security, and Physical Storage.

The first section of this document provides an overview of AWS SCT and the AWS Data Migration Service (DMS) tools for automating the migration of schema, objects and data. The remainder of the document contains individual sections for the source database features and their Aurora counterparts. Each section provides a short overview of the feature, examples, and potential workaround solutions for incompatibilities.

You can use this playbook either as a reference to investigate the individual action codes generated by the AWS SCT tool, or to explore a variety of topics where you expect to have some incompatibility issues. When using the AWS SCT, you may see a report that lists *Action codes* , which indicates some manual conversion is required, or that a manual verification is recommended. For your convenience, this Playbook includes an SCT Action Code Index section providing direct links to the relevant topics that discuss the manual conversion tasks needed to address these action codes. Alternatively, you can explore the Tables of Feature Compatibility section that provides high-level graphical indicators and descriptions of the feature compatibility between the source database and Aurora. It also includes a graphical compatibility indicator and links to the actual sections in the playbook.

There is appendix at the end of this playbook: Appendix: Migration Quick Tips provides a list of tips for administrators or developers who have little experience with Aurora (PostgreSQL or MySQL). It briefly highlights key differences between the source database and Aurora that they are likely to encounter.

Note that not all of the source database features are fully compatible with Aurora or have simple workarounds. From a migration perspective, this document does not yet cover all source database features and capabilities. This first release focuses on some of the most important features and will be expanded over time.

Disclaimer

The various code snippets, commands, guides, best practices, and scripts included in this document should be used for reference only and are provided as-is without warranty. Test all of the code, commands, best practices, and scripts outlined in this document in a non-production environment first. Amazon and its affiliates are not responsible for any direct or indirect damage that may occur from the information contained in this document.

Tables of Feature Compatibility

Feature Compatibility Legend

Compatibility Score Symbol	Description
	**Very high compatibility:** None or minimal low-risk and low-effort rewrites needed
	**High compatibility:** Some low-risk rewrites needed, easy workarounds exist for incompatible features
	**Medium compatibility:** More involved low-medium risk rewrites needed, some redesign may be needed for incompatible features
	**Low compatibility:** Medium to high risk rewrites needed, some incompatible features require redesign and reasonable-effort workarounds exist
	**Very low compatibility:** High risk and/or high-effort rewrites needed, some features require redesign and workarounds are challenging
	**Not compatible:** No practical workarounds yet, may require an application level architectural solution to work around incompatibilities

SCT/DMS Automation Level Legend

SCT/DMS Automation Level Symbol	Description
	**Full Automation** Perform fully automatic conversion, no manual conversion needed.
	**High Automation:** Minor, simple manual conversions may be needed.
	**Medium Automation:** Low-medium complexity manual conversions may be needed.
	**Low Automation:** Medium-high complexity manual conversions may be needed.
	**Very Low Automation:** High risk or complex manual conversions may be needed.
	**No Automation:** Not currently supported, manual conversion is required for this feature.

ANSI SQL

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Constraints	Constraints	• SET DEFAULT option is missing • Check constraint with subquery.	
Creating Tables	Creating Tables	• Auto generated value column is different • Can't use physical attribute ON • Missing table variable and memory optimized table	
Common Table Expressions	Common Table Expressions	• Must use RECURSIVE key word for recursive CTE queries	
GROUP BY	GROUP BY		
Table JOIN	Table JOIN	• OUTER JOIN with commas • CROSS APPLY and OUTER APPLY are not supported	
Data Types	Data Types	• Syntax and handling differences	
Views	Views	• Indexed and Partitioned view are not supported	
Windowed Functions	Windowed Functions		
Derived Tables	Derived Tables		

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Temporal Tables	Temporal Tables	• Temporal tables are not supported	

T-SQL

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Collations	Collations	• UTF16 and NCHAR/NVARCHAR data types are not supported	
Cursors	Cursors	• Different cursor options	
Date and Time Functions	Date and Time Functions	• PostgreSQL is using different function names	
String Functions	String Functions	• Syntax and option differences	
Databases and Schemas	Databases and Schemas		
Transactions	Transactions	• Nested transactions are not supported • syntax differences for initializing a transaction	
DELETE and UPDATE FROM	DELETE and UPDATE FROM	• DELETE...FROM from_list is not supported - rewrite to use subqueries	
Stored Procedures	Stored Procedures	• Syntax and option differences	
Error Handling	Error Handling	• Different paradigm and syntax will require rewrite of error handling	

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
		code	
Full Text Search	Full Text Search	• Different paradigm and syntax will require application/drivers rewrite.	
Flow Control	Flow Control	• Postgres does not support GOTO and WAITFOR TIME	
JSON and XML	JSON and XML	• Syntax and option differences, similar functionality • Missing FOR XML clause	
PIVOT	PIVOT	• Straight forward rewrite to use traditional SQL syntax	
MERGE	MERGE	• Rewrite to use INSERT… ON CONFLICT	
Triggers	Triggers	• Syntax and option differences, similar functionality - PostgreSQL trigger calling a function	
User Defined Functions	User Defined Functions	• Syntax and option differences	
User Defined Types	User Defined Types	• Syntax and option differences	
Sequences and Identity	Sequences and Identity	• Less options with SERIAL • Reseeding need to be rewrited	
Synonyms	Synonyms	• PostgreSQL does not support Synonym - there is an available workaround	

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
TOP and FETCH	LIMIT and OFFSET	• TOP is not supported	
Dynamic SQL	Dynamic SQL	• Different paradigm and syntax will require application/drivers rewrite.	
CAST and CONVERT	CAST and CONVERT	• CONVERT is used only to convert between collations • CAST uses different syntax	
Broker	Broker	• Use Amazon Lambda for similar functionality	
CLR Objects	CLR Objects	• Migrating CLR objects will require a full code rewrite	

Configuration

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Session Options	Session Options	• SET options are significantly different, except for transaction isolation control	
Database Options	Database Options	• Use Cluster and Database/Cluster Parameters	
Server Options	Server Options	• Use Cluster and Database/Cluster Parameters	

High Availability and Disaster Recovery (HADR)

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Backup and Restore	Backup and Restore	• Storage level backup managed by Amazon RDS	

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
High Availability Essentials	High Availability Essentials	• Multi replica, scale out solution using Amazon Aurora clusters and Availability Zones	

Indexes

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Clustered and Non Clustered Indexes	Clustered and Non Clustered Indexes	• CLUSTERED INDEX is not supported • There are few missing options	
Indexed Views	Indexed Views	• Different paradigm and syntax will require application/drivers rewrite.	
Columnstore	Columnstore	• Aurora PostgreSQL offers no comparable feature	

Management

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
SQL Server Agent	SQL Agent	• See Alerting and Maintenance Plans	
Alerting	Alerting	• Use Event Notifications Subscription with Amazon Simple Notification Service (SNS)	
ETL	ETL	• Use Amazon Glue for ETL	
Database Mail	Database Mail	• Use Lambda Integration	
Viewing Server Logs	Viewing Server Logs	• View logs from the Amazon RDS console, the Amazon RDS API, the AWS CLI, or the AWS SDKs	
Maintenance Plans	Maintenance Plans	• Backups via the RDS services • Table maintenance via SQL	
Monitoring	Monitoring	• Use Amazon Cloud Watch service	

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Resource Governor	Resource Governor	• Distribute load/applications/users across multiple instances	
Linked Servers	Linked Servers	• Syntax and option differences, similar functionality	
Scripting & PowerShell	Scripting & PowerShell	• Non-compatible tool sets and scripting languages • Use PostgreSQL pgAdmin, Amazon RDS API, AWS Management Console, and Amazon CLI	
Import and Export	Import and Export	• Non-compatible tool	

Performance Tuning

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Execution Plans	Execution Plans	• Syntax differences • Completely different optimizer with different operators and rules	
Query Hints and Plan Guides	Query Hints and Plan Guides	• Very limited set of hints - Index hints and optimizer hints as comments • Syntax differences	
Managing Statistics	Managing Statistics	• Syntax and option differences, similar functionality	

Physical Storage

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Partitioning	Partitioning	• Does not support LEFT partition or foreign keys referencing partitioned tables	

Security

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Column Encryption	Column Encryption	• Syntax and option differences, similar functionality	
Data Control Language	Data Control Language	• Similar syntax and similar functionality	
Transparent Data Encryption	Transparent Data Encryption	• Storage level encryption managed by Amazon RDS	

SQL Server	Aurora PostgreSQL	Key Differences	Compatibility
Users and Roles	Users and Roles	• Syntax and option differences, similar functionality • There are no users - only roles	

What's New

The previous playbook covered the Aurora PostgreSQL 9.6 compatible and SQL Server 2016, this playbook will cover the main updates for Aurora PostgreSQL 12 compatible and SQL Server 2019.

AWS is keep updating all the services, for the open-source databases, AWS is trying to keep up with the releases of the brand.

In order to provide the complete picture to all users, RDS related information is being mentioned in this playbook as well. Sections formatted in the following way are relevant for RDS only:

> **RDS ONLY:** This paragraph is about the latest db engine version which is supported only in RDS (and not Aurora)

Update	Aspect	Link
Updated screen shots	AWS	AWS SCT
Updated SCT warning lists	AWS	AWS SCT Error Codes
Amazon RDS on Outposts	AWS	RDS Outposts
Amazon RDS Proxy	AWS	RDS Proxy
Amazon Aurora Serverless	AWS	Aurora Serverless
AWS RDS Backtrack	AWS	RDS Backtrack
New features for pg_dump support for extension dependencies pg_dump dump files can not only be plain text files but also with custom and compressed format support for WHERE in COPY	PostgreSQL	pg_dump
Rewrite partitioning topic to present declarative partitions	PostgreSQL	Partitions
Monitoring index creation	PostgreSQL	Overall Indexes
Monitoring VACUUM FULL and CLUSTER operations Monitoring index creation New system views to monitor shared memory usage and ANALYZE progress	PostgreSQL	Information Views
New option AND CHAIN for COMMIT / ROLLBACK	PostgreSQL	Transactions
Generated columns	PostgreSQL	Virtual Columns
New supported collation versions	PostgreSQL	Character Set
New ability to rename view columns	PostgreSQL	Views
Table storage parameters that can trigger autovacuum	PostgreSQL	Statistics
Automatic Tuning in SQL Server 2017	SQL Server	Execution Plan
Cancel queries automatically	PostgreSQL	Execution Plans
Case sensitive topic to call out the difference between the two engines	PostgreSQL	Case Sensitive

Update	Aspect	Link
Graph Features in SQL Server 2017 and updates for 2019	New topic	Graph Features
- Availability Groups in SQL Server 2017 - Database Snapshots Databases in SQL Server 2019	SQL Server	High Availability
New System Views in SQL Server 2017 Lightweight Query Profiling Infrastructure	SQL Server	Monitoring
Upgrades	New topic	Upgrades
Scalar UDF Inline in SQL Server 2019	SQL Server	User Defined Functions
Changes Resource governance SQL operations in SQL Server 2019	SQL Server	Resource Governor
UTF-8 support in SQL Server 2019	SQL Server	Collations

We will dive into each change in the relevant topics.

General migration tips topic has been added here: link

For additional details, see: https://www.postgresql.org/docs/13/release-13.html

AWS Schema and Data Migration Tools

AWS Schema Conversion Tool (SCT)

Usage

The AWS Schema Conversion Tool (SCT) is a Java utility that connects to source and target databases, scans the source database schema objects (tables, views, indexes, procedures, etc.), and converts them to target database objects.

This section provides a step-by-step process for using AWS SCT to migrate an Oracle database to an Aurora PostgreSQL database cluster. Since AWS SCT can automatically migrate most of the database objects, it greatly reduces manual effort.

It is recommended to start every migration with the process outlined in this section and then use the rest of the Playbook to further explore manual solutions for objects that could not be migrated automatically. For more information, see
http://docs.aws.amazon.com/SchemaConversionTool/latest/userguide/Welcome.html

Migrating a Database

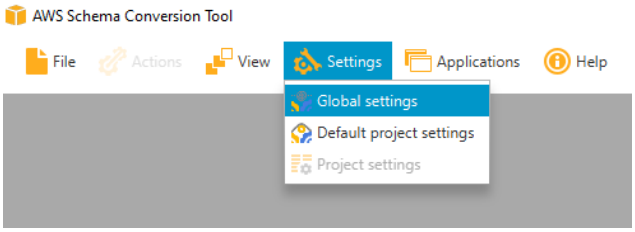
> **Note:** This walkthrough uses the AWS DMS Sample Database. You can download it from https://-github.com/aws-samples/aws-database-migration-samples.

Download the Software and Drivers

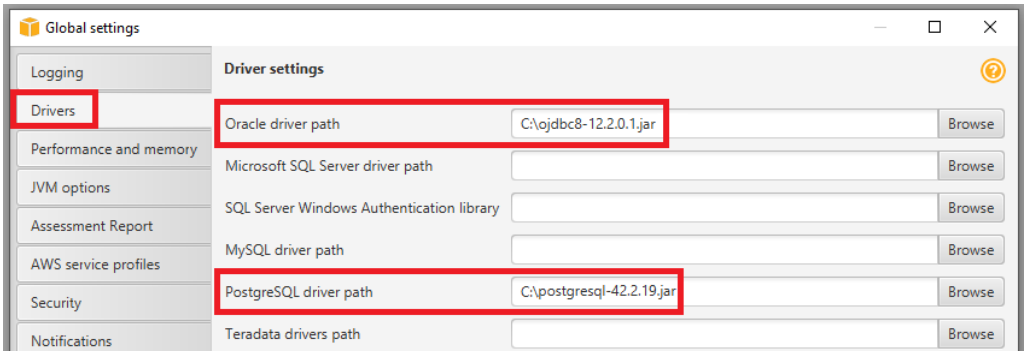
1. Download and install the AWS SCT from
   https://docs.aws.amazon.com/SchemaConversionTool/latest/userguide/CHAP_Installing.html.
2. Download the relevant drivers:
   - Oracle
     http://www.oracle.com/technetwork/database/features/jdbc/jdbc-drivers-12c-download-1958347.html
   - SQL Server
     https://www.microsoft.com/en-us/download/details.aspx?displaylang=en&id=11774
   - PostgreSQL
     https://jdbc.postgresql.org/
   - MySQL
     https://www.mysql.com/products/connector/
   - Other link to supported drivers can be found in here:
     https://docs.aws.amazon.com/SchemaConversionTool/latest/userguide/CHAP_Installing.html#CHAP_Installing.JDBCDrivers

Configure SCT

Launch SCT. Click the **Settings** button and select **Global Settings**.

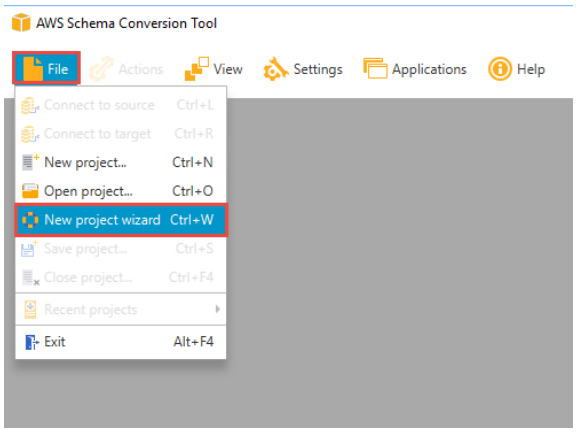


On the left navigation bar, click **Drivers**. Enter the paths for the Oracle and PostgreSQL drivers downloaded in the first step. Click **Apply** and then **OK**.

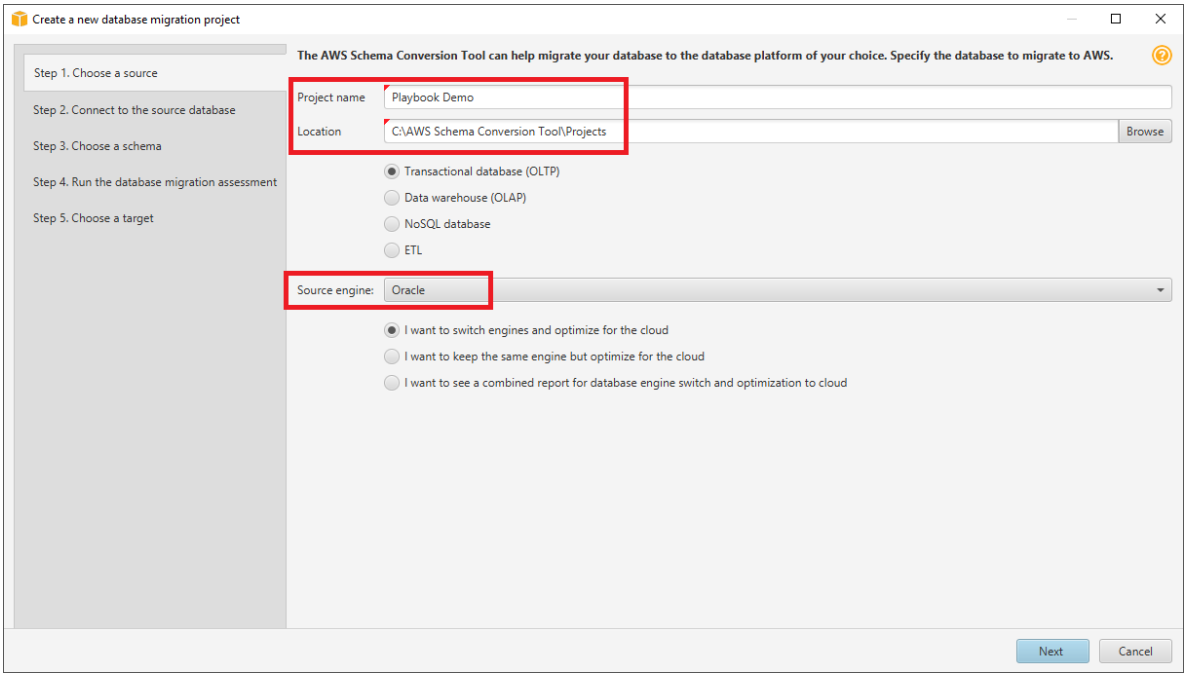


Create a New Migration Project

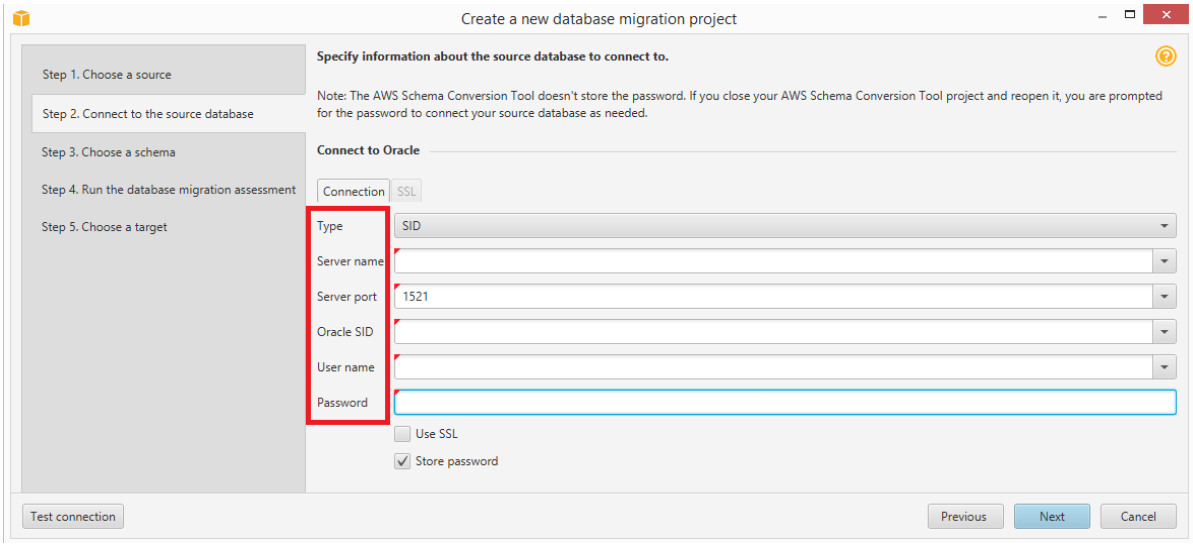
Click **File > New project wizard**. Alternatively, use the keyboard shortcut **<Ctrl+W>**.



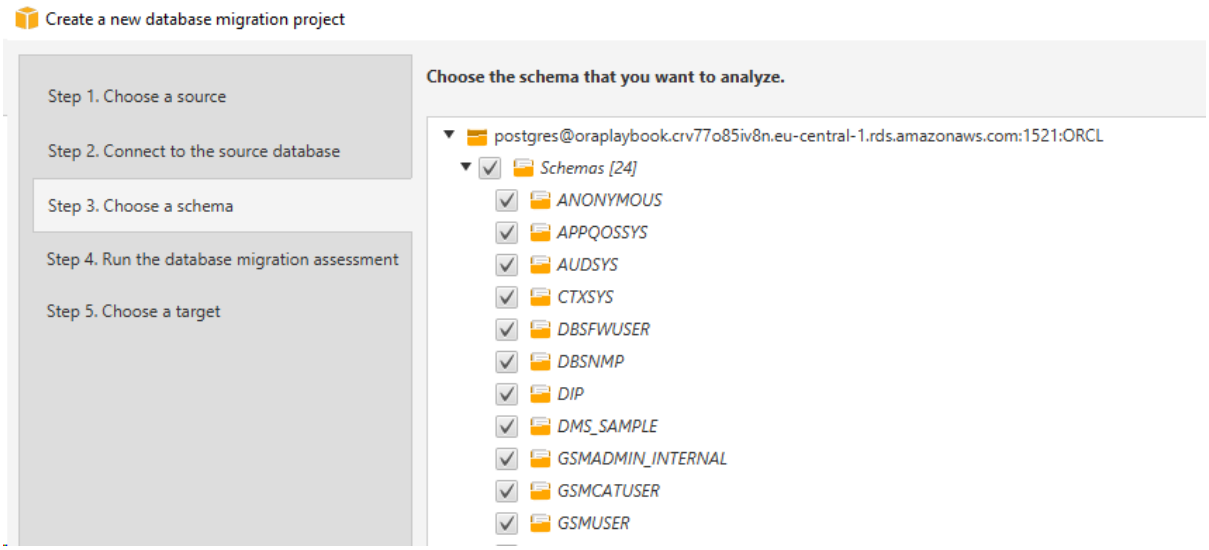
Enter a project name and select a location for the project files. Click **Next**.



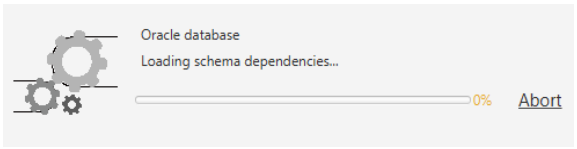
Enter connection details for the source Oracle database and click **Test Connection** to verify. Click **Next**.



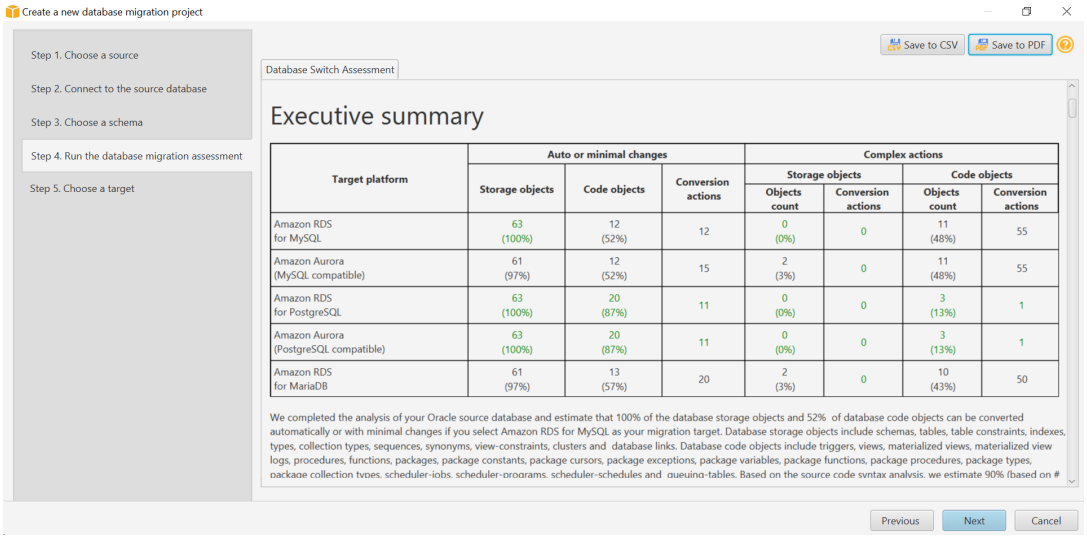
Select the schema or database to migrate and click **Next**.



The progress bar displays the objects being analyzed.



The Database Migration Assessment Report is displayed when the analysis completes. Read the Executive summary and other sections. Note that the information on the screen is only partial. To read the full report, including details of the individual issues, click **Save to PDF** and open the PDF document.



Scroll down to the section **Database objects with conversion actions for Amazon Aurora (PostgreSQL compatible)**.

Of the total 63 database storage object(s) and 23 database code object(s) in the source database, we identifed 63 (100%) database storage object(s) and 20 (87%) database code object(s) that can be converted to Amazon Aurora (PostgreSQL compatible) automatically or with minimal changes.

3 (13%) database code object(s) require 1 complex user action(s) to complete the conversion.

Figure: Conversion statistics for database storage objects

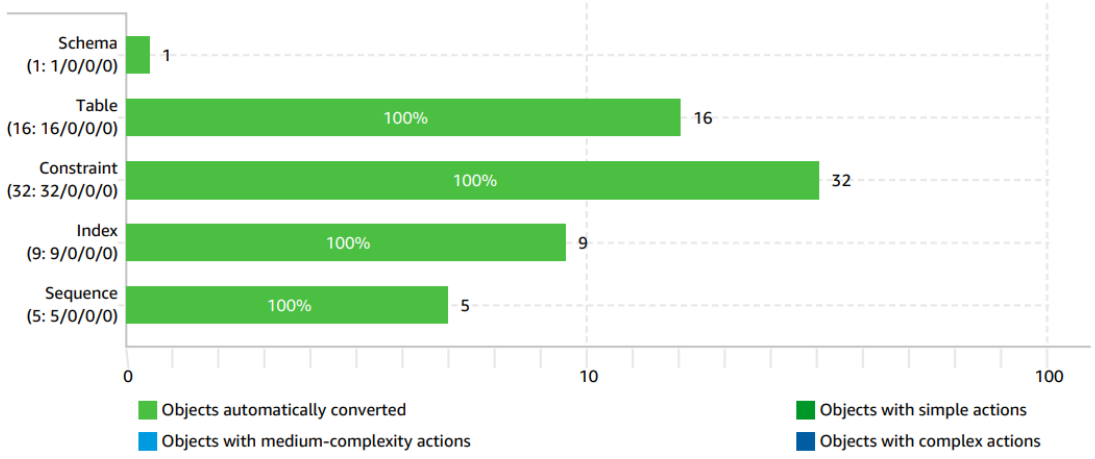
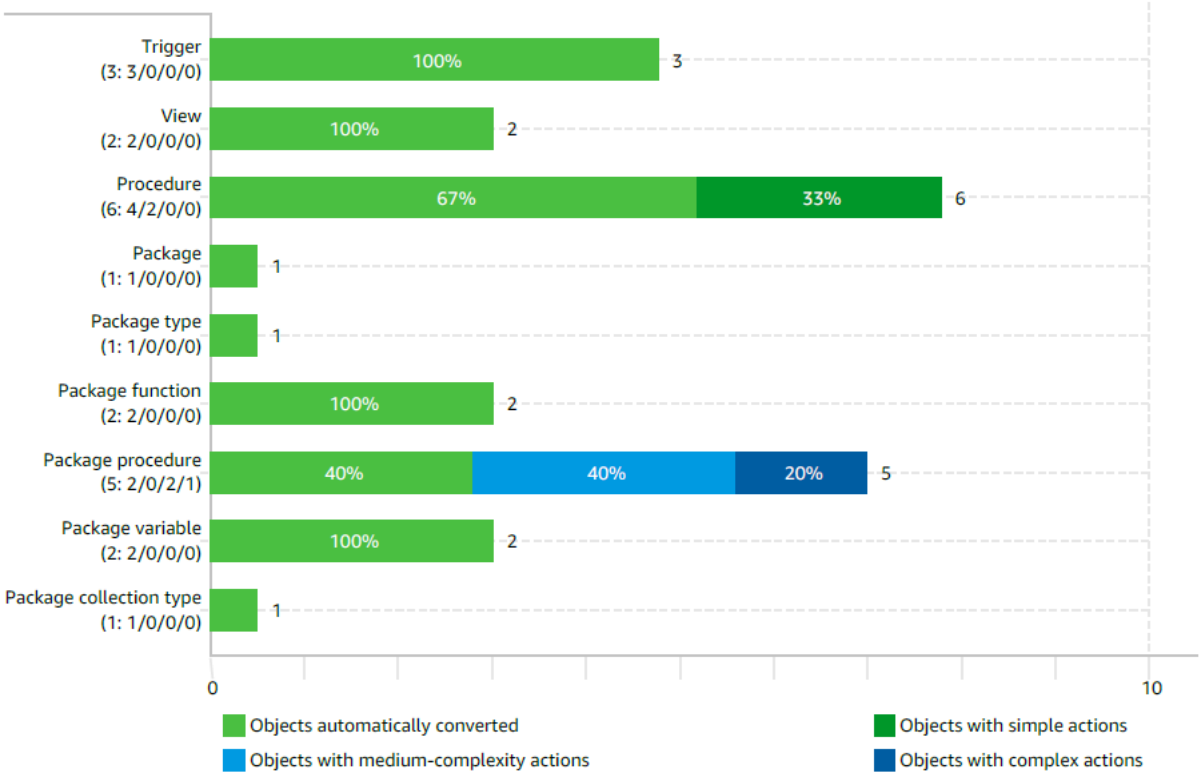
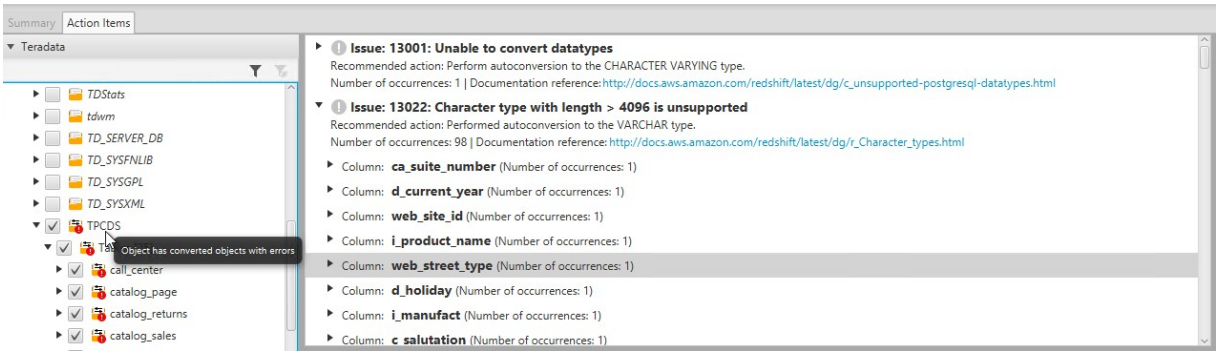


Figure: Conversion statistics for database code objects

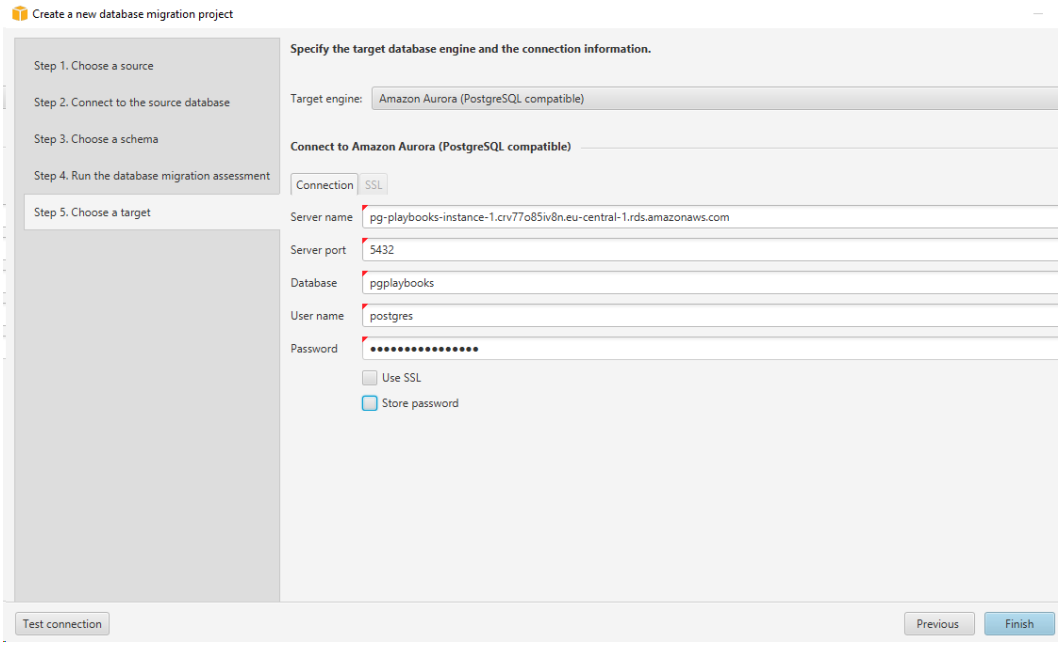


Scroll further down to the section **Detailed recommendations for Amazon Aurora (PostgreSQL compatible) migrations**.



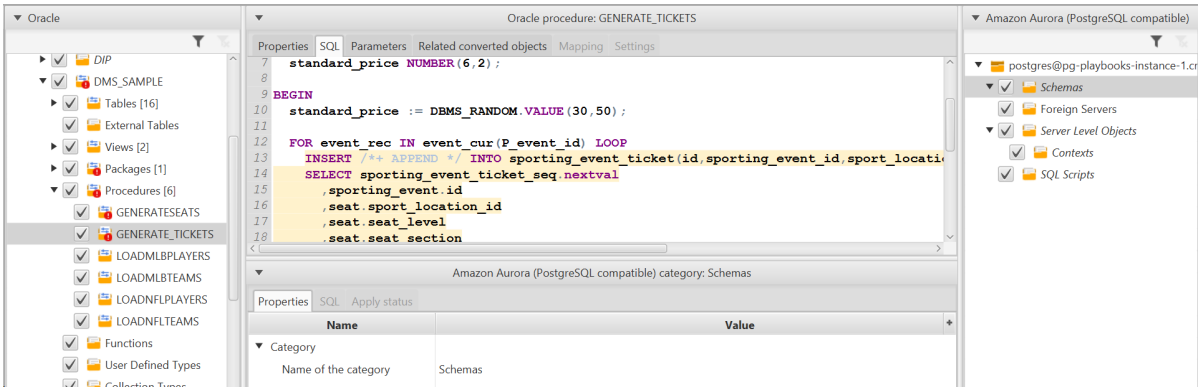
Return to AWS SCT and click **Next**. Enter the connection details for the target Aurora PostgreSQL database and click **Finish**.

> **Note:** The changes have not yet been saved to the target.

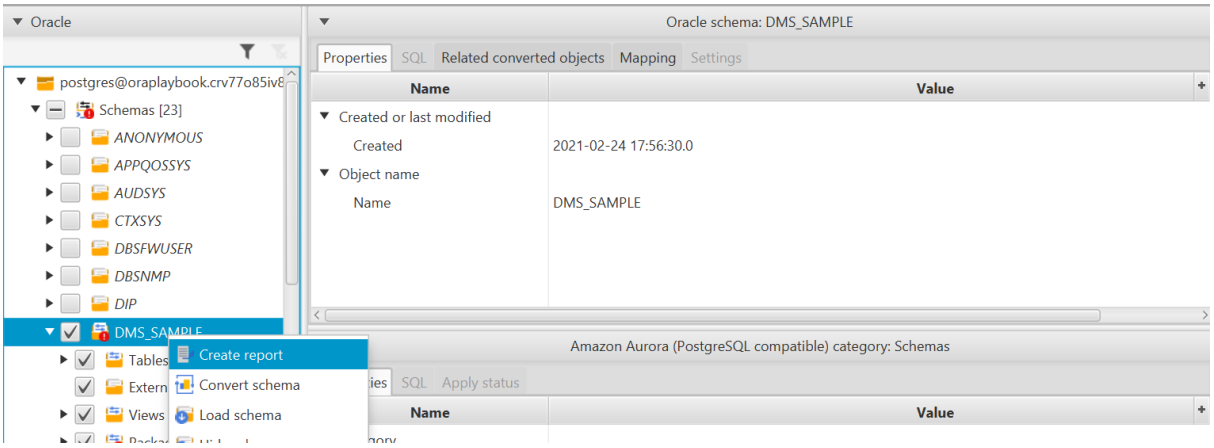


When the connection is complete, AWS SCT displays the main window. In this interface, you can explore the individual issues and recommendations discovered by AWS SCT.

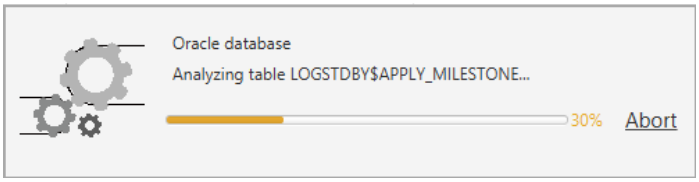
For example, expand **sample database > dms sample > Proceduress > generate_tickets**. This issue has a red marker indicating it could not be automatically converted and requires a manual code change (issue 811 above). Select the object to highlight the incompatible code section.



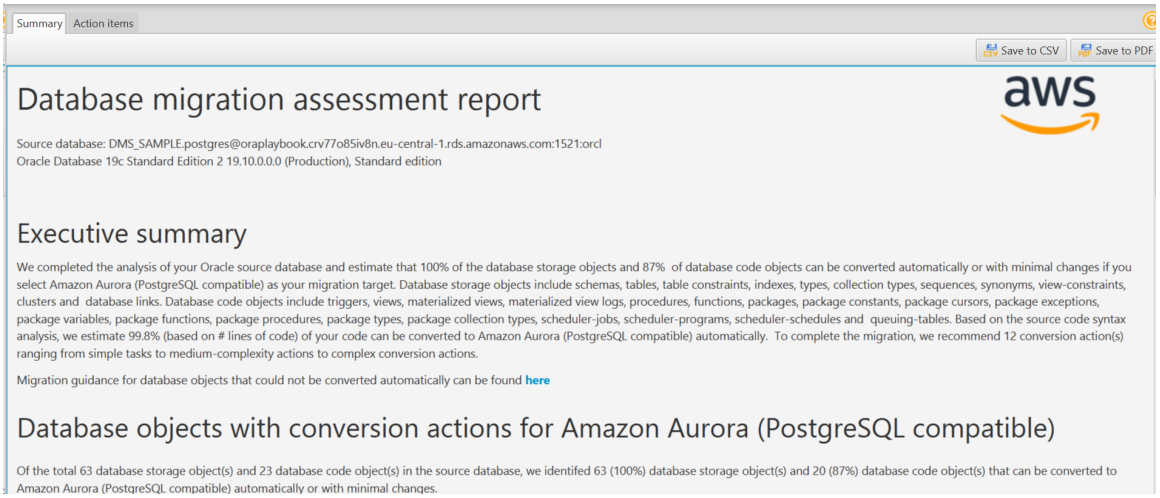
Right-click the schema and then click **Create Report** to create a report tailored for the target database type. It can be viewed in AWS SCT.



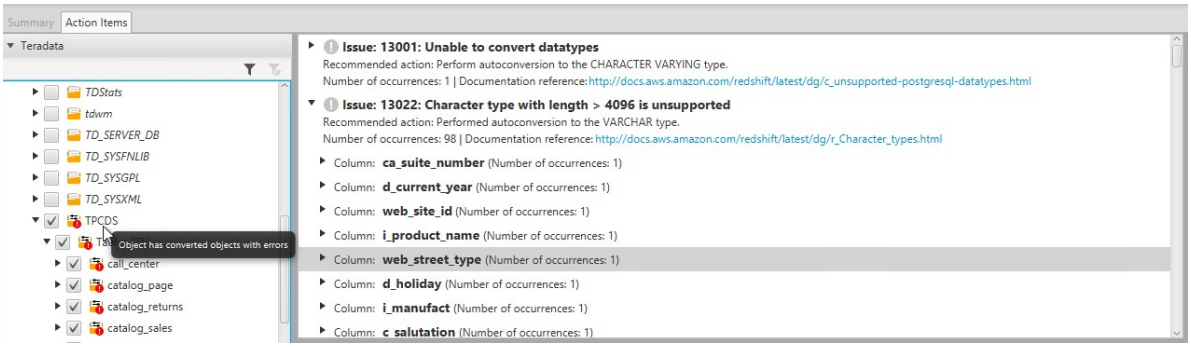
The progress bar updates while the report is generated.



The executive summary page displays. Click the **Action Items** tab.



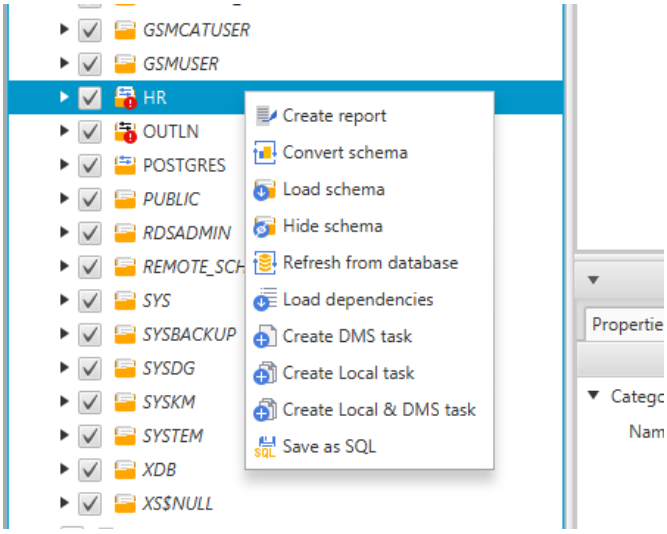
In this window, you can investigate each issue in detail and view the suggested course of action. For each issue, drill down to view all instances of that issue.



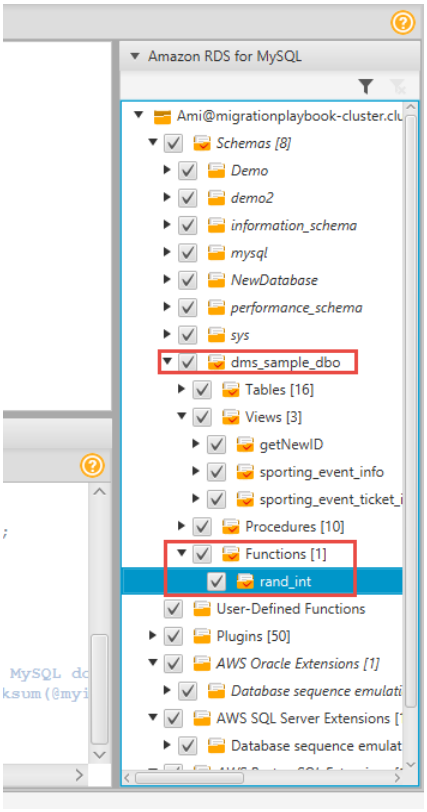
Right-click the database name and click **Convert Schema**.

Be sure to uncheck the **sys** and **information_schema** system schemas. Aurora PostgreSQL already has an **information_schema** schema.

This step does not make any changes to the target database.

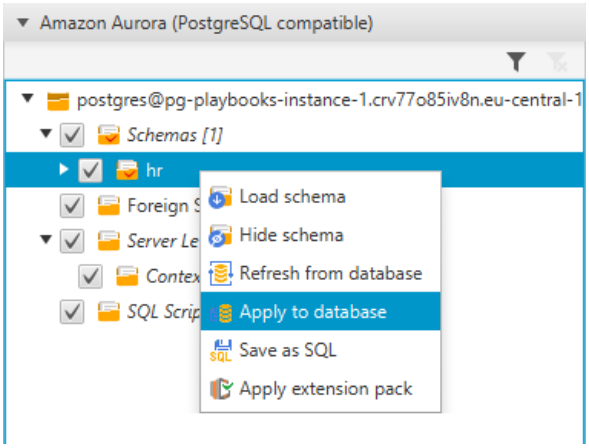


On the right pane, the new virtual schema is displayed as if it exists in the target database. Drilling down into individual objects displays the actual syntax generated by AWS SCT to migrate the objects.



Right-click the database on the right pane and choose either **Apply to database** to automatically execute the conversion script against the target database, or click **Save as SQL** to save to an SQL file.

Saving to an SQL file is recommended because it allows you to verify and QA the SCT code. Also, you can make the adjustments needed for objects that could not be automatically converted.



For more information, see https://docs.aws.amazon.com/SchemaConversionTool/latest/userguide/CHAP_Welcome.html

SCT Action Code Index

Legend

SCT/DMS Automation Level Symbol	Description
	**Full Automation** SCT performs fully automatic conversion, no manual conversion needed.
	**High Automation:** Minor, simple manual conversions may be needed.
	**Medium Automation:** Low-medium complexity manual conversions may be needed.
	**Low Automation:** Medium-high complexity manual conversions may be needed.
	**Very Low Automation:** High risk or complex manual conversions may be needed.
	**No Automation:** Not currently supported by SCT, manual conversion is required for this feature.

The following sections list the Schema Conversion Tool Action codes for topics that are covered in this playbook.

> **Note:** The links in the table point to the Microsoft SQL Server topic pages, which are immediately followed by the PostgreSQL pages for the same topics.

Creating Tables

AWS SCT automatically converts the most commonly used constructs of the CREATE TABLE statement as both SQL Server and Aurora PostgreSQL support the entry level ANSI compliance. These items include table names, containing security schema (or database), column names, basic column data types, column and table constraints, column default values, primary, candidate (UNIQUE), and foreign keys. Some changes may be required for computed columns and global temporary tables.

For more details, see Creating Tables.

Action Code	Action Message
7659	The scope table-variables and temporary tables is different. You must apply manual conversion, if you are using recursion
7665	PostgreSQL doesn't support FILESTREAM option for storing column values
7678	A computed column is replaced by regular column. Automatically fill is not supported
7679	A computed column is replaced by the triggers
7680	PostgreSQL doesn't support global temporary tables

Action Code	Action Message
7812	Temporary table must be removed before the end of the function
7835	PostgreSQL does not support the Filetable option

Data Types

Data type syntax and rules are very similar between SQL Server and Aurora PostgreSQL and most are converted automatically by AWS SCT. Note that date and time handling paradigms are different for SQL Server and Aurora PostgreSQL and require manual verifications and/or conversion. Also note that due to differences in data type behavior between SQL Server and Aurora PostgreSQL , manual verification and strict testing are highly recommended.

For more details, see Data Types.

Action Code	Action Message
7657	PostgreSQL doesn't support this type. A manual conversion is required
7658	PostgreSQL doesn't support this type. A manual conversion is required
7662	PostgreSQL doesn't support this type. A manual conversion is required
7664	PostgreSQL doesn't support this type. A manual conversion is required
7690	PostgreSQL doesn't support table types
7706	Unable convert the variable declaration of unsupported %s datatype
7707	Unable convert variable reference of unsupported %s datatype
7708	Unable convert complex usage of unsupported %s datatype
7773	Unable to perform an automated migration of arithmetic operations with several dates
7775	Check the data type conversion. Possible loss of accuracy

Collations

The collation paradigms of SQL Server and Aurora PostgreSQL are significantly different. The AWS SCT tool can not migrate collation automaticly to PostgreSQL

For more details, see Collations.

Action Code	Action Message
7646	Automatic conversion of collation is not supported

PIVOT and UNPIVOT

Aurora PostgreSQL version 10 does not support the PIVOT and UNPIVOT syntax and it cannot be automatically converted by AWS SCT.

For workarounds using traditional SQL syntax, see PIVOT and UNPIVOT.

Action Code	Action Message
7905	PostgreSQL doesn't support the PIVOT clause for the SELECT statement
7906	PostgreSQL doesn't support the UNPIVOT clause for the SELECT statement

TOP and FETCH

Aurora PostgreSQL supports the non-ANSI compliant (but popular with other engines) LIMIT... OFFSET operator for paging results sets. Some options such as WITH TIES cannot be automatically converted and require manual conversion.

For more details, see TOP and FETCH.

Action Code	Action Message
7605	PostgreSQL doesn't support the WITH TIES option
7796	PostgreSQL doesn't support TOP option in the operator UPDATE
7798	PostgreSQL doesn't support TOP option in the operator DELETE
7799	PostgreSQL doesn’t support TOP option in the operator INSERT

Cursors

PostgreSQL has PL/pgSQL cursors that enable you to iterate business logic on rows read from the database. They can encapsulate the query and read the query results a few rows at a time. All access to cursors in PL/pgSQL is performed through cursor variables, which are always of the refcursor data type.
There are specific options which are not supported for automatic conversion by SCT.

For more details, see Cursors.

Action Code	Action Message
7637	PostgreSQL doesn't support GLOBAL CURSORS. Requires manual Conversion
7639	PostgreSQL doesn't support DYNAMIC cursors
7700	The membership and order of rows never changes for cursors in PostgreSQL, so this option is skipped
7701	Setting this option corresponds to the typical behavior of cursors in PostgreSQL, so this option is skipped
7702	All PostgreSQL cursors are read-only, so this option is skipped
7704	PostgreSQL doesn't support the option OPTIMISTIC, so this option is skipped
7705	PostgreSQL doesn't support the option TYPE_WARNING, so this option is skipped
7803	PostgreSQL doesn't support the option FOR UPDATE, so this option is skipped

Flow Control

Although the flow control syntax of SQL Server differs from Aurora PostgreSQL , the AWS SCT can convert most constructs automatically including loops, command blocks, and delays. Aurora PostgreSQL does not support the GOTO command nor the WAITFOR TIME command, which require manual conversion.

For more details, see Flow Control.

Action Code	Action Message
7628	PostgreSQL doesn't support the GOTO option. Automatic conversion can't be performed
7691	PostgreSQL doesn't support WAITFOR TIME feature
7801	The table can be locked open cursor
7802	A table that is created within the procedure, must be deleted before the end of the procedure
7810	PostgreSQL doesn’t support the SET NOCOUNT
7821	Automatic conversion operator WAITFOR with a variable is not supported
7826	Check the default value for a DateTime variable
7827	Unable to convert default value

Transaction Isolation

Aurora PostgreSQL supports the four transaction isolation levels specified in the SQL:92 standard: READ UNCOMMITTED, READ COMMITTED, REPEATABLE READ, and SERIALIZABLE, all of which are automatically converted by AWS SCT. AWS SCT also converts BEGIN / COMMIT and ROLLBACK commands that use slightly different syntax. Manual conversion is required for named, marked, and delayed durability transactions that are not supported by Aurora PostgreSQL .

For more details, see Transaction Isolation.

Action Code	Action Message
7807	PostgreSQL does not support explicit transaction management in functions

Stored Procedures

Aurora PostgreSQL Stored Procedures (functions) provides very similar functionality to SQL Server stored procedures and can be automatically converted by AWS SCT. Manual conversion is required for procedures that use RETURN values and some less common EXECUTE options such as the RECOMPILE and RESULTS SETS options.

For more details, see Stored Procedures.

Action Code	Action Message
7640	The EXECUTE with RECOMPILE option is ignored
7641	The EXECUTE with RESULT SETS UNDEFINED option is ignored
7642	The EXECUTE with RESULT SETS NONE option is ignored
7643	The EXECUTE with RESULT SETS DEFINITION option is ignored
7672	Automatic conversion of this command is not supported
7695	PostgreSQL doesn't support the execution of a procedure as a variable
7800	PostgreSQL doesn't support result sets in the style of MSSQL
7830	Automatic conversion arithmetic operations with operand CASE is not supported
7838	The EXECUTE with LOGIN | USER option is ignored
7839	Converted code might be incorrect because of the parameter names

Triggers

Aurora PostgreSQL supports BEFORE and AFTER triggers for INSERT, UPDATE, and DELETE. However, Aurora PostgreSQL triggers differ substantially from SQL Server's triggers, but most common use cases can be migrated with minimal code changes.

For more details, see Triggers.

Action Code	Action Message
7809	PostgreSQL does not support INSTEAD OF triggers on tables
7832	Unable to convert INSTEAD OF triggers on view
7909	Unable to convert the clause

MERGE

Aurora PostgreSQL version 10 does not support the MERGE statement and it cannot be automatically converted by AWS SCT. Manual conversion is straight-forward in most cases.

For more details and potential workarounds, see MERGE.

Action Code	Action Message
7915	Please check unique(exclude) constraint existence on field %s
7916	Current MERGE statement can not be emulated by INSERT ON CONFLICT usage

Query hints

Basic query hints such as index hints can be converted automatically by AWS SCT, except for DML statements. Note that specific optimizations used for SQL Server may be completely inapplicable to a new query optimizer. It is recommended to start migration testing with all hints removed. Then, selectively apply hints as a last resort if other means such as schema, index, and query optimizations have failed. Plan guides are not supported by Aurora PostgreSQL.

For more details, see Query hints and Plan Guides.

Action Code	Action Message
7823	PostgreSQL doesn't support table hints in DML statements

Full Text Search

Migrating Full-Text indexes from SQL Server to Aurora PostgreSQL requires a full rewrite of the code that deals with both creating, managing, and querying Full-Text indexes. They cannot be automatically converted by AWS SCT.

For more details, see Full Text Search.

Action Code	Action Message
7688	PostgreSQL doesn't support the FREETEXT predicate

Indexes

Basic non-clustered indexes, which are the most commonly used type of indexes are automatically migrated by AWS SCT. In addition, filtered indexes, indexes with included columns, and some SQL Server specific index options can not be migrated automatically and require manual conversion.

For more details, see Indexes.

Action Code	Action Message
7675	PostgreSQL doesn't support sorting options (ASC | DESC) for constraints
7681	PostgreSQL doesn't support clustered indexes
7682	PostgreSQL doesn't support the INCLUDE option in indexes
7781	PostgreSQL doesn't support the PAD_INDEX option in indexes
7782	PostgreSQL doesn't support the SORT_IN_TEMPDB option in indexes
7783	PostgreSQL doesn't support the IGNORE_DUP_KEY option in indexes
7784	PostgreSQL doesn't support the STATISTICS_NORECOMPUTE option in indexes
7785	PostgreSQL doesn't support the STATISTICS_INCREMENTAL option in indexes
7786	PostgreSQL doesn't support the DROP_EXISTING option in indexes
7787	PostgreSQL doesn't support the ONLINE option in indexes
7788	PostgreSQL doesn't support the ALLOW_ROW_LOCKS option in indexes
7789	PostgreSQL doesn't support the ALLOW_PAGE_LOCKS option in indexes
7790	PostgreSQL doesn't support the MAXDOP option in indexes

Action Code	Action Message
7791	PostgreSQL doesn't support the DATA_COMPRESSION option in indexes

Partitioning

Aurora PostgreSQL uses "table inheritance", some of the physical aspects of partitioning in SQL Server do not apply to Aurora PostgreSQL . For example, the concept of file groups and assigning partitions to file groups. Aurora PostgreSQL supports a much richer framework for table partitioning than SQL Server, with many additional options such as hash partitioning, and sub partitioning.

For more details, see Partitioning.

Action Code	Action Message
7910	NULL columns not supported for partitioning
7911	PostgreSQL does not support foreign keys referencing partitioned tables
7912	PostgreSQL does not support foreign key references from a partitioned table to some other table
7913	PostgreSQL does not support LEFT partitioning - partition values distribution could vary
7914	Update of the partitioned table may lead to errors

Backup

Migrating from a self-managed backup policy to a Platform as a Service (PaaS) environment such as Aurora PostgreSQL is a complete paradigm shift. You no longer need to worry about transaction logs, file groups, disks running out of space, and purging old backups. Amazon RDS provides guaranteed continuous backup with point-in-time restore up to 35 days. Therefor, AWS SCT does not automatically convert backups.

For more details, see Backup and Restore.

Action Code	Action Message
7903	PostgreSQL does not have functionality similar to SQL Server Backup

SQL Server Mail

Aurora PostgreSQL does not provide native support sending mail from the database.

For more details and potential workarounds, see Database Mail.

Action Code	Action Message
7900	PostgreSQL does not have functionality similar to SQL Server Database Mail

Graph

For more details and potential workarounds, see Graph.

Action Code	Action Message
7931	Automatic migration of sql graph tables not supported
7932	Automatic migration of DML constructs for SQL Graph Architecture is not supported

SQL Server Agent

Aurora PostgreSQL does not provide functionality similar to SQL Server Agent as an external, cross-instance scheduler. However, Aurora PostgreSQL does provide a native, in-database scheduler. It is limited to the cluster scope and can't be used to manage multiple clusters. Therefore, AWS SCT can not automatically convert Agent jobs and alerts.

For more details, see SQL Server Agent.

Action Code	Action Message
7902	PostgreSQL does not have functionality similar to SQL Server Agent

Service Broker

Aurora PostgreSQL does not provide a compatible solution to the SQL Server Service Broker. However, you can use DB Links and AWS Lambda to achieve similar functionality.

For more details, see Service Broker.

Action Code	Action Message
7901	PostgreSQL does not have functionality similar to SQL Server Service Broker

XML

The XML options and features in Aurora PostgreSQL are similar to SQL Server and the most important functions (XPATH and XQUERY) or almost identical.
PostgreSQL does not support FOR XML clause, the walkaround for that is using string_agg instead. In some cases, it might be more efficient to use JSON instead of XML.

For more details, see XML.

Action Code	Action Message
7816	PostgreSQL doesn't support any methods for datatype XML
7817	PostgreSQL doesn't support option [for xml path] in the SQL-queries
7920	PostgreSQL doesn’t support FOR XML mode EXPLICIT
7924	Columns XPath expression could return multiple elements. PostgreSQL does not support such functionality, so the error can be occurred

Constraints

Constraints feature is almost fully automated and compatible between SQL Server and Aurora PostgreSQL.
The differences are: missing SET DEFAULT and Check constraint with sub-query.

For more details, see Constraints.

Action Code	Action Message
7606	PostgreSQL doesn’t support foreign keys referencing partitioned tables
7675	PostgreSQL doesn’t support sorting options (ASC | DESC) for constraints
7825	The default value for a DateTime column removed
7915	Please check unique(exclude) constraint existence on field %s

Linked Servers

Aurora PostgreSQL does support remote data access from the database. Connectivity between schemas is trivial, but connectivity to other instances require an extension installation

For more details, see Linked Servers.

Action Code	Action Message
7645	PostgreSQL doesn't support executing a pass-through command on a linked server

Synonyms

Aurora PostgreSQL does support synonyms, if these are referring to table/views/function then these can be replaced with views or functions to wrap those. It becomes more challengeing when these referes to other objects.

For more details, see Synonyms.

Action Code	Action Message
7792	PostgreSQL doesn’t support synonyms

AWS Database Migration Service (DMS)

Usage

The AWS Database Migration Service (DMS) helps you migrate databases to AWS quickly and securely. The source database remains fully operational during the migration, minimizing downtime to applications that rely on the database. The AWS Database Migration Service can migrate your data to and from most widely-used commercial and open-source databases.

The service supports homogenous migrations such as Oracle to Oracle as well as heterogeneous migrations between different database platforms such as Oracle to Amazon Aurora or Microsoft SQL Server to MySQL. It also allows you to stream data to Amazon Redshift, Amazon DynamoDB, and Amazon S3 from any of the supported sources, which are Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle Database, SAP ASE, SQL Server, IBM DB2 LUW, and MongoDB, enabling consolidation and easy analysis of data in a petabyte-scale data warehouse. The AWS Database Migration Service can also be used for continuous data replication with high-availability.

When migrating databases to Aurora, Redshift or DynamoDB, you can use DMS free for six months.

For all supported sources for DMS, see
https://docs.aws.amazon.com/dms/latest/userguide/CHAP_Source.html

For all supported targets for DMS, see
https://docs.aws.amazon.com/dms/latest/userguide/CHAP_Target.html

Migration Tasks Performed by AWS DMS

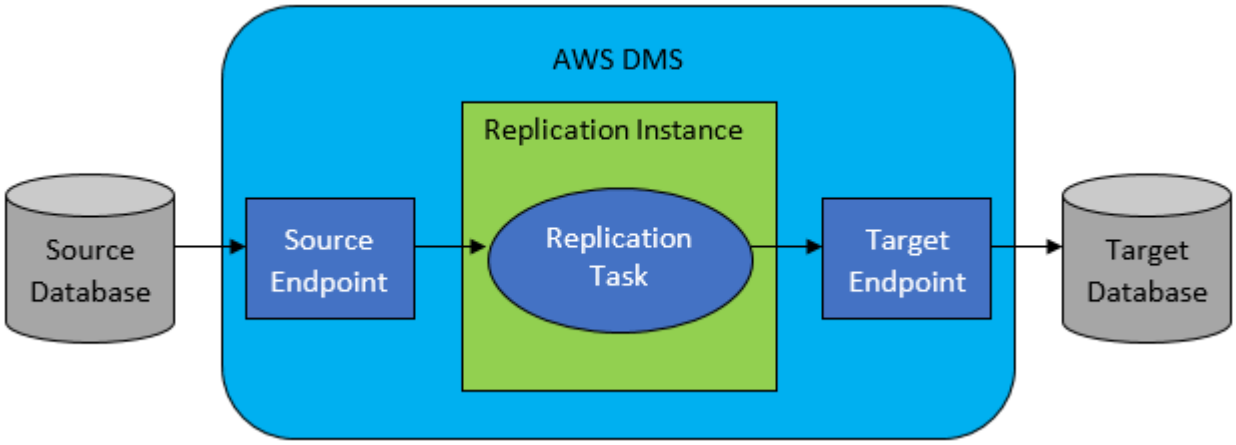
- In a traditional solution, you need to perform capacity analysis, procure hardware and software, install and administer systems, and test and debug the installation. AWS DMS automatically manages the deployment, management, and monitoring of all hardware and software needed for your migration. Your migration can be up and running within minutes of starting the AWS DMS configuration process.
- With AWS DMS, you can scale up (or scale down) your migration resources as needed to match your actual workload. For example, if you determine that you need additional storage, you can easily increase your allocated storage and restart your migration, usually within minutes. On the other hand, if you discover that you aren't using all of the resource capacity you configured, you can easily downsize to meet your actual workload.
- AWS DMS uses a pay-as-you-go model. You only pay for AWS DMS resources while you use them as opposed to traditional licensing models with up-front purchase costs and ongoing maintenance charges.
- AWS DMS automatically manages all of the infrastructure that supports your migration server including hardware and software, software patching, and error reporting.
- AWS DMS provides automatic failover. If your primary replication server fails for any reason, a backup replication server can take over with little or no interruption of service.
- AWS DMS can help you switch to a modern, perhaps more cost-effective database engine than the one you are running now. For example, AWS DMS can help you take advantage of the managed database services provided by Amazon RDS or Amazon Aurora. Or, it can help you move to the managed data warehouse service provided by Amazon Redshift, NoSQL platforms like Amazon DynamoDB, or low-cost storage platforms like Amazon S3. Conversely, if you want to migrate away from old infrastructure but continue to use the same database engine, AWS DMS also supports that process.

- AWS DMS supports nearly all of today's most popular DBMS engines as data sources, including Oracle, Microsoft SQL Server, MySQL, MariaDB, PostgreSQL, Db2 LUW, SAP, MongoDB, and Amazon Aurora.
- AWS DMS provides a broad coverage of available target engines including Oracle, Microsoft SQL Server, PostgreSQL, MySQL, Amazon Redshift, SAP ASE, S3, and Amazon DynamoDB.
- You can migrate from any of the supported data sources to any of the supported data targets. AWS DMS supports fully heterogeneous data migrations between the supported engines.
- AWS DMS ensures that your data migration is secure. Data at rest is encrypted with AWS Key Management Service (AWS KMS) encryption. During migration, you can use Secure Socket Layers (SSL) to encrypt your in-flight data as it travels from source to target.

How AWS DMS Works

At its most basic level, AWS DMS is a server in the AWS Cloud that runs replication software. You create a source and target connection to tell AWS DMS where to extract from and load to. Then, you schedule a task that runs on this server to move your data. AWS DMS creates the tables and associated primary keys if they don't exist on the target. You can pre-create the target tables manually if you prefer. Or you can use AWS SCT to create some or all of the target tables, indexes, views, triggers, and so on.

The following diagram illustrates the AWS DMS process.



Latest updates

DMS is continuously evolving and supporting more and more options, find below some of the updates add since last edition of this playbook:

- CDC tasks and Oracle source tables created using CREATE TABLE AS AWS -DMS now supports both full-load and CDC and CDC-only tasks running against Oracle source tables created using the CREATE TABLE AS statement.

- New MySQL version AWS DMS now supports MySQL version 8.0 as a source except when the transaction payload is compressed.
- Support for AWS Secrets Manager integration You can store the database connection details (user credentials) for supported endpoints securely in AWS Secrets Manager. You can then submit the corresponding secret instead of plain-text credentials to AWS DMS when you create or modify an endpoint. AWS DMS then connects to the endpoint databases using the secret. For more information on creating secrets for AWS DMS endpoints see Using secrets to access AWS Database Migration Service endpoints.
- Support for Oracle extended data types Oracle extended data types for both Oracle source and targets are now supported.
- TLS 1.2 support for MySQL AWS DMS now supports TLS 1.2 for MySQL endpoints.
- TLS 1.2 support for SQL Server AWS DMS now supports TLS 1.2 for SQL Server endpoints.

For a complete guide with a step-by-step walkthrough including all the latest notes for migrating SQL Server to Aurora MySQL (which is very similar to the Oracle-PostgreSQL migration process) with DMS, see https://docs.aws.amazon.com/dms/latest/sbs/CHAP_SQLServer2Aurora.html

For more information about DMS, see:

- *https://docs.aws.amazon.com/dms/latest/userguide/Welcome.html*
- *https://docs.aws.amazon.com/dms/latest/userguide/CHAP_BestPractices.html*

Amazon RDS on Outposts

PLEASE NOTE, ENTIRE TOPIC IS RELATED TO RDS AND IS NOT SUPPORTED WITH AURORA

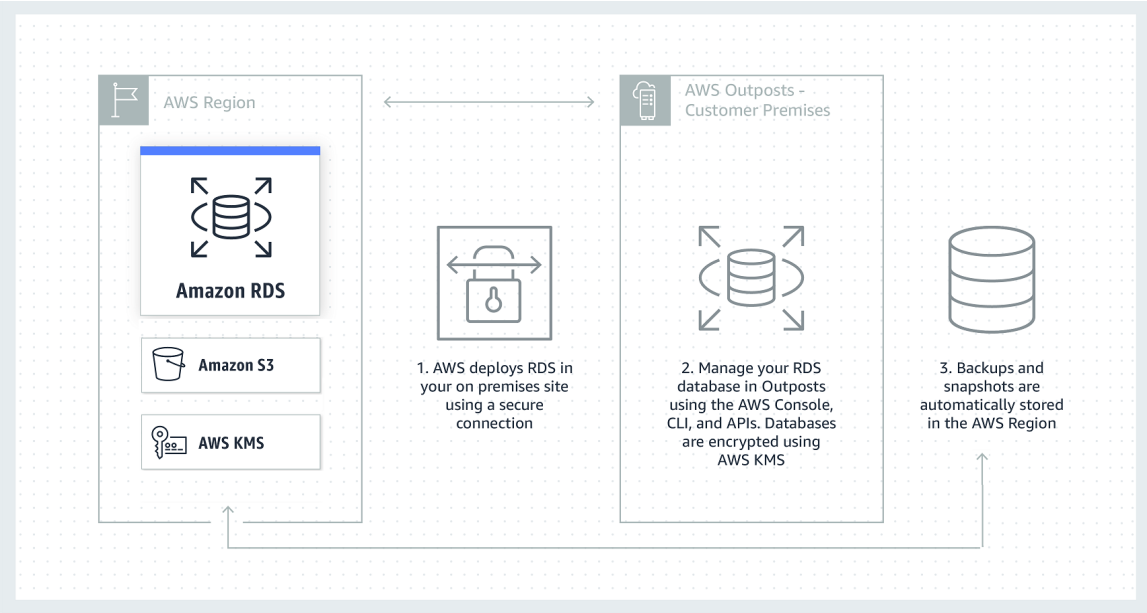
Usage

Amazon RDS on Outposts is a fully managed service that offers the same AWS infrastructure, AWS services, APIs, and tools to virtually any data center, co-location space, or on-premises facility for a truly consistent hybrid experience. Amazon RDS on Outposts is ideal for workloads that require low latency access to on-premises systems, local data processing, data residency, and migration of applications with local system inter-dependencies.

When you deploy Amazon RDS on Outposts, you can run RDS on premises for low latency workloads that need to be run in close proximity to your on-premises data and applications. Amazon RDS on Outposts also enables automatic backup to an AWS Region. You can manage RDS databases both in the cloud and on premises using the same AWS Management Console, APIs, and CLI. Amazon RDS on Outposts supports Microsoft SQL Server, MySQL, and PostgreSQL database engines, with support for additional database engines coming soon.

How it works

Amazon RDS on Outposts lets you run Amazon RDS in your on-premises or co-location site. You can deploy and scale an RDS database instance in Outposts just as you do in the cloud, using the AWS console, APIs, or CLI. RDS databases in Outposts are encrypted at rest using AWS KMS keys. RDS automatically stores all automatic backups and manual snapshots in the AWS Region.



This option is helpful when you need to run RDS on premises for low latency workloads that need to be run in close proximity to your on-premises data and applications

For more information, see:

- https://aws.amazon.com/outposts/
- https://aws.amazon.com/rds/outposts/
- https://aws.amazon.com/blogs/aws/new-create-amazon-rds-db-instances-on-aws-outposts/

Amazon RDS Proxy

Amazon RDS Proxy is a fully managed, highly available database proxy for Amazon Relational Database Service (RDS) that makes applications more scalable, more resilient to database failures, and more secure.

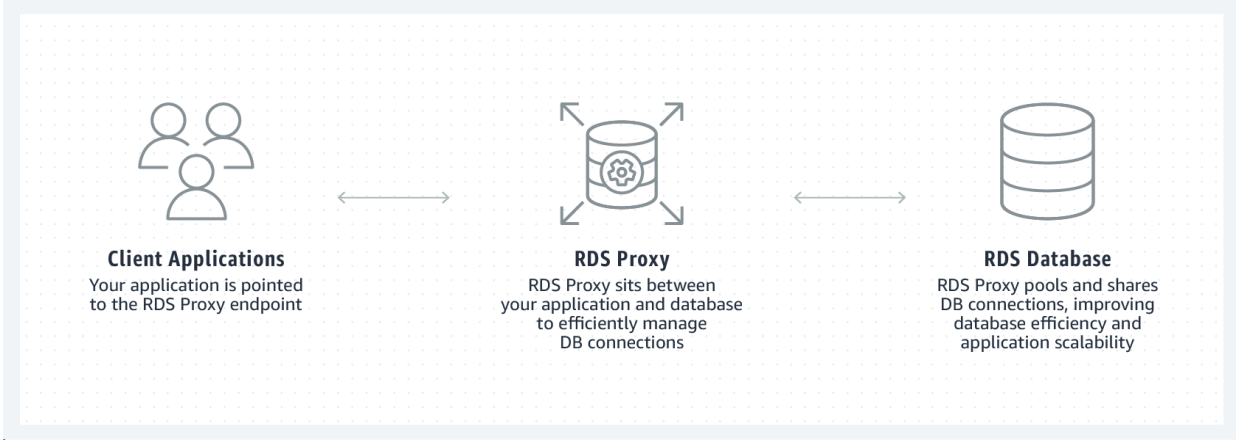
Many applications, including those built on modern server-less architectures, can have many open connections to the database server, and may open and close database connections at a high rate, exhausting database memory and compute resources. Amazon RDS Proxy allows applications to pool and share connections established with the database, improving database efficiency and application scalability. With RDS Proxy, fail-over times for Aurora and RDS databases are reduced by up to 66% and database credentials, authentication, and access can be managed through integration with AWS Secrets Manager and AWS Identity and Access Management (IAM).

Amazon RDS Proxy can be enabled for most applications with no code changes, and you don't need to provision or manage any additional infrastructure. Pricing is simple and predictable: you pay per vCPU of the database instance for which the proxy is enabled. Amazon RDS Proxy is now generally available for Aurora MySQL, Aurora PostgreSQL, RDS MySQL and RDS PostgreSQL.

Benefits

- Improved application performance
  Amazon RDS proxy manages a connection pooling which helps with reducing the stress on database compute and memory resources that typically occurs when new connections are established and it is useful to efficiently support a large number and frequency of application connections
- Increase application availability
  By automatically connecting to a new database instance while preserving application connections Amazon RDS Proxy can reduce fail-over time by 66%
- Manage application security
  RDS Proxy also enables you to centrally manage database credentials using AWS Secrets Manager
- Fully managed
  Amazon RDS Proxy gives you the benefits of a database proxy without requiring additional burden of patching and managing your own proxy server.
- Fully compatible with your database
  Amazon RDS Proxy is fully compatible with the protocols of supported database engines, so you can deploy RDS Proxy for your application without making changes to your application code.
- Available and durable
  Amazon RDS Proxy is highly available and deployed over multiple Availability Zones (AZs) to protect you from infrastructure failure

How it works



For more information, see:

- https://aws.amazon.com/blogs/aws/amazon-rds-proxy-now-generally-available/
- https://aws.amazon.com/rds/proxy/

Amazon Aurora Serverless v1

Usage

Amazon Aurora Serverless v1 (Amazon Aurora Serverless version 1) is an on-demand autoscaling configuration for Amazon Aurora. An Aurora Serverless DB cluster is a DB cluster that scales compute capacity up and down based on your application's needs. This contrasts with Aurora provisioned DB clusters, for which you manually manage capacity. Aurora Serverless v1 provides a relatively simple, cost-effective option for infrequent, intermittent, or unpredictable workloads. It is cost-effective because it automatically starts up, scales compute capacity to match your application's usage, and shuts down when it's not in use.

To learn more about pricing, see Serverless Pricing under MySQL-Compatible Edition or PostgreSQL-Compatible Edition on the Amazon Aurora pricing page.

Aurora Serverless v1 clusters have the same kind of high-capacity, distributed, and highly available storage volume that is used by provisioned DB clusters. The cluster volume for an Aurora Serverless v1 cluster is always encrypted. You can choose the encryption key, but you can't disable encryption. That means that you can perform the same operations on an Aurora Serverless v1 that you can on encrypted snapshots. For more information, see Aurora Serverless v1 and snapshots.

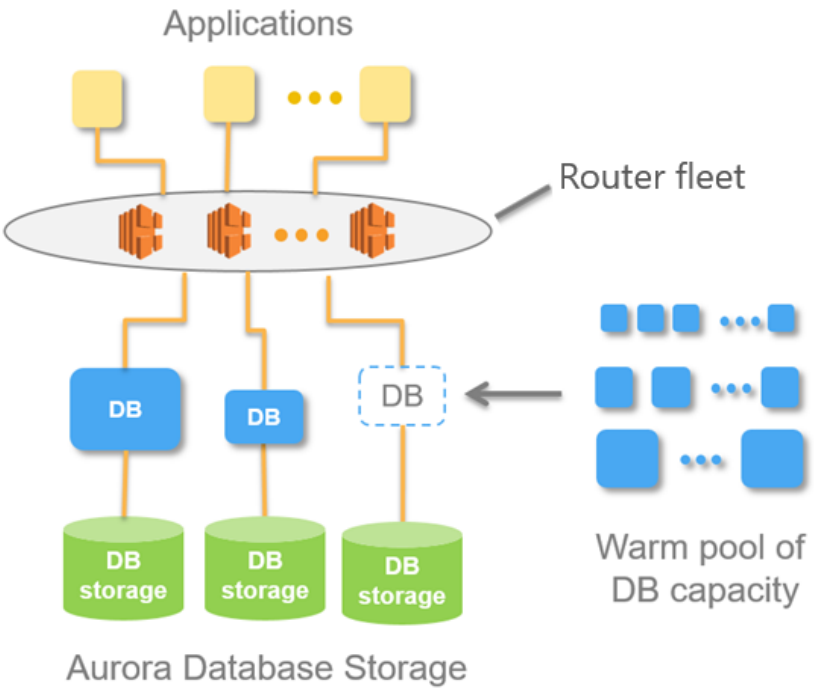
Aurora Serverless v1 provides the following advantages:

- **Simpler than provisioned** – Aurora Serverless v1 removes much of the complexity of managing DB instances and capacity.
- **Scalable** – Aurora Serverless v1 seamlessly scales compute and memory capacity as needed, with no disruption to client connections.
- **Cost-effective** – When you use Aurora Serverless v1, you pay only for the database resources that you consume, on a per-second basis.
- **Highly available storage** – Aurora Serverless v1 uses the same fault-tolerant, distributed storage system with six-way replication as Aurora to protect against data loss.

Aurora Serverless v1 is designed for the following use cases:

- **Infrequently used applications** – You have an application that is only used for a few minutes several times per day or week, such as a low-volume blog site. With Aurora Serverless v1, you pay for only the database resources that you consume on a per-second basis.
- **New applications** – You're deploying a new application and you're unsure about the instance size you need. By using Aurora Serverless v1, you can create a database endpoint and have the database auto-scale to the capacity requirements of your application.
- **Variable workloads** – You're running a lightly used application, with peaks of 30 minutes to several hours a few times each day, or several times per year. Examples are applications for human resources, budgeting, and operational reporting applications. With Aurora Serverless v1, you no longer need to provision for peak or average capacity.
- **Unpredictable workloads** – You're running daily workloads that have sudden and unpredictable increases in activity. An example is a traffic site that sees a surge of activity when it starts raining. With Aurora Serverless v1, your database autoscales capacity to meet the needs of the application's peak load and scales back down when the surge of activity is over.
- **Development and test databases** – Your developers use databases during work hours but don't need them on nights or weekends. With Aurora Serverless v1, your database automatically shuts down when it's not in use.
- **Multi-tenant applications** – With Aurora Serverless v1, you don't have to individually manage database capacity for each application in your fleet. Aurora Serverless v1 manages individual database capacity for you.

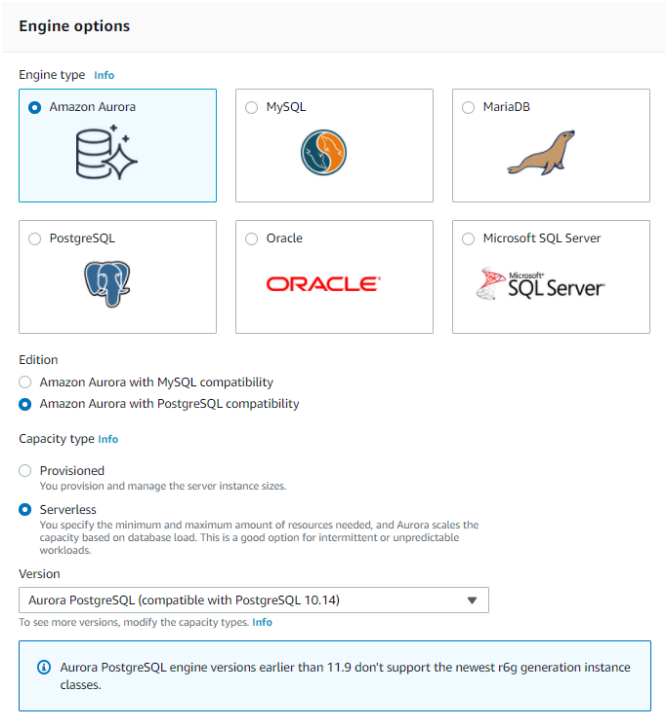
This process takes almost no time and since the storage is shared between nodes Aurora can scale up or down in seconds for most workloads. The service currently has autoscaling thresholds of 1.5 minutes to scale up and 5 minutes to scale down. That means metrics must exceed the limits for 1.5 minutes to trigger a scale up or fall below the limits for 5 minutes to trigger a scale down. The cool-down period between scaling activities is 5 minutes to scale up and 15 minutes to scale down. Before scaling can happen the service has to find a “scaling point” which may take longer than anticipated if you have long-running transactions. Scaling operations are transparent to the connected clients and applications since existing connections and session state are transferred to the new nodes. The only difference with pausing and resuming is a higher latency for the first connection, typically around 25 seconds. You can find more details in the documentation.



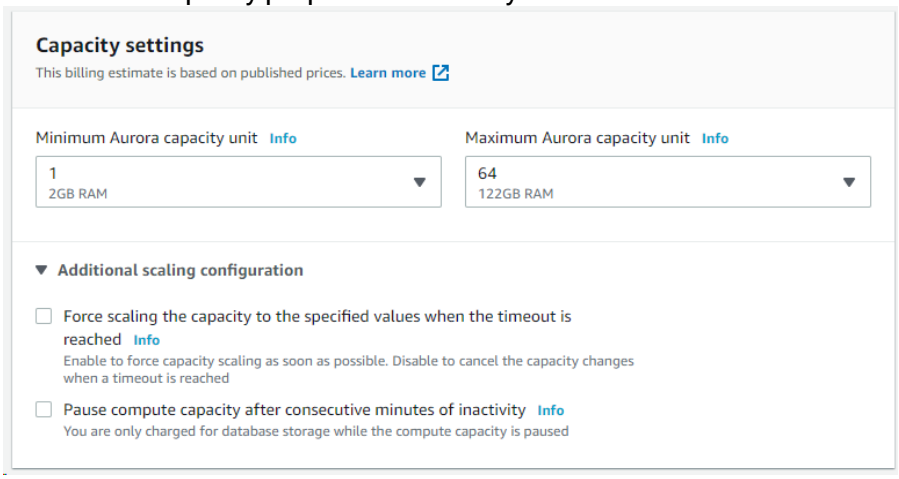
How to provision

Browse to the Databases page and click on "Create database"

Pick "Serverless" capacity type



Choose the capacity properties suite for you use case



For more information, see:

- https://aws.amazon.com/rds/aurora/serverless/
- https://aws.amazon.com/blogs/aws/aurora-serverless-ga/
- https://aws.amazon.com/blogs/aws/amazon-aurora-postgresql-serverless-now-generally-available/

Amazon Aurora Backtrack

Usage

We've all been there, you need to make a quick, seemingly simple fix to an important production database. You compose the query, give it a once-over, and let it run. Seconds later you realize that you forgot the WHERE clause, dropped the wrong table, or made another serious mistake, and interrupt the query, but the damage has been done. You take a deep breath, whistle through your teeth, wish that reality came with an Undo option.

Backtracking "rewinds" the DB cluster to the time you specify. Backtracking is not a replacement for backing up your DB cluster so that you can restore it to a point in time. However, backtracking provides the following advantages over traditional backup and restore:

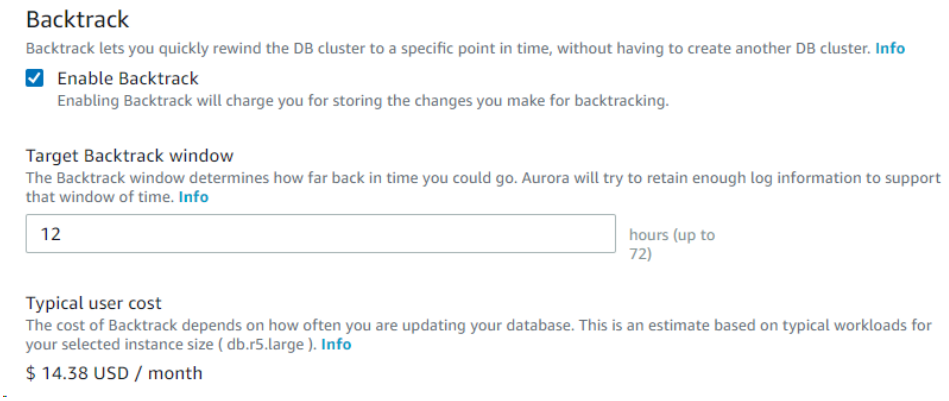
- You can easily undo mistakes. If you mistakenly perform a destructive action, such as a DELETE without a WHERE clause, you can backtrack the DB cluster to a time before the destructive action with minimal interruption of service.
- You can backtrack a DB cluster quickly. Restoring a DB cluster to a point in time launches a new DB cluster and restores it from backup data or a DB cluster snapshot, which can take hours. Backtracking a DB cluster doesn't require a new DB cluster and rewinds the DB cluster in minutes.
- You can explore earlier data changes. You can repeatedly backtrack a DB cluster back and forth in time to help determine when a particular data change occurred. For example, you can backtrack a DB cluster three hours and then backtrack forward in time one hour. In this case, the backtrack time is two hours before the original time.

Aurora uses a distributed, log-structured storage system (read Design Considerations for High Throughput Cloud-Native Relational Databases to learn a lot more); each change to your database generates a new log

record, identified by a Log Sequence Number (LSN). Enabling the backtrack feature provisions a FIFO buffer in the cluster for storage of LSNs. This allows for quick access and recovery times measured in seconds.

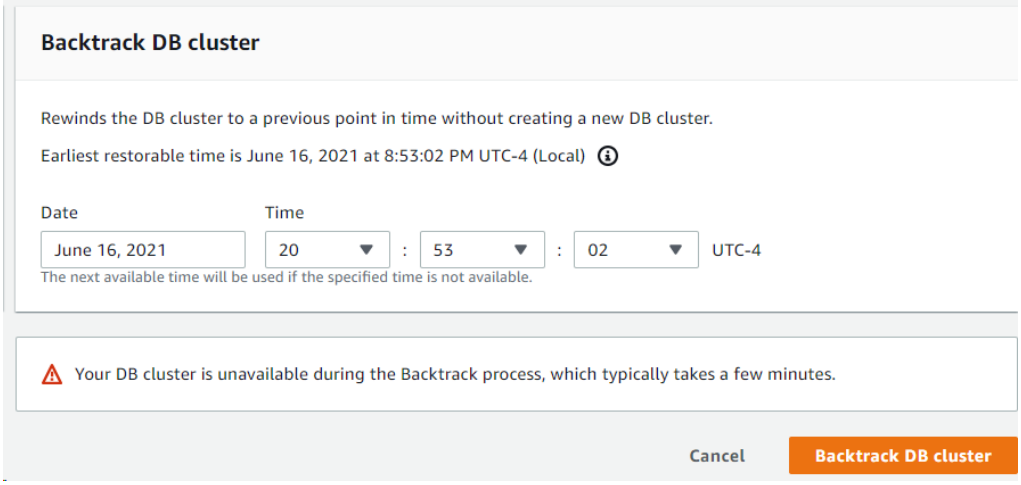
When you create a new Aurora MySQL DB cluster, backtracking is configured when you choose Enable Backtrack and specify a Target Backtrack window value that is greater than zero in the Backtrack section.

To create a DB cluster, follow the instructions in Creating an Amazon Aurora DB cluster. The following image shows the Backtrack section.



After a production error, you can simply pause your application, open up the Aurora Console, select the cluster, and click Backtrack DB cluster

Then you select Backtrack and choose the point in time just before your epic fail, and click Backtrack DB cluster:



Then you wait for the rewind to take place, unpause your application and proceed as if nothing had happened. When you initiate a backtrack, Aurora will pause the database, close any open connections, drop uncommitted writes, and wait for the backtrack to complete. Then it will resume normal operation and be able to accept requests. The instance state will be backtracking while the rewind is underway.

Backtrack window

With backtracking, there is a target backtrack window and an actual backtrack window:

- The target backtrack window is the amount of time you want to be able to backtrack your DB cluster. When you enable backtracking, you specify a target backtrack window. For example, you might specify a target backtrack window of 24 hours if you want to be able to backtrack the DB cluster one day.
- The actual backtrack window is the actual amount of time you can backtrack your DB cluster, which can be smaller than the target backtrack window. The actual backtrack window is based on your workload and the storage available for storing information about database changes, called change records.

As you make updates to your Aurora DB cluster with backtracking enabled, you generate change records. Aurora retains change records for the target backtrack window, and you pay an hourly rate for storing them. Both the target backtrack window and the workload on your DB cluster determine the number of change records you store. The workload is the number of changes you make to your DB cluster in a given amount of time. If your workload is heavy, you store more change records in your backtrack window than you do if your workload is light.

You can think of your target backtrack window as the goal for the maximum amount of time you want to be able to backtrack your DB cluster. In most cases, you can backtrack the maximum amount of time that you specified. However, in some cases, the DB cluster can't store enough change records to backtrack the maximum amount of time, and your actual backtrack window is smaller than your target. Typically, the actual backtrack window is smaller than the target when you have extremely heavy workload on your DB cluster. When your actual backtrack window is smaller than your target, we send you a notification.

When backtracking is enabled for a DB cluster, and you delete a table stored in the DB cluster, Aurora keeps that table in the backtrack change records. It does this so that you can revert back to a time before you deleted the table. If you don't have enough space in your backtrack window to store the table, the table might be removed from the backtrack change records eventually.

Backtracking limitations

The following limitations apply to backtracking:

- Backtracking an Aurora DB cluster is available in certain AWS Regions and for specific Aurora MySQL versions only. For more information, see Backtracking in Aurora.
- Backtracking is only available for DB clusters that were created with the Backtrack feature enabled. You can enable the Backtrack feature when you create a new DB cluster or restore a snapshot of a DB cluster. For DB clusters that were created with the Backtrack feature enabled, you can create a clone DB cluster with the Backtrack feature enabled. Currently, you can't perform backtracking on DB clusters that were created with the Backtrack feature disabled.
- The limit for a backtrack window is 72 hours.
- Backtracking affects the entire DB cluster. For example, you can't selectively backtrack a single table or a single data update.

- Backtracking isn't supported with binary log (binlog) replication. Cross-Region replication must be disabled before you can configure or use backtracking.
- You can't backtrack a database clone to a time before that database clone was created. However, you can use the original database to backtrack to a time before the clone was created. For more information about database cloning, see Cloning an Aurora DB cluster volume.
- Backtracking causes a brief DB instance disruption. You must stop or pause your applications before starting a backtrack operation to ensure that there are no new read or write requests. During the backtrack operation, Aurora pauses the database, closes any open connections, and drops any uncommitted reads and writes. It then waits for the backtrack operation to complete.
- Backtracking isn't supported for the following AWS Regions:
    - Africa (Cape Town)
    - China (Ningxia)
    - Asia Pacific (Hong Kong)
    - Europe (Milan)
    - Europe (Stockholm)
    - Middle East (Bahrain)
    - South America (São Paulo)
- You can't restore a cross-Region snapshot of a backtrack-enabled cluster in an AWS Region that doesn't support backtracking.
- You can't use Backtrack with Aurora multi-master clusters.
- If you perform an in-place upgrade for a backtrack-enabled cluster from Aurora MySQL version 1 to version 2, you can't backtrack to a point in time before the upgrade happened

For more information, see: https://aws.amazon.com/blogs/aws/amazon-aurora-backtrack-turn-back-time/

Migration Quick Tips

This section provides migration tips that can help save time as you transition from SQL Server to Aurora PostgreSQL. They address many of the challenges faced by administrators new to Aurora PostgreSQL. Some of these tips describe functional differences in similar features between SQL Server and Aurora PostgreSQL.

Management

- The equivalent of SQL Server's CREATE DATABASE... AS SNAPSHOT OF... resembles Aurora PostgreSQL Database cloning. However, unlike SQL Server snapshots, which are read only, Aurora PostgreSQL cloned databases are updatable.
- In Aurora PostgreSQL, the term "Database Snapshot" is equivalent to SQL Server's BACKUP DATABASE... WITH COPY_ONLY.
- Partitioning in Aurora PostgreSQL is called "INHERITS" tables and act completely different in terms of management
- Unlike SQL Server's statistics, Aurora PostgreSQL does not collect detailed key value distribution; it relies on selectivity only. When troubleshooting execution, be aware that parameter values are insignificant to plan choices.
- Many missing features such as sending emails can be achieved with quick implementations of Amazon's services (like Lambda).
- Parameters and backups are managed by Amazon's RDS. It is very useful in terms of checking parameter's value against its default and comparing them to another parameter group.
- High Availability can be implemented in few clicks to create Replicas.
- With Database Links, there are two options. The db_link extension is similar to SQL Server.

SQL

- Triggers work differently in Aurora PostgreSQL. Triggers can be also executed for each row (not just once). The syntax for inserted and deleted is new and old.
- Aurora PostgreSQL does not support the @@FETCH_STATUS system parameter for cursors. When declaring cursors in Aurora PostgreSQL, you must create an explicit HANDLER object.
- To execute a stored procedure (functions), use SELECT instead of EXECUTE.
- To execute a string as a query, use Aurora PostgreSQL Prepared Statements instead of either sp_executesql, or EXECUTE(<String>) syntax.
- In Aurora PostgreSQL, IF blocks must be terminated with END IF. WHILE..LOOP loops must be terminated with END LOOP.
- Aurora PostgreSQL syntax for opening a transaction is START TRANSACTION as opposed to BEGIN TRANSACTION. COMMIT and ROLLBACK are used without the TRANSACTION keyword.
- Aurora PostgreSQL does not use special data types for UNICODE data. All string types may use any character set and any relevant collation.
- Collations can be defined at the server, database, and column level, similar to SQL Server. They cannot be defined at the table level.
- SQL Server's DELETE <Table Name> syntax, which allows omitting the FROM keyword, is invalid in Aurora PostgreSQL. Add the FROM keyword to all delete statements.

- Aurora PostgreSQL allows multiple rows with NULL for a UNIQUE constraint; SQL Server allows only one. Aurora PostgreSQL follows the behavior specified in the ANSI standard.
- Aurora PostgreSQL SERIAL column property is similar to IDENTITY in SQL Server. However, there is a major difference in the way sequences are maintained. While SQL Server caches a set of values in memory, the last allocation is recorded on disk. When the service restarts, some values may be lost, but the sequence continues from where it left off. In Aurora PostgreSQL, each time the service is restarted, the seed value to SERIAL is reset to one increment interval larger than the largest existing value. Sequence position is not maintained across service restarts.
- Parameter names in Aurora PostgreSQL do not require a preceding "@". You can declare local variables such as SET schema.test = 'value' and get the value by SELECT current_setting('username.test');
- Local parameter scope is not limited to an execution scope. You can define or set a parameter in one statement, execute it, and then query it in the following batch.
- Error handling in Aurora PostgreSQL has less features, but for special requirements, you can log or send alerts by inserting into tables or catching errors.
- Aurora PostgreSQL does not support the MERGE statement. Use the REPLACE statement and the INSERT... ON DUPLICATE KEY UPDATE statement as alternatives.
- You cannot concatenate strings in Aurora PostgreSQL using the "+" operator. 'A' + 'B' is not a valid expression. Use the CONCAT function instead. For example, CONCAT('A', 'B').
- Aurora PostgreSQL does not support aliasing in the select list using the 'String Alias' = Expression. Aurora PostgreSQL treats it as a logical predicate, returns 0 or FALSE, and will alias the column with the full expression. USE the AS syntax instead. Also note that this syntax has been deprecated as of SQL Server 2008 R2.
- Aurora PostgreSQL has a large set of string functions that is much more diverse than SQL Server. Some of the more useful string functions are:
    - TRIM is not limited to full trim or spaces. The syntax is TRIM([{BOTH | LEADING | TRAILING} [<remove string>] FROM] <source string>)).
    - LENGTH in PostgreSQL is equivalent to DATALENGTH in T-SQL. CHAR_LENGTH is the equivalent of T-SQL LENGTH.
    - SUBSTRING_INDEX returns a substring from a string before the specified number of occurrences of the delimiter.
    - FIELD returns the index (position) of the first argument in the subsequent arguments.
    - POSITION returns the index position of the first argument within the second argument.
    - REGEXP_MATCHES provides support for regular expressions.
    - For more string functions, see https://www.postgresql.org/docs/13/static/functions-string.html
- The Aurora PostgreSQL CAST function is for casting between collation and not other data types. Use CONVERT for casting data types.
- Aurora PostgreSQL is much stricter than SQL Server in terms of statement terminators. Be sure to always use a semicolon at the end of statements.
- There is no CREATE PROCEDURE syntax; only CREATE FUNCTION. You can create a function that returns void.
- Beware of control characters when copying and pasting a script to Aurora PostgreSQL clients. Aurora PostgreSQL is much more sensitive to control characters than SQL Server and they result in frustrating syntax errors that are hard to find.

ANSI SQL

Case Sensitivity Differences for SQL Server and PostgreSQL

Object name case sensitivity might be different for SQL Server and PostgreSQL. SQL Server names are depended on the used collection and can be either case sensitive or not. PostgreSQL names are case sensitive.

By default, AWS SCT uses object name in lower-case for PostgreSQL. In most cases, you'll want to use AWS DMS transformations to change schema, table, and column names to lower case.

To have an upper-case name, you must place the objects names within doubles quotes.

For example, to create a table named EMPLOYEES (upper-case) in PostgreSQL, you should use the following:

```
CREATE TABLE "EMPLOYEES" (
         EMP_ID        NUMERIC PRIMARY KEY,
         EMP_FULL_NAME VARCHAR(60) NOT NULL,
         AVG_SALARY    NUMERIC NOT NULL);
```

The command below will create a table named employees (lower-case).

```
CREATE TABLE EMPLOYEES (
         EMP_ID        NUMERIC PRIMARY KEY,
         EMP_FULL_NAME VARCHAR(60) NOT NULL,
         AVG_SALARY    NUMERIC NOT NULL);
```

If doubles quotes weren't used, PostgreSQL will look for object names in their lower-case form, for CREATE commands where doubles quotes weren't used, objects will be created with lower-case names, therefore, to create / query / manipulate an upper-cased (or mixed) object names you must use doubles quotes.

SQL Server Constraints vs. PostgreSQL Table Constraints

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		Constraints	SET DEFAULT option is missing Check constraint with subquery

SQL Server Usage

Column and table constraints are defined by the SQL standard and enforce relational data consistency. There are four types of SQL constraints: Check Constraints, Unique Constraints, Primary Key Constraints, and Foreign Key Constraints.

Check Constraints

Syntax

```
CHECK (<Logical Expression>)
```

CHECK constraints enforce domain integrity by limiting the data values stored in table columns. They are logical boolean expressions that evaluate to one of three values: TRUE, FALSE, and UNKNOWN.

> **Note:** CHECK constraint expressions behave differently than predicates in other query clauses. For example, in a WHERE clause, a logical expression that evaluates to UNKNOWN is functionally equivalent to FALSE and the row is filtered out. For CHECK constraints, an expression that evaluates to UNKNOWN is functionally equivalent to TRUE because the value is permitted by the constraint.

Multiple CHECK constraints may be assigned to a column. A single CHECK constraint may apply to multiple columns (in this case, it is known as a Table-Level Check Constraint).

In ANSI SQL, CHECK constraints can not access other rows as part of the expression. SQL Server allows using User Defined Functions in constraints to access other rows, tables, or databases.

Unique Constraints

Syntax

```
UNIQUE [CLUSTERED | NONCLUSTERED] (<Column List>)
```

UNIQUE constraints should be used for all candidate keys. A candidate key is an attribute or a set of attributes (columns) that uniquely identify each tuple (row) in the relation (table data).

UNIQUE constraints guarantee that no rows with duplicate column values exist in a table.

A UNIQUE constraint can be simple or composite. Simple constraints are composed of a single column. Composite constraints are composed of multiple columns. A column may be a part of more than one constraint.

Although the ANSI SQL standard allows multiple rows having NULL values for UNIQUE constraints, SQL Server allows a NULL value for only one row. Use a NOT NULL constraint in addition to a UNIQUE constraint to disallow all NULL values.

To improve efficiency, SQL Server creates a unique index to support UNIQUE constraints. Otherwise, every INSERT and UPDATE would require a full table scan to verify there are no duplicates. The default index type for UNIQUE constraints is non- clustered.

Primary Key Constraints

Syntax

```
PRIMARY KEY [CLUSTERED | NONCLUSTERED] (<Column List>)
```

A PRIMARY KEY is a candidate key serving as the unique identifier of a table row. PRIMARY KEYS may consist of one or more columns. All columns that comprise a primary key must also have a NOT NULL constraint. Tables can have one primary key.

The default index type for PRIMARY KEYS is a clustered index.

Foreign Key Constraints

Syntax

```
FOREIGN KEY (<Referencing Column List>)
REFERENCES <Referenced Table>(<Referenced Column List>)
```

FOREIGN KEY constraints enforce domain referential integrity. Similar to CHECK constraints, FOREIGN KEYS limit the values stored in a column or set of columns.

FOREIGN KEYS reference columns in other tables, which must be either PRIMARY KEYS or have UNIQUE constraints. The set of values allowed for the referencing table is the set of values existing the referenced table.

Although the columns referenced in the parent table are indexed (since they must have either a PRIMARY KEY or UNIQUE constraint), no indexes are automatically created for the referencing columns in the child table. A best practice is to create appropriate indexes to support joins and constraint enforcement.

FOREIGN KEY constraints impose DML limitations for the referencing child and parent tables. The purpose of a constraint is to guarantee that no "orphan" rows (rows with no corresponding matching values in the parent table) exist in the referencing table. The constraint limits INSERT and UPDATE to the child table and UPDATE and DELETE to the parent table. For example, you can not delete an order having associated order items.

Foreign keys support Cascading Referential Integrity (CRI). CRI can be used to enforce constraints and define action paths for DML statements that violate the constraints. There are four CRI options:

- **NO ACTION:** When the constraint is violated due to a DML operation, an error is raised and the operation is rolled back.
- **CASCADE:** Values in a child table are updated with values from the parent table when they are updated or deleted along with the parent.

- **SET NULL:** All columns that are part of the foreign key are set to NULL when the parent is deleted or updated.
- **SET DEFAULT:** All columns that are part of the foreign key are set to their DEFAULT value when the parent is deleted or updated.

These actions can be customized independently of others in the same constraint. For example, a cascading constraint may have CASCADE for UPDATE, but NO ACTION for UPDATE.

Examples

Create a composite non-clustered PRIMARY KEY.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL,
Col2 INT NOT NULL,
Col3 VARCHAR(20) NULL,
CONSTRAINT PK_MyTable
 PRIMARY KEY NONCLUSTERED (Col1, Col2)
);
```

Create a table-level CHECK constraint.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL,
Col2 INT NOT NULL,
Col3 VARCHAR(20) NULL,
CONSTRAINT PK_MyTable
 PRIMARY KEY NONCLUSTERED (Col1, Col2),
CONSTRAINT CK_MyTableCol1Col2
 CHECK (Col2 >= Col1)
);
```

Create a simple non-null UNIQUE constraint.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL,
Col2 INT NOT NULL,
Col3 VARCHAR(20) NULL,
CONSTRAINT PK_MyTable
 PRIMARY KEY NONCLUSTERED (Col1, Col2),
CONSTRAINT UQ_Col2Col3
 UNIQUE (Col2, Col3)
);
```

Create a FOREIGN KEY with multiple cascade actions.

```
CREATE TABLE MyParentTable
(
Col1 INT NOT NULL,
Col2 INT NOT NULL,
Col3 VARCHAR(20) NULL,
CONSTRAINT PK_MyTable
```

```
 PRIMARY KEY NONCLUSTERED (Col1, Col2)
);
```

```
CREATE TABLE MyChildTable
(
Col1 INT NOT NULL PRIMARY KEY,
Col2 INT NOT NULL,
Col3 INT NOT NULL,
CONSTRAINT FK_MyChildTable_MyParentTable
 FOREIGN KEY (Col2, Col3)
 REFERENCES MyParentTable (Col1, Col2)
 ON DELETE NO ACTION
 ON UPDATE CASCADE
);
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/tables/unique-constraints-and-check-constraints?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/tables/primary-and-foreign-key-constraints?view=sql-server-ver15*

PostgreSQL Usage

PostgreSQL supports the following types of table constraints:

- PRIMARY KEY
- FOREIGN KEY
- UNIQUE
- NOT NULL
- EXCLUDE (unique to PostgreSQL)

Similar to constraint declaration in SQL Server, PostgreSQL allows creating constraints in-line or out-of-line when specifying table columns.

PostgreSQL constraints can be specified using CREATE / ALTER TABLE. Constraints on views are not supported.

You must have privileges (CREATE / ALTER) on the table in which constraints are created. For foreign key constraints, you must also have the REFERENCES privilege.

Primary Key Constraints

- Uniquely identify each row and cannot contain NULL values.
- Use the same ANSI SQL syntax as SQL Server.
- Can be created on a single column or on multiple columns (composite primary keys) as the only PRIMARY KEY in a table.
- Creating a PRIMARY KEY constraint automatically creates a unique B-Tree index on the column or group of columns marked as the primary key of the table.

- Constraint names can be generated automatically by PostgreSQL or explicitly specified during constraint creation.

Examples

Create an inline primary key constraint with a system-generated constraint name.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID NUMERIC PRIMARY KEY,
        FIRST_NAME  VARCHAR(20),
        LAST_NAME   VARCHAR(25),
        EMAIL       VARCHAR(25));
```

Create an inline primary key constraint with a user-specified constraint name.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID NUMERIC CONSTRAINT PK_EMP_ID PRIMARY KEY,
        FIRST_NAME  VARCHAR(20),
        LAST_NAME   VARCHAR(25),
        EMAIL       VARCHAR(25));
```

Create an out-of-line primary key constraint.

```
CREATE TABLE EMPLOYEES(
        EMPLOYEE_ID NUMERIC,
        FIRST_NAME  VARCHAR(20),
        LAST_NAME   VARCHAR(25),
        EMAIL       VARCHAR(25)),
        CONSTRAINT PK_EMP_ID PRIMARY KEY (EMPLOYEE_ID));
```

Add a primary key constraint to an existing table.

```
ALTER TABLE SYSTEM_EVENTS
         ADD CONSTRAINT PK_EMP_ID PRIMARY KEY (EVENT_CODE, EVENT_TIME);
```

Drop the primary key.

```
ALTER TABLE SYSTEM_EVENTS DROP CONSTRAINT PK_EMP_ID;
```

Foreign Key Constraints

- Enforce referential integrity in the database. Values in specific columns or a group of columns must match the values from another table (or column).
- Creating a FOREIGN KEY constraint in PostgreSQL uses the same ANSI SQL syntax as SQL Server.
- Can be created in-line or out-of-line during table creation.
- Use the REFERENCES clause to specify the table referenced by the foreign key constraint.
- When specifying REFERENCES in the absence of a column list in the referenced table, the PRIMARY KEY of the referenced table is used as the referenced column or columns.
- A table can have multiple FOREIGN KEY constraints.
- Use the ON DELETE clause to handle FOREIGN KEY parent record deletions (such as cascading deletes).

- Foreign key constraint names are generated automatically by the database or specified explicitly during constraint creation.

ON DELETE Clause

PostgreSQL provides three main options to handle cases where data is deleted from the parent table and a child table is referenced by a FOREIGN KEY constraint. By default, without specifying any additional options, PostgreSQL uses the NO ACTION method and raises an error if the referencing rows still exist when the constraint is verified.

- **ON DELETE CASCADE:** Any dependent foreign key values in the child table are removed along with the referenced values from the parent table.
- **ON DELETE RESTRICT:** Prevents the deletion of referenced values from the parent table and the deletion of dependent foreign key values in the child table.
- **ON DELETE NO ACTION:** Performs no action (the default). The fundamental difference between RESTRICT and NO ACTION is that NO ACTION allows the check to be postponed until later in the transaction; RESTRICT does not.

ON UPDATE Clause

Handling updates on FOREIGN KEY columns is also available using the ON UPDATE clause, which shares the same options as the ON DELETE clause:

- ON UPDATE CASCADE
- ON UPDATE RESTRICT
- ON UPDATE NO ACTION

Examples

Create an inline foreign key with a user-specified constraint name.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID   NUMERIC PRIMARY KEY,
        FIRST_NAME    VARCHAR(20),
        LAST_NAME     VARCHAR(25),
        EMAIL         VARCHAR(25),
        DEPARTMENT_ID NUMERIC REFERENCES DEPARTMENTS(DEPARTMENT_ID));
```

Create an out-of-line foreign key constraint with a system-generated constraint name.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID   NUMERIC PRIMARY KEY,
        FIRST_NAME    VARCHAR(20),
        LAST_NAME     VARCHAR(25),
        EMAIL         VARCHAR(25),
        DEPARTMENT_ID NUMERIC,
        CONSTRAINT FK_FEP_ID
        FOREIGN KEY(DEPARTMENT_ID) REFERENCES DEPARTMENTS(DEPARTMENT_ID));
```

Create a foreign key using the ON DELETE CASCADE clause.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID   NUMERIC PRIMARY KEY,
        FIRST_NAME    VARCHAR(20),
        LAST_NAME     VARCHAR(25),
        EMAIL         VARCHAR(25),
        DEPARTMENT_ID NUMERIC,
        CONSTRAINT FK_FEP_ID
        FOREIGN KEY(DEPARTMENT_ID) REFERENCES DEPARTMENTS(DEPARTMENT_ID)
        ON DELETE CASCADE);
```

Add a foreign key to an existing table.

```
ALTER TABLE EMPLOYEES ADD CONSTRAINT FK_DEPT
        FOREIGN KEY (department_id)
        REFERENCES DEPARTMENTS (department_id) NOT VALID;

ALTER TABLE EMPLOYEES VALIDATE CONSTRAINT FK_DEPT;
```

UNIQUE Constraints

- Ensure that values in a column, or a group of columns, are unique across the entire table.
- PostgreSQL UNIQUE constraint syntax is ANSI SQL compatible.
- Automatically creates a B-Tree index on the respective column, or a group of columns, when creating a UNIQUE constraint.
- If duplicate values exist in the column(s) on which the constraint was defined during UNIQUE constraint creation, the UNIQUE constraint creation fails and returns an error message.
- UNIQUE constraints in PostgreSQL accept multiple NULL values (similar to SQL Server).
- UNIQUE constraint naming can be system-generated or explicitly specified.

Example

Create an inline unique constraint ensuring uniqueness of values in the email column.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID   NUMERIC PRIMARY KEY,
        FIRST_NAME    VARCHAR(20),
        LAST_NAME     VARCHAR(25),
        EMAIL         VARCHAR(25) CONSTRAINT UNIQ_EMP_EMAIL UNIQUE,
        DEPARTMENT_ID NUMERIC);
```

CHECK Constraints

- Enforce that values in a column satisfy a specific requirement.
- CHECK constraints in PostgreSQL use the same ANSI SQL syntax as SQL Server.
- Can only be defined using a Boolean data type to evaluate the values of a column.
- CHECK constraints naming can be system-generated or explicitly specified by the user during constraint creation.

Check constraints are using Boolean data datatype, therefor sub-query can't be used in CHECK constraint. if you want to use a similar feature you can create a Boolean function that will check the query resulsts and return TRUE or FALSE values accordingly.

Example

Create an inline CHECK constraint using a regular expression to enforce the email column contains email addresses with an “@aws.com” suffix.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID   NUMERIC PRIMARY KEY,
        FIRST_NAME    VARCHAR(20),
        LAST_NAME     VARCHAR(25),
        EMAIL         VARCHAR(25) CHECK(EMAIL ~ '(^[A-Za-z]+@aws.com$)'),
        DEPARTMENT_ID NUMERIC);
```

NOT NULL Constraints

- Enforce that a column cannot accept NULL values. This behavior is different from the default column behavior in PostgreSQL where columns can accept NULL values.
- NOT NULL constraints can only be defined inline during table creation.
- You can explicitly specify names for NOT NULL constraints when used with a CHECK constraint.

Example

Define two not null constraints on the FIRST_NAME and LAST_NAME columns. Define a check constraint (with an explicitly user-specified name) to enforce not null behavior on the EMAIL column.

```
CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID NUMERIC PRIMARY KEY,
        FIRST_NAME  VARCHAR(20) NOT NULL,
        LAST_NAME   VARCHAR(25) NOT NULL,
        EMAIL       VARCHAR(25) CONSTRAINT CHK_EMAIL
                                 CHECK(EMAIL IS NOT NULL));
```

SET Constraints Syntax

```
SET CONSTRAINTS { ALL | name [, ...] } { DEFERRED | IMMEDIATE }
```

PostgreSQL provides controls for certain aspects of constraint behavior:

- **DEFERRABLE | NOT DEFERRABLE:** Using the PostgreSQL SET CONSTRAINTS statement. Constraints can be defined as:
  - **DEFERRABLE:** Allows you to use the SET CONSTRAINTS statement to set the behavior of constraint checking within the current transaction until transaction commit.
  - **IMMEDIATE:** Constraints are enforced only at the end of each statement. Note that each constraint has its own IMMEDIATE or DEFERRED mode.

- **NOT DEFERRABLE:** This statement always runs as IMMEDIATE and is not affected by the SET CONSTRAINTS command.

- **VALIDATE CONSTRAINT | NOT VALID:**
  - **VALIDATE CONSTRAINT:** Validates foreign key or check constraints (only) that were previously created as NOT VALID. This action performs a validation check by scanning the table to ensure all records satisfy the constraint definition.
  - **NOT VALID:** Can be used only for foreign key or check constraints. When specified, new records are not validated with the creation of the constraint. Only when the VALIDATE CONSTRAINT state is applied is the constraint state enforced on all records.

Using Existing Indexes During Constraint Creation

PostgreSQL can add a new primary key or unique constraints based on an existing unique Index . All index columns are included in the constraint. When creating constraints using this method, the index is owned by the constraint. When dropping the constraint, the index is also dropped.

Use an existing unique Index to create a primary key constraint.

```
CREATE UNIQUE INDEX IDX_EMP_ID ON EMPLOYEES(EMPLOYEE_ID);

ALTER TABLE EMPLOYEES
        ADD CONSTRAINT PK_CON_UNIQ PRIMARY KEY USING INDEX IDX_EMP_ID;
```

Summary

The following table identifies similarities, differences, and key migration considerations.

Feautre	SQL Server	Aurora PostgreSQL
CHECK constraints	CHECK	CHECK
UNIQUE constraints	UNIQUE	UNIQUE
PRIMARY KEY constraints	PRIMARY KEY	PRIMARY KEY
FOREIGN KEY constraints	FOREIGN KEY	FOREIGN KEY
Cascaded referential actions	NO ACTION | CASCADE | SET NULL | SET DEFAULT	RESTRICT | CASCADE | SET NULL | NO ACTION
Indexing of referencing columns	Not required	N/A
Indexing of referenced columns	PRIMARY KEY or UNIQUE	PRIMARY KEY or UNIQUE

For additional details:

- *https://www.postgresql.org/docs/13/static/ddl-constraints.html*
- *https://www.postgresql.org/docs/13/static/sql-set-constraints.html*
- *https://www.postgresql.org/docs/13/static/sql-altertable.html*

SQL Server Creating Tables vs. PostgreSQL Creating Tables

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - CREATE TABLE	Auto generated value column is different Can't use physical attribute ON Missing table variable and memory optimized table

SQL Server Usage

ANSI Syntax Conformity

Tables in SQL Server are created using the CREATE TABLE statement and conform to the ANSI/ISO entry level standard. The basic features of CREATE TABLE are similar for most relational database management engines and are well defined in the ANSI/ISO standards.

In its most basic form, the CREATE TABLE statement in SQL Server is used to define:

- Table names, the containing security schema, and database
- Column names
- Column data types
- Column and table constraints
- Column default values
- Primary, candidate (UNIQUE), and foreign keys

T-SQL Extensions

SQL Server extends the basic syntax and provides many additional options for the CREATE TABLE or ALTER TABLE statements. The most often used options are:

- Supporting index types for primary keys and unique constraints, clustered or non-clustered, and index properties such as FILLFACTOR
- Physical table data storage containers using the ON <File Group> clause
- Defining IDENTITY auto-enumerator columns
- Encryption
- Compression
- Indexes

For more information, see Data Types, Column Encryption, and Databases and Schemas.

Table Scope

SQL Server provides five scopes for tables:

- Standard tables are created on disk, globally visible, and persist through connection resets and server restarts.
- Temporary Tables are designated with the "# " prefix. They are persisted in TempDB and are visible to the execution scope where they were created (and any sub-scopes). Temporary tables are cleaned up by the server when the execution scope terminates and when the server restarts.
- Global Temporary Tables are designated by the "## " prefix. They are similar in scope to temporary tables, but are also visible to concurrent scopes.
- Table Variables are defined with the DECLARE statement, not with CREATE TABLE. They are visible only to the execution scope where they were created.
- Memory-Optimized tables are special types of tables used by the In-Memory Online Transaction Processing (OLTP) engine. They use a non-standard CREATE TABLE syntax.

Creating a Table Based on an Existing Table or Query

SQL Server allows creating new tables based on SELECT queries as an alternate to the CREATE TABLE statement. A SELECT statement that returns a valid set with unique column names can be used to create a new table and populate data.

SELECT INTO is a combination of DML and DDL. The simplified syntax for SELECT INTO is:

```
SELECT <Expression List>
INTO <Table Name>
[FROM <Table Source>]
[WHERE <Filter>]
[GROUP BY <Grouping Expressions>...];
```

When creating a new table using SELECT INTO, the only attributes created for the new table are column names, column order, and the data types of the expressions. Even a straight forward statement such as SELECT * INTO <New Table> FROM <Source Table> does not copy constraints, keys, indexes, identity property, default values, or any other related objects.

TIMESTAMP Syntax for ROWVERSION Deprecated Syntax

The TIMESTAMP syntax synonym for ROWVERSION has been deprecated as of SQL Server 2008R2 in accordance with https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/ms143729(v=sql.105).

Previously, you could use either the TIMESTAMP or the ROWVERSION keywords to denote a special data type that exposes an auto-enumerator. The auto-enumerator generates unique eight-byte binary numbers typically used to version-stamp table rows. Clients read the row, process it, and check the ROWVERSION value against the current row in the table before modifying it. If they are different, the row has been modified since the client read it. The client can then apply different processing logic.

Note that when migrating to Aurora PostgreSQL using the Amazon RDS Schema Conversion Tool (SCT), neither ROWVERSION nor TIMESTAMP are supported. You must add customer logic, potentially in the form of a trigger, to maintain this functionality.

See a full example in Creating Tables.

Syntax

Simplified syntax for CREATE TABLE:

```
CREATE TABLE [<Database Name>.<Schema Name>].<Table Name> (<Column Definitions>)
[ON{<Partition Scheme Name> (<Partition Column Name>)];
```

```
<Column Definition>:
<Column Name> <Data Type>
[CONSTRAINT <Column Constraint>
[DEFAULT <Default Value>]]
[IDENTITY [(<Seed Value>, <Increment Value>)]
[NULL | NOT NULL]
[ENCRYPTED WITH (<Encryption Specifications>)
[<Column Constraints>]
[<Column Index Specifications>]
```

```
<Column Constraint>:
[CONSTRAINT <Constraint Name>]
{{PRIMARY KEY | UNIQUE} [CLUSTERED | NONCLUSTERED]
[WITH FILLFACTOR = <Fill Factor>]
| [FOREIGN KEY]
REFERENCES <Referenced Table> (<Referenced Columns>)]
```

```
<Column Index Specifications>:
INDEX <Index Name> [CLUSTERED | NONCLUSTERED]
[WITH(<Index Options>]
```

Examples

Create a basic table.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
);
```

Create a table with column constraints and an identity.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL PRIMARY KEY IDENTITY (1,1),
Col2 VARCHAR(20) NOT NULL CHECK (Col2 <> ''),
Col3 VARCHAR(100) NULL
 REFERENCES MyOtherTable (Col3)
);
```

Create a table with an additional index.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL PRIMARY KEY,
```

```
Col2 VARCHAR(20) NOT NULL
 INDEX IDX_Col2 NONCLUSTERED
);
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/create-table-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Like SQL Server, Aurora PostgreSQL provides ANSI/ISO syntax entry level conformity for CREATE TABLE and custom extensions to support Aurora PostgreSQL specific functionality.

In its most basic form, and very similar to SQL Server, the CREATE TABLE statement in Aurora PostgreSQL is used to define:

- Table names containing security schema and/or database
- Column names
- Column data types
- Column and table constraints
- Column default values
- Primary, candidate (UNIQUE), and foreign keys

Starting with PostgreSQL 12 support for generated columns has been added. Generated columns can be either calculated from other columns values on the fly or calculated and stored.

```
CREATE TABLE tst_gen(
n NUMERIC,
n_gen GENERATED ALWAYS AS (n*0.01)
);
```

Aurora PostgreSQL Extensions

Aurora PostgreSQL extends the basic syntax and allows many additional options to be defined as part of the CREATE TABLE or ALTER TABLE statements. The most often used option is in-line index definition.

Table Scope

Aurora PostgreSQL provides two table scopes:

- **Standard Tables** are created on disk, visible globally, and persist through connection resets and server restarts.
- **Temporary Tables** are created using the CREATE GLOBAL TEMPORARY TABLE statement. A TEMPORARY table is visible only to the session that creates it and is dropped automatically when the session is closed.

Creating a Table Based on an Existing Table or Query

Aurora PostgreSQL provides two ways to create standard or temporary tables based on existing tables and queries:

```
CREATE TABLE <New Table> LIKE <Source Table> and CREATE TABLE ... AS <Query Expression>.

CREATE TABLE <New Table> LIKE <Source Table> creates an empty table based on the definition of another table including any column attributes and indexes defined in the original table.

CREATE TABLE ... AS <Query Expression> is very similar to SQL Server's SELECT INTO. It allows creating a new table and populating data in a single step.
```

For example:

```
CREATE TABLE SourceTable(Col1 INT);

INSERT INTO SourceTable VALUES (1)

CREATE TABLE NewTable(Col1 INT) AS SELECT Col1 AS Col2 FROM SourceTable;

INSERT INTO NewTable (Col1, Col2) VALUES (2,3);

SELECT * FROM NewTable

Col1    Col2
----    ----
NULL    1
2       3
```

Converting TIMESTAMP and ROWVERSION Columns

SQL server provides an automatic mechanism for stamping row versions for application concurrency control. For example:

```
CREATE TABLE WorkItems
(
 WorkItemID INT IDENTITY(1,1) PRIMARY KEY,
 WorkItemDescription XML NOT NULL,
 Status VARCHAR(10) NOT NULL DEFAULT ('Pending'),
 -- other columns...
 VersionNumber ROWVERSION
);
```

The VersionNumber column automatically updates when a row is modified. The actual value is meaningless. Just the fact that it changed is what indicates a row modification. The client can now read a work item row, process it, and ensure no other clients updated the row before updating the status.

```
SELECT @WorkItemDescription = WorkItemDescription,
       @Status = Status,
       @VersionNumber = VersionNumber
FROM WorkItems
```

```
WHERE WorkItemID = @WorkItemID;

EXECUTE ProcessWorkItem @WorkItemID, @WorkItemDescription, @Stauts OUTPUT;

IF (
    SELECT VersionNumber
    FROM WorkItems
    WHERE WorkItemID = @WorkItemID
   ) = @VersionNumber;
 EXECUTE UpdateWorkItems @WorkItemID, 'Completed'; -- Success
ELSE
 EXECUTE ConcurrencyExceptionWorkItem; -- Row updated while processing
```

In Aurora PostgreSQL, you can add a trigger to maintain the updated stamp per row.

```
CREATE OR REPLACE FUNCTION IncByOne()
 RETURNS TRIGGER
 AS $$
 BEGIN
      UPDATE WorkItems SET VersionNumber = VersionNumber+1
      WHERE WorkItemID = OLD.WorkItemID;
  END; $$
 LANGUAGE  PLPGSQL;

CREATE TRIGGER MaintainWorkItemVersionNumber
 AFTER UPDATE OF WorkItems
 FOR EACH ROW
 EXECUTE PROCEDURE IncByOne();
```

For more information on PostgreSQL triggers, see the Triggers.

Syntax

```
CREATE [ [ GLOBAL | LOCAL ] { TEMPORARY | TEMP } | UNLOGGED ] TABLE [ IF NOT EXISTS ]
table_name ( [
  { column_name data_type [ COLLATE collation ] [ column_constraint [ ... ] ]
    | table_constraint
    | LIKE source_table [ like_option ... ] }
    [, ... ]
] )
[ INHERITS ( parent_table [, ... ] ) ]
[ PARTITION BY { RANGE | LIST } ( { column_name | ( expression ) } [ COLLATE collation
] [ opclass ] [, ... ] ) ]
[ WITH ( storage_parameter [= value] [, ... ] ) | WITH OIDS | WITHOUT OIDS ]
[ ON COMMIT { PRESERVE ROWS | DELETE ROWS | DROP } ]
[ TABLESPACE tablespace_name ]

CREATE [ [ GLOBAL | LOCAL ] { TEMPORARY | TEMP } | UNLOGGED ] TABLE [ IF NOT EXISTS ]
table_name
    OF type_name [ (
  { column_name [ WITH OPTIONS ] [ column_constraint [ ... ] ]
    | table_constraint }
```

```
    [, ... ]
) ]
[ PARTITION BY { RANGE | LIST } ( { column_name | ( expression ) } [ COLLATE collation
] [ opclass ] [, ... ] ) ]
[ WITH ( storage_parameter [= value] [, ... ] ) | WITH OIDS | WITHOUT OIDS ]
[ ON COMMIT { PRESERVE ROWS | DELETE ROWS | DROP } ]
[ TABLESPACE tablespace_name ]

CREATE [ [ GLOBAL | LOCAL ] { TEMPORARY | TEMP } | UNLOGGED ] TABLE [ IF NOT EXISTS ]
table_name
    PARTITION OF parent_table [ (
  { column_name [ WITH OPTIONS ] [ column_constraint [ ... ] ]
    | table_constraint }
    [, ... ]
) ] FOR VALUES partition_bound_spec
[ PARTITION BY { RANGE | LIST } ( { column_name | ( expression ) } [ COLLATE collation
] [ opclass ] [, ... ] ) ]
[ WITH ( storage_parameter [= value] [, ... ] ) | WITH OIDS | WITHOUT OIDS ]
[ ON COMMIT { PRESERVE ROWS | DELETE ROWS | DROP } ]
[ TABLESPACE tablespace_name ]

where column_constraint is:

[ CONSTRAINT constraint_name ]
{ NOT NULL |
  NULL |
  CHECK ( expression ) [ NO INHERIT ] |
  DEFAULT default_expr |
  GENERATED { ALWAYS | BY DEFAULT } AS IDENTITY [ ( sequence_options ) ] |
  UNIQUE index_parameters |
  PRIMARY KEY index_parameters |
  REFERENCES reftable [ ( refcolumn ) ] [ MATCH FULL | MATCH PARTIAL | MATCH SIMPLE ]
    [ ON DELETE action ] [ ON UPDATE action ] }
[ DEFERRABLE | NOT DEFERRABLE ] [ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]

and table_constraint is:

[ CONSTRAINT constraint_name ]
{ CHECK ( expression ) [ NO INHERIT ] |
  UNIQUE ( column_name [, ... ] ) index_parameters |
  PRIMARY KEY ( column_name [, ... ] ) index_parameters |
  EXCLUDE [ USING index_method ] ( exclude_element WITH operator [, ... ] ) index_para-
meters [ WHERE ( predicate ) ] |
  FOREIGN KEY ( column_name [, ... ] ) REFERENCES reftable [ ( refcolumn [, ... ] ) ]
    [ MATCH FULL | MATCH PARTIAL | MATCH SIMPLE ] [ ON DELETE action ] [ ON UPDATE
action ] }
[ DEFERRABLE | NOT DEFERRABLE ] [ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]

and like_option is:

{ INCLUDING | EXCLUDING } { COMMENTSDEFAULTS  | CONSTRAINTS | DEFAULTS | IDENTITY |
INDEXES | STATISTICS | STORAGE |COMMENTS |  ALL }

and partition_bound_spec is:
```

```
IN ( { numeric_literal | string_literal | TRUE | FALSE | NULL } [, ...] ) |
FROM ( { numeric_literal | string_literal | TRUE | FALSE | MINVALUE | MAXVALUE } [,
...] )
  TO ( { numeric_literal | string_literal | TRUE | FALSE | MINVALUE | MAXVALUE } [,
...] )

index_parameters in UNIQUE, PRIMARY KEY, and EXCLUDE constraints are:

[ WITH ( storage_parameter [= value] [, ... ] ) ]
[ USING INDEX TABLESPACE tablespace_name ]

exclude_element in an EXCLUDE constraint is:

{ column_name | ( expression ) } [ opclass ] [ ASC | DESC ] [ NULLS { FIRST | LAST } ]
```

Examples

Create a basic table.

```
CREATE TABLE MyTable
(
Col1 INT PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
);
```

Create a table with column constraints.

```
CREATE TABLE MyTable
(
Col1 INT PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
 CHECK (Col2 <> ''),
Col3 VARCHAR(100) NULL
 REFERENCES MyOtherTable (Col3)
);
```

Summary

Feature	SQL Server	Aurora PostgreSQL
ANSI compliance	Entry level	Entry level
Auto generated enumerator	IDENTITY	SERIAL
Reseed auto generated value	DBCC CHECKIDENT	N/A
Index types	CLUSTERED / NONCLUSTERED	See the Clustered and Non Clustered Indexes .
Physical storage location	ON <File Group>	Not supported
Temporary tables	#TempTable	CREATE GLOBAL TEMPORARY TABLE
Global Temporary Tables	##GlobalTempTable	CREATE TEMPORARY TABLE

Feature	SQL Server	Aurora PostgreSQL
Table Variables	DECLARE @Table	Not supported
Create table as query	SELECT... INTO	CREATE TABLE... AS
Copy table structure	Not supported	CREATE TABLE... LIKE
Memory optimized tables	Supported	N/A

For more information, see https://www.postgresql.org/docs/13/sql-createtable.html

SQL Server Common Table Expressions vs. PostgreSQL Common Table Expressions (CTE)

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Must use RECURSIVE key word for recursive CTE queries

SQL Server Usage

Common Table Expressions (CTE), which have been a part of the ANSI standard since SQL:1999, simplify queries and make them more readable by defining a temporary view, or derived table, that a subsequent query can reference. SQL Server CTEs can be the target of DML modification statements. They have similar restrictions as updateable views.

SQL Server CTEs provide recursive functionality in accordance with the the ANSI 99 standard. Recursive CTEs can reference themselves and re-execute queries until the data set is exhausted, or the maximum number of iterations is exceeded.

CTE Syntax (simplified)

```
WITH <CTE NAME>
AS
(
SELECT ....
)
SELECT ...
FROM CTE
```

Recursive CTE syntax

```
WITH <CTE NAME>
AS (
    <Anchor SELECT query>
    UNION ALL
    <Recursive SELECT query with reference to <CTE NAME>>
    )
SELECT ... FROM <CTE NAME>...
```

Examples

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Washer', 100);
```

Define a CTE to calculate the total quantity in every order and then join to the OrderItems table to obtain the relative quantity for each item.

```
WITH AggregatedOrders
AS
( SELECT OrderID, SUM(Quantity) AS TotalQty
  FROM OrderItems
  GROUP BY OrderID
)
SELECT  O.OrderID, O.Item,
        O.Quantity,
        (O.Quantity / AO.TotalQty) * 100 AS PercentOfOrder
FROM    OrderItems AS O
        INNER JOIN
        AggregatedOrders AS AO
        ON O.OrderID = AO.OrderID;
```

The example above produces the following results:

```
OrderID     Item      Quantity  PercentOfOrder
-------     ----      --------  --------------
1           M8 Bolt   100       100.0000000000
2           M8 Nut    100       100.0000000000
3           M8 Washer 100       33.3333333300
3           M6 Washer 200       66.6666666600
```

Using a Recursive CTE, create and populate the Employees table with the DirectManager for each employee.

```
CREATE TABLE Employees
(
Employee VARCHAR(5) NOT NULL PRIMARY KEY,
DirectManager VARCHAR(5) NULL
);
```

```
INSERT INTO Employees(Employee, DirectManager)
VALUES
```

```
('John', 'Dave'),
('Jose', 'Dave'),
('Fred', 'John'),
('Dave', NULL);
```

Use a recursive CTE to display the employee-management hierarchy.

```
WITH EmpHierarchyCTE AS
(
-- Anchor query retrieves the top manager
SELECT  0 AS LVL,
        Employee,
        DirectManager
FROM Employees AS E
WHERE DirectManager IS NULL
UNION ALL
-- Recursive query gets all Employees managed by the previous level
SELECT  LVL + 1 AS LVL,
        E.Employee,
        E.DirectManager
FROM    EmpHierarchyCTE AS EH
INNER JOIN
Employees AS E
ON E.DirectManager = EH.Employee
)
SELECT *
FROM EmpHierarchyCTE;
```

The example above displays the following results:

```
LVL     Employee   DirectManager
---     --------   -------------
0       Dave       NULL
1       John       Dave
1       Jose       Dave
2       Fred       John
```

For more information, see https://technet.microsoft.com/en-us/library/ms186243.aspx

PostgreSQL Usage

PostgreSQL conforms to the ANSI SQL-99 standard and implementing CTEs in PostgreSQL is similar to SQL Server.

CTE also non as WITH query, this type of query helps you to simplify long queries, it is similar to defining temporary tables that exist only for the running of the query. The statement in a WITH clause can be a SELECT, INSERT, UPDATE, or DELETE, and the WITH clause itself is attached to a primary statement that can also be a SELECT, INSERT, UPDATE, or DELETE.

CTE Syntax (simplified)

```
WITH <CTE NAME>
AS
(
SELECT OR DML
)
SELECT OR DML
```

Recursive CTE syntax

```
WITH RECURSIVE <CTE NAME>
AS (
    <Anchor SELECT query>
    UNION ALL
    <Recursive SELECT query with reference to <CTE NAME>>
    )
SELECT OR DML
```

Examples

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Washer', 100);
```

Create a CTE.

```
WITH DEPT_COUNT
           (DEPARTMENT_ID, DEPT_COUNT) AS (
            SELECT DEPARTMENT_ID, COUNT(*) FROM   EMPLOYEES GROUP BY DEPARTMENT_ID)
            SELECT E.FIRST_NAME ||' '|| E.LAST_NAME AS EMP_NAME,
            D.DEPT_COUNT AS EMP_DEPT_COUNT
            FROM   EMPLOYEES E JOIN DEPT_COUNT D USING  (DEPARTMENT_ID) ORDER BY 2;
```

PostgreSQL provides an additional feature when using a CTE as a recursive modifier. The following example uses a recursive WITH clause to access its own result set.

```
WITH RECURSIVE t(n) AS (
        VALUES (0)
        UNION ALL
        SELECT n+1 FROM t WHERE n < 5)
        SELECT * FROM t;

WITH RECURSIVE t(n) AS (
VALUES (0)
UNION ALL
SELECT n+1 FROM t WHERE n < 5)

SELECT * FROM t;

n
--
0
...
5
```

Note that using the SQL Server example will get undesired results:

Define a CTE to calculate the total quantity in every order and then join to the OrderItems table to obtain the relative quantity for each item.

```
WITH AggregatedOrders
AS
( SELECT OrderID, SUM(Quantity) AS TotalQty
  FROM OrderItems
  GROUP BY OrderID
)
SELECT  O.OrderID, O.Item,
        O.Quantity,
        (O.Quantity / AO.TotalQty) * 100 AS PercentOfOrder
FROM    OrderItems AS O
        INNER JOIN
        AggregatedOrders AS AO
        ON O.OrderID = AO.OrderID;
```

The example above produces the following results:

```
OrderID     Item      Quantity  PercentOfOrder
-------     ----      --------  -------------
1           M8 Bolt   100       100
2           M8 Nut    100       100
3           M8 Washer 100       0
3           M6 Washer 200       0
```

This is because divide INT by INT will return round result, if another data type is in used such as DECIMAL there will be no problem, in order to fix the current issue the columns can be casted using '::decimal'.

```
WITH AggregatedOrders
AS
( SELECT OrderID, SUM(Quantity) AS TotalQty
  FROM OrderItems
  GROUP BY OrderID
)
SELECT  O.OrderID, O.Item,
        O.Quantity,
        trunc((O.Quantity::decimal / AO.TotalQty::decimal)*100,2) AS PercentOfOrder
FROM    OrderItems AS O
        INNER JOIN
        AggregatedOrders AS AO
        ON O.OrderID = AO.OrderID;
```

The example above produces the following results:

```
OrderID     Item      Quantity  PercentOfOrder
-------     ----      --------  -------------
1           M8 Bolt   100       100.00
2           M8 Nut    100       100.00
3           M8 Washer 100       66.66
3           M6 Washer 200       33.33
```

For RECURSIVE WITH query, the 'RECURSIVE' word must be used (unlike in SQL Server).

The equivalent query to SQL Server example will be:

Use a recursive CTE to display the employee-management hierarchy.

```
WITH RECURSIVE EmpHierarchyCTE AS
(
-- Anchor query retrieves the top manager
SELECT  0 AS LVL,
        Employee,
        DirectManager
FROM Employees AS E
WHERE DirectManager IS NULL
UNION ALL
-- Recursive query gets all Employees managed by the previous level
SELECT  LVL + 1 AS LVL,
        E.Employee,
        E.DirectManager
FROM    EmpHierarchyCTE AS EH
INNER JOIN
Employees AS E
ON E.DirectManager = EH.Employee
)
SELECT *
FROM EmpHierarchyCTE;
```

The example above displays the following results:

```
LVL     Employee   DirectManager
---     --------   -------------
0       Dave
1       John       Dave
```

```
1       Jose        Dave
2       Fred        John
```

For additional details, see: https://www.postgresql.org/docs/13/static/queries-with.html

SQL Server Data Types vs. PostgreSQL Data Types

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Data Types	Syntax and handling differences

SQL Server Usage

In SQL Server, each table column, variable, expression, and parameter has an associated data type. SQL Server provides a rich set of built-in data types as summarized in the following table.

Category	Data Types
Numeric	BIT, TINYINT, SMALLINT, INT, BIGINT, NUMERIC, DECIMAL, MONEY, SMALLMONEY, FLOAT, REAL
String and Character	CHAR, VARCHAR, NCHAR, NVARCHAR
Temporal	DATE, TIME, SMALLDATETIME, DATETIME, DATETIME2, DATETIMEOFFSET
Binary	BINARY, VARBINARY
Large Object (LOB)	TEXT, NTEXT, IMAGE, VARCHAR(MAX), NVARCHAR(MAX), VARBINARY(MAX)
Cursor	CURSOR
GUID	UNIQUEIDENTIFIER
Hierarchical identifier	HIERARCHYID
Spatial	GEOMETRY, GEOGRAPHY
Sets (Table type)	TABLE
XML	XML
Other Specialty Types	ROW VERSION, SQL_VARIANT

Note: You can create custom user defined data types using T-SQL, and the .NET Framework. Custom data types are based on the built-in system data types and are used to simplify development. For more information, see User Defined Types.

TEXT, NTEXT, and IMAGE Deprecated Data Types

The TEXT, NTEXT, and IMAGE data types have been deprecated as of SQL Server 2008R2 in accordance with https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/ms143729(v=sql.105).

These data types are legacy types for storing BLOB and CLOB data. The TEXT data type was used to store ASCII text CLOBS, the NTEXT data type to store UNICODE CLOBS, and IMAGE was used as a generic data type for storing all BLOB data. In SQL Server 2005, Microsoft introduced the new and improved VARCHAR (MAX), NVARCHAR(MAX), and VARBINARY(MAX) data types as the new BLOB and CLOB standard. These new types support a wider range of functions and operations. They also provide enhanced performance over the legacy types.

If your code uses TEXT, NTEXT or IMAGE data types, SCT automatically converts them to the appropriate Aurora PostgreSQL BYTEA data type. TEXT and NTEXT are converted to LONGTEXT and image to LONGBLOB. Make sure you use the proper collations. For more details, see the Collations.

Examples

Define table columns.

```
CREATE TABLE MyTable
(
Col1 AS INTEGER NOT NULL PRIMARY KEY,
Col2 AS NVARCHAR(100) NOT NULL
);
```

Define variable types.

```
DECLARE @MyXMLType AS XML,
        @MyTemporalType AS DATETIME2
```

```
DECLARE @MyTableType
AS TABLE
(
Col1 AS BINARY(16) NOT NULL PRIMARY KEY,
Col2 AS XML NULL
);
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/data-types/data-types-transact-sql?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL provides multiple data types equivalent to certain SQL Server data types. The following table provides the full list of PostgreSQL data types:

SQL Server Data Type Family	SQL ServerData Type	SQL Server Data Type Characteristic	PostgreSQL Identical Compatibility	PostgreSQL Corresponding Data Type
Character	CHAR	Fixed length 1-8,000	Yes	CHAR
	VARCHAR	Variable length 1-8,000	Yes	VARCHAR
	NCHAR	Fixed length 1-4,000	Yes	NCHAR
	NVARCHAR	Variable length 1-4,000	Yes	NVARCHAR
Numeric	BIT	first 8 BIT column will consume 1	Yes	BIT

SQL Server Data Type Family	SQL ServerData Type	SQL Server Data Type Characteristic	PostgreSQL Identical Compatibility	PostgreSQL Corresponding Data Type
		byte, 9 to 16 BIT columns will be 2 bytes etc..		
	TINYINT	8-bit unsigned integer, 0 to 255	No	SMALLINT
	SMALLINT	16-bit integer	Yes	SMALLINT
	INT, INTEGER	32-bit integer	Yes	INT, INTEGER
	BIGINT	64-bit integer	Yes	BIGINT
	NUMERIC	Fixed-point number	Yes	NUMERIC
	DECIMAL	Fixed-point number	Yes	DECIMAL
	MONEY	64-bit currency amount	Yes	MONEY
	SMALLMONEY	32-bit currency amount	No	MONEY
	FLOAT	Floating-point number	Yes	FLOAT
	REAL	Single-precision floating-point number	Yes	REAL
Temporal	DATE	Date (year, month and day)	Yes	DATE
	TIME	Time (hour, minute, second and fraction)	Yes	TIME
	SMALLDATETIME	Date and time	No	TIMESTAMP(0)
	DATETIME	Date and time with fraction	No	TIMESTAMP(3)
	DATETIME2	Date and time with fraction	No	TIMESTAMP(p)
Temporal	DATETIMEOFFSET	Date and time with fraction and time zone	No	TIMESTAMP(p) WITH TIME ZONE
Binary	BINARY	Fixed-length byte string	No	BYTEA
	VARBINARY	Variable length 1-8,000	No	BYTEA
LOB	TEXT	Variable-length character data up to 2 GB	Yes	TEXT
	NTEXT	Variable-length Unicode UCS-2 data up to 2 GB	No	TEXT
	IMAGE	Variable-length character data up to 2 GB	No	BYTEA
	VARCHAR(MAX)	Variable-length character data up to 2 GB	Yes	TEXT
	NVARCHAR(MAX)	Variable-length Unicode UCS-2 data up to 2 GB	No	TEXT
	VARBINARY(MAX)	Variable-length character data up to 2 GB	No	BYTEA

SQL Server Data Type Family	SQL ServerData Type	SQL Server Data Type Characteristic	PostgreSQL Identical Compatibility	PostgreSQL Corresponding Data Type
XML	XML	XML data	Yes	XML
GUID	UNIQUEIDENTIFIER	16-byte GUID (UUID)	No	CHAR(16)
Hierarchical identifier	HIERARCHYID	Approximately 5 bytes	No	NVARCHAR (4000)
Spatial - For using with Aurora PostgreSQL, see: AWS Docs	GEOMETRY	Euclidean (flat) coordinate system	Yes	GEOMETRY
	GEOGRAPHY	Round-earth coordinate system	Yes	GEOGRAPHY
	SQL_VARIANT	Maximum length of 8016	No	No equivalent
Other	ROWVERSION	8 bytes	No	TIMESTAMP(p)

PostgreSQL Character Column Semantics

PostgreSQL only supports CHAR for column size semantics. If you define a field as VARCHAR (10), PostgreSQL can store 10 characters regardless of how many bytes it takes to store each non-English character. VARCHAR(n) stores strings up to n characters (not bytes) in length.

Migration of SQL Server Data Types to PostgreSQL Data Types

Automatic migration and conversion of SQL Server Tables and Data Types can be performed using Amazon's Schema Conversion Tool (Amazon SCT).

Examples

To demonstrate SCT's capability for migrating SQL Server tables to their PostgreSQL equivalents, a table containing columns representing the majority of SQL Server data types was created and converted using Amazon SCT.

Source SQL Server compatible DDL for creating the DATATYPES table:

```
CREATE TABLE "DataTypes"(
  "BINARY_FLOAT"             REAL,
 "BINARY_DOUBLE"             FLOAT,
 "BLOB"                      VARBINARY(4000),
 "CHAR"                      CHAR(10),
 "CHARACTER"                 CHAR(10),
 "CLOB"                      VARCHAR(4000),
 "DATE"                      DATE,
 "DECIMAL"                   NUMERIC(3,2),
 "DOUBLE_PRECISION"          FLOAT(52),
 "FLOAT"                     FLOAT(3),
 "INTEGER"                   INTEGER,
 "LONG"                      TEXT,
 "NCHAR"                     NCHAR(10),
 "NUMBER"                    NUMERIC(9,9),
 "NUMBER1"                   NUMERIC(9,0),
```

```
 "NUMERIC"                   NUMERIC(9,9),
 "RAW"                       BINARY(10),
 "REAL"                      FLOAT(52),
 "SMALLINT"                  SMALLINT,
 "TIMESTAMP"                 TIMESTAMP,
 "TIMESTAMP_WITH_TIME_ZONE" DATETIMEOFFSET(5),
 "VARCHAR"                   VARCHAR(10),
 "VARCHAR2"                  VARCHAR(10),
 "XMLTYPE"                   XML
);
```

Target PostgreSQL compatible DDL for creating the DATATYPES table migrated from SQL Server with Amazon SCT:

```
CREATE TABLE IF NOT EXISTS datatypes(
binary_float             real DEFAULT NULL,
binary_double            double precision DEFAULT NULL,
blob                     bytea DEFAULT NULL,
char                     character(10) DEFAULT NULL,
character                character(10) DEFAULT NULL,
clob                     text DEFAULT NULL,
date                     TIMESTAMP(0) without time zone DEFAULT NULL,
decimal                  numeric(3,2) DEFAULT NULL,
dec                      numeric(3,2) DEFAULT NULL,
double_precision         double precision DEFAULT NULL,
float                    double precision DEFAULT NULL,
integer                  numeric(38,0) DEFAULT NULL,
long                     text DEFAULT NULL,
nchar                    character(10) DEFAULT NULL,
number                   numeric(9,9) DEFAULT NULL,
number1                  numeric(9,0) DEFAULT NULL,
numeric                  numeric(9,9) DEFAULT NULL,
raw                      bytea DEFAULT NULL,
real                     double precision DEFAULT NULL,
smallint                 numeric(38,0) DEFAULT NULL,
timestamp                TIMESTAMP(5) without time zone DEFAULT NULL,
timestamp_with_time_zone TIMESTAMP(5) with time zone DEFAULT NULL,
varchar                  character varying(10) DEFAULT NULL,
varchar2                 character varying(10) DEFAULT NULL,
xmltype                  xml DEFAULT NULL
)
WITH (
OIDS=FALSE
);
```

Summary:

All incompatible data type being converted by SCT.

SQL Server CREATE TABLE command:

```
CREATE TABLE scttest(
SMALLDATETIMEcol SMALLDATETIME,
datetimecol DATETIME,
datetime2col DATETIME2,
datetimeoffsetcol DATETIMEOFFSET,
binarycol BINARY,
```

```
varbinarycol VARBINARY,
ntextcol NTEXT,
imagecol IMAGE,
nvarcharmaxcol NVARCHAR(MAX),
varbinarymaxcol VARBINARY(MAX),
uniqueidentifiercol UNIQUEIDENTIFIER,
hierarchyiDcol HIERARCHYID,
sql_variantcol SQL_VARIANT,
rowversioncol ROWVERSION);
```

The equivalent command that was created using the SCT:

```
CREATE TABLE scttest(
smalldatetimecol TIMESTAMP WITHOUT TIME ZONE,
datetimecol TIMESTAMP WITHOUT TIME ZONE,
datetime2col TIMESTAMP(6) WITHOUT TIME ZONE,
datetimeoffsetcol TIMESTAMP(6) WITH TIME ZONE,
binarycol BYTEA,
varbinarycol BYTEA,
ntextcol TEXT,
imagecol BYTEA,
nvarcharmaxcol TEXT,
varbinarymaxcol BYTEA,
uniqueidentifiercol UUID,
hierarchyidcol VARCHAR(8000),
sql_variantcol VARCHAR(8000),
rowversioncol VARCHAR(8000) NOT NULL);
```

For additional details, see:

- *https://www.postgresql.org/docs/13/static/ddl-system-columns.html*
- *https://www.postgresql.org/docs/13/static/datatype.html*
- *https://aws.amazon.com/documentation/SchemaConversionTool*

SQL Server Derived Tables vs. PostgreSQL Derived Tables

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	

SQL Server Usage

SQL Server implements Derived Tables as specified in ANSI SQL:2011.A derived tables are similar to a CTE, but the reference to another query is used inside the FROM clause of a query.

This feature enables you to write more sophisticated, complex join queries.

Examples

```
SELECT name, salary, average_salary
FROM (SELECT AVG(salary)
      FROM employee) AS workers (average_salary), employee
WHERE salary > average_salary
ORDER BY salary DESC;
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/queries/from-transact-sql?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL implements Derived Tables and is fully compatible with SQL Server Derived Tables.

Examples

```
SELECT name, salary, average_salary
FROM (SELECT AVG(salary)
      FROM employee) AS workers (average_salary), employee
WHERE salary > average_salary
ORDER BY salary DESC;
```

For more information, see https://www.postgresql.org/docs/13/static/queries-table-expressions.html

SQL Server GROUP BY vs. PostgreSQL GROUP BY

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	

SQL Server Usage

GROUP BY is an ANSI SQL query clause used to group individual rows that have passed the WHERE filter clause into groups to be passed on to the HAVING filter and then to the SELECT list. This grouping supports the use of aggregate functions such as SUM, MAX, AVG, and others.

Syntax

ANSI compliant GROUP BY Syntax:

```
GROUP BY
[ROLLUP | CUBE]
<Column Expression> ...n
[GROUPING SETS (<Grouping Set>)...n
```

Backward compatibility syntax:

```
GROUP BY
    [ ALL ] <Column Expression> ...n
    [ WITH  CUBE | ROLLUP ]
```

The basic ANSI syntax for GROUP BY supports multiple grouping expressions, the CUBE and ROLLUP keywords, and the GROUPING SETS clause; all used to add super-aggregate rows to the output.

Up to SQL Server 2008 R2, the database engine supported a legacy, proprietary syntax (not ANSI Compliant) using the WITH CUBE and WITH ROLLUP clauses. These clauses added super-aggregates to the output.

Also, up to SQL Server 2008 R2, SQL Server supported the GROUP BY ALL syntax, which was used to create an empty group for rows that failed the WHERE clause.

SQL Server supports the following aggregate functions:

```
AVG, CHECKSUM_AGG, COUNT, COUNT_BIG, GROUPING, GROUPING_ID, STDEV, STDEVP, STRING_AGG,
SUM, MIN, MAX, VAR, VARP
```

Examples

Legacy CUBE and ROLLUP Syntax

```
CREATE TABLE Orders
(
       OrderID INT IDENTITY(1,1) NOT NULL
       PRIMARY KEY,
       Customer VARCHAR(20) NOT NULL,
       OrderDate DATE NOT NULL
);
```

```
INSERT INTO Orders(Customer, OrderDate)
VALUES ('John', '20180501'),  ('John', '20180502'), ('John', '20180503'),
       ('Jim', '20180501'), ('Jim', '20180503'), ('Jim', '20180504')
```

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY Customer, OrderDate
WITH ROLLUP
```

```
Customer             OrderDate  NumOrders
-------------------- ---------- -----------
Jim                  2018-05-01 1
Jim                  2018-05-03 1
Jim                  2018-05-04 1
Jim                  NULL       3
John                 2018-05-01 1
John                 2018-05-02 1
John                 2018-05-03 1
```

```
John                NULL        3
NULL                NULL        6
```

The highlighted rows were added as a result of the WITH ROLLUP clause and contain super aggregates for the following:

- All orders for Jim and John regardless of OrderDate (Orange).
- A super aggregated for all customers and all dates (Red).

Using CUBE instead of ROLLUP adds super aggregates in all possible combinations, not only in GROUP BY expression order.

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY Customer, OrderDate
WITH CUBE
```

```
Customer             OrderDate  NumOrders
-------------------- ---------- -----------
Jim                  2018-05-01 1
John                 2018-05-01 1
NULL                 2018-05-01 2
John                 2018-05-02 1
NULL                 2018-05-02 1
Jim                  2018-05-03 1
John                 2018-05-03 1
NULL                 2018-05-03 2
Jim                  2018-05-04 1
NULL                 2018-05-04 1
NULL                 NULL       6
Jim                  NULL       3
John                 NULL       3
```

Note the additional four green highlighted rows, which were added by the CUBE. They provide super aggregates for every date for all customers that were not part of the ROLLUP results above.

Legacy GROUP BY ALL

Use the Orders table from the previous example.

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM   Orders AS O
WHERE  OrderDate <= '20180503'
GROUP BY ALL Customer, OrderDate
```

```
Customer             OrderDate  NumOrders
-------------------- ---------- -----------
Jim                  2018-05-01 1
John                 2018-05-01 1
John                 2018-05-02 1
```

```
Jim                  2018-05-03 1
John                 2018-05-03 1
Jim                  2018-05-04 0
Warning: Null value is eliminated by an aggregate or other SET operation.
```

The row highlighted in orange for 2018-05-04 failed the WHERE clause and was returned as an empty group as indicated by the warning for the empty COUNT(*) = 0.

Use GROUPING SETS

The following query uses the ANSI compliant GROUPING SETS syntax to provide all possible aggregate combinations for the Orders table, similar to the result of the CUBE syntax. This syntax requires specifying each dimension that needs to be aggregated.

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM   Orders AS O
GROUP BY GROUPING SETS (
                        (Customer, OrderDate),
                        (Customer),
                        (OrderDate),
                        ()
                       )
```

```
Customer             OrderDate  NumOrders
-------------------- ---------- -----------
Jim                  2018-05-01 1
John                 2018-05-01 1
NULL                 2018-05-01 2
John                 2018-05-02 1
NULL                 2018-05-02 1
Jim                  2018-05-03 1
John                 2018-05-03 1
NULL                 2018-05-03 2
Jim                  2018-05-04 1
NULL                 2018-05-04 1
NULL                 NULL       6
Jim                  NULL       3
John                 NULL       3
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/t-sql/functions/aggregate-functions-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/queries/select-group-by-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL supports the basic ANSI syntax for GROUP BY and also supports GROUPING SETS CUBE, and ROLLUP.

Like SQL Server, Aurora PostgreSQL does allow using ROLLUP and ORDER BY clauses in the same query, but the syntax is a bit different from SQL Server; there is no WITH clause in the statement.

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY ROLLUP (Customer, OrderDate)
```

The main difference is the need to move from writing the column to GROUP BY after the ROLLUP.

For the CUBE option, it's the same change:

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY CUBE (Customer, OrderDate);
```

GROUPING SET:

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY GROUPING SETS (
                      (Customer, OrderDate),
                      (Customer),
                      (OrderDate),());
```

For more information, see https://www.postgresql.org/docs/13/static/queries-table-expressions.html

Syntax

```
SELECT <Select List>
FROM <Table Source>
WHERE <Row Filter>
GROUP BY
     [ROLLUP | CUBE | GROUPING SETS]
<Column Name> | <Expression> | <Position>
```

Migration Considerations

The GROUP BY functionality exists (except for the ALL option).

Every query must be converted to use the column name after the GROUP BY option (CUBE, ROLLUP, or CUBE).

Examples

Rewrite SQL Server WITH CUBE modifier for migration. Also, see the example in SQL Server GROUP BY.

```
CREATE TABLE Orders
(
       OrderID serial NOT NULL
       PRIMARY KEY,
       Customer VARCHAR(20) NOT NULL,
       OrderDate DATE NOT NULL
);
```

```
INSERT INTO Orders(Customer, OrderDate)
VALUES ('John', '20180501'),  ('John', '20180502'), ('John', '20180503'),
       ('Jim', '20180501'), ('Jim', '20180503'), ('Jim', '20180504');
```

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM Orders AS O
GROUP BY CUBE (Customer, OrderDate);
```

```
Customer OrderDate NumOrders
-------- --------- ---------
Jim      2018-05-01    1
Jim      2018-05-03    1
Jim      2018-05-04    1
Jim      NULL          3
John     2018-05-01    1
John     2018-05-02    1
John     2018-05-03    1
John     NULL          3
NULL     NULL          6
NULL     2018-05-01    2
NULL     2018-05-02    1
NULL     2018-05-03    2
NULL     2018-05-04    1
```

Rewrite SQL Server GROUP BY ALL for migration. Also see the example in SQL Server GROUP BY.

```
SELECT  Customer,
        OrderDate,
        COUNT(*) AS NumOrders
FROM   Orders AS O
WHERE  OrderDate <= '20180503'
GROUP BY Customer, OrderDate
UNION ALL -- Add the empty groups
SELECT DISTINCT Customer,
       OrderDate,
       0
FROM   Orders AS O
WHERE  OrderDate > '20180503';
```

```
Customer OrderDate NumOrders
-------- --------- ---------
Jim      2018-05-01    1
Jim      2018-05-03    1
John     2018-05-01    1
```

```
John      2018-05-02    1
John      2018-05-03    1
Jim       2018-05-04    0
```

Summary

Table of similarities, differences, and key migration considerations.

SQL Server feature	Aurora PostgreSQL feature	Comments
MAX, MIN, AVG, COUNT, COUNT_BIG	MAX, MIN, AVG, COUNT	In Aurora PostgreSQL, COUNT returns a BIGINT and is compatible with SQL Server's COUNT and COUNT_BIG.
CHECKSUM_AGG	N/A	Use a loop to calculate checksums.
GROUPING, GROUPING_ID	GROUPING	Reconsider query logic to avoid having NULL groups that are ambiguous with the super aggregates.
STDEV, STDEVP, VAR, VARP	STDDEV, STDDEV_POP, VARIANCE, VAR_POP	Rewrite keywords only.
STRING_AGG	STRING_AGG	
WITH ROLLUP	ROLLUP	Remove WITH and change the columns names to be after the ROLLUP keyword
WITH CUBE	CUBE	Remove WITH and change the columns names to be after the CUBE keyword
GROUPING SETS	GROUPING SETS	

For more information, see https://www.postgresql.org/docs/13/static/functions-aggregate.html

SQL Server Table JOIN vs. PostgreSQL Table JOIN

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	OUTER JOIN with commas and CROSS APPLY and OUTER APPLY are not supported

SQL Server Usage

ANSI JOIN

SQL Server supports the standard ANSI join types:

- **<Set A> CROSS JOIN <Set B>:** Results in a Cartesian product of the two sets. Every JOIN starts as a Cartesian product.

- **<Set A> INNER JOIN <Set B> ON <Join Condition>:** Filters the Cartesian product to only the rows where the join predicate evaluates to TRUE.
- **<Set A> LEFT OUTER JOIN <Set B> ON <Join Condition>:** Adds to the INNER JOIN all the rows from the reserved left set with NULL for all the columns that come from the right set.
- **<Set A> RIGHT OUTER JOIN <Set B> ON <Join Condition>:** Adds to the INNER JOIN all the rows from the reserved right set with NULL for all the columns that come from the left set.
- **<Set A> FULL OUTER JOIN <Set B> ON <Join Condition>:** Designates both sets as reserved and adds non matching rows from both, similar to a LEFT OUTER JOIN and a RIGHT OUTER JOIN.

APPLY

SQL Server also supports the APPLY operator, which is somewhat similar to a join. However, APPLY operators enable the creation of a correlation between <Set A> and <Set B> such that <Set B> may consist of a sub query, a VALUES row value constructor, or a table valued function that is evaluated per row of <Set A> where the <Set B> query can reference columns from the current row in <Set A>. This functionality is not possible with any type of standard JOIN operator.

There are two APPLY types:

- **<Set A> CROSS APPLY <Set B>:** Similar to a CROSS JOIN in the sense that every row from <Set A> is matched with every row from <Set B>.
- **<Set A> OUTER APPLY <Set B>:** Similar to a LEFT OUTER JOIN in the sense that rows from <Set A> are returned even if the sub query for <Set B> produces an empty set. In that case, NULL is assigned to all columns of <Set B>.

ANSI SQL 89 JOIN Syntax

Up until version 2008R2, SQL Server also supported the "old style" JOIN syntax including LEFT and RIGHT OUTER JOIN.

The ANSI syntax for a CROSS JOIN operator was to list the sets in the FROM clause using commas as separators. For example:

```
SELECT *
FROM Table1,
     Table2,
     Table3...
```

To perform an INNER JOIN, you only needed to add the JOIN predicate as part of the WHERE clause. For example:

```
SELECT *
FROM Table1,
     Table2
WHERE Table1.Column1 = Table2.Column1
```

Although the ANSI standard didn't specify outer joins at the time, most RDBMS supported them in one way or another. T-SQL supported outer joins by adding an asterisk to the left or the right of equality sign of the join predicate to designate the reserved table. For example:

```
SELECT *
FROM Table1,
```

```
     Table2
WHERE Table1.Column1 *= Table2.Column1
```

To perform a FULL OUTER JOIN, asterisks were placed on both sides of the equality sign of the join predicate.

As of SQL Server 2008R2, outer joins using this syntax have been deprecated in accordance with https://-technet.microsoft.com/it-it/library/ms143729(v=sql.105).aspx.

> **Note:** Even though INNER JOINs using the ANSI SQL 89 syntax are still supported, they are highly discouraged due to being notorious for introducing hard-to-catch programming bugs.

Syntax

CROSS JOIN

```
FROM  <Table Source 1>
      CROSS JOIN
      <Table Source 2>
```

```
-- ANSI 89
FROM  <Table Source 1>,
      <Table Source 2>
```

INNER / OUTER JOIN

```
FROM <Table Source 1>
     [ { INNER | { { LEFT | RIGHT | FULL } [ OUTER ] } }] JOIN
     <Table Source 2>
     ON <JOIN Predicate>
```

```
-- ANSI 89
FROM  <Table Source 1>,
      <Table Source 2>
WHERE <Join Predicate>
<Join Predicate>:: <Table Source 1 Expression> | = | *= | =* | *=* <Table Source 2
Expression>
```

APPLY

```
FROM <Table Source 1>
     { CROSS | OUTER } APPLY
     <Table Source 2>
<Table Source 2>:: <SELECT sub-query> | <Table Valued UDF> | <VALUES clause>
```

Examples

Create the Orders and Items tables.

```
CREATE TABLE Items
(
```

```
Item VARCHAR(20) NOT NULL
  PRIMARY KEY
Category VARCHAR(20) NOT NULL,
Material VARCHAR(20) NOT NULL
);
```

```
INSERT INTO Items (Item, Category, Material)
VALUES
('M8 Bolt', 'Metric Bolts', 'Stainless Steel'),
('M8 Nut', 'Metric Nuts', 'Stainless Steel'),
('M8 Washer', 'Metric Washers', 'Stainless Steel'),
('3/8" Bolt', 'Imperial Bolts', 'Brass')
```

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL
REFERENCES Items(Item),
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200)
```

INNER JOIN

```
SELECT *
FROM Items AS I
     INNER JOIN
     OrderItems AS OI
     ON I.Item = OI.Item;

-- ANSI SQL 89
SELECT *
FROM Items AS I,
     OrderItems  AS OI
WHERE I.Item = OI.Item;
```

LEFT OUTER JOIN

Find Items that were never ordered.

```
SELECT I.Item
FROM Items AS I
     LEFT OUTER JOIN
     OrderItems AS OI
     ON I.Item = OI.Item
WHERE OI.OrderID IS NULL;
```

```
-- ANSI SQL 89
SELECT Item
FROM
(
 SELECT I.Item, O.OrderID
 FROM Items AS I,
     OrderItems  AS OI
 WHERE I.Item *= OI.Item
) AS LeftJoined
WHERE LeftJoined.OrderID IS NULL;
```

FULL OUTER JOIN

```
CREATE TABLE T1(Col1 INT, COl2 CHAR(2));
CREATE TABLE T2(Col1 INT, COl2 CHAR(2));

INSERT INTO T1 (Col1, Col2)
VALUES (1, 'A'), (2,'B');

INSERT INTO T2 (Col1, Col2)
VALUES (2,'BB'), (3,'CC');

SELECT *
FROM   T1
       FULL OUTER JOIN
       T2
       ON T1.Col1 = T2.Col1;
```

```
Result:
Col1     COl2     Col1     COl2
----     ----     ----     ----
1        A        NULL     NULL
2        B        2        BB
NULL     NULL     3        CC
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/queries/from-transact-sql?view=sql-server-ver15

PostgreSQL Overview

Aurora PostgreSQL supports all types of joins in the same way as SQL Server:

- **<Set A> CROSS JOIN <Set B>:** Results in a Cartesian product of the two sets. Every JOIN starts as a Cartesian product.
- **<Set A> INNER JOIN <Set B> ON <Join Condition>:** Filters the Cartesian product to only the rows where the join predicate evaluates to TRUE.
- **<Set A> LEFT OUTER JOIN <Set B> ON <Join Condition>:** Adds to the INNER JOIN all the rows from the reserved left set with NULL for all the columns that come from the right set.
- **<Set A> RIGHT OUTER JOIN <Set B> ON <Join Condition>:** Adds to the INNER JOIN all the rows from the reserved right set with NULL for all the columns that come from the left set.

- **<Set A> FULL OUTER JOIN <Set B> ON <Join Condition>:** Designates both sets as reserved and adds non matching rows from both, similar to a LEFT OUTER JOIN and a RIGHT OUTER JOIN.

SQL Server's APPLY options are not supported but can be replaced with INNER JOIN LATERAL and LEFT JOIN LATERAL.

Syntax

```
FROM
    <Table Source 1> CROSS JOIN <Table Source 2>
  | <Table Source 1> INNER JOIN <Table Source 2>
     ON <Join Predicate>
  | <Table Source 1> {LEFT|RIGHT|FULL} [OUTER] JOIN <Table Source 2>
     ON <Join Predicate>
```

Migration Considerations

For most JOINs, the syntax should be equivalent and no rewrites should be needed, a few differences can be found below:

- ANSI SQL 89 is not supported.
- FULL OUTER JOIN and OUTER JOIN using the pre-ANSI SQL 92 syntax are not supported, but they can be easily worked around (see the examples below).
- CROSS APPLY and OUTER APPLY are not supported and need to be rewritten using INNER JOIN LATERAL and LEFT JOIN LATERAL.

Examples

Create the Orders and Items tables.

```
CREATE TABLE Items
(
Item VARCHAR(20) NOT NULL
  PRIMARY KEY
Category VARCHAR(20) NOT NULL,
Material VARCHAR(20) NOT NULL
);
```

```
INSERT INTO Items (Item, Category, Material)
VALUES
('M8 Bolt', 'Metric Bolts', 'Stainless Steel'),
('M8 Nut', 'Metric Nuts', 'Stainless Steel'),
('M8 Washer', 'Metric Washers', 'Stainless Steel'),
('3/8" Bolt', 'Imperial Bolts', 'Brass')
```

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL
REFERENCES Items(Item),
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200)
```

INNER JOIN

```
SELECT *
FROM Items AS I
     INNER JOIN
     OrderItems AS OI
     ON I.Item = OI.Item;
```

LEFT OUTER JOIN

Find Items that were never ordered.

```
SELECT Item
FROM Items AS I
     LEFT OUTER JOIN
     OrderItems AS OI
     ON I.Item = OI.Item
WHERE OI.OrderID IS NULL;
```

FULL OUTER JOIN

```
CREATE TABLE T1(Col1 INT, COl2 CHAR(2));
CREATE TABLE T2(Col1 INT, COl2 CHAR(2));

INSERT INTO T1 (Col1, Col2)
VALUES (1, 'A'), (2,'B');

INSERT INTO T2 (Col1, Col2)
VALUES (2,'BB'), (3,'CC');

SELECT *
FROM   T1
       FULL OUTER JOIN
       T2
       ON T1.Col1 = T2.Col1;
```

```
Result:
Col1    COl2    Col1    COl2
----    ----    ----    ----
1       A       NULL    NULL
2       B       2       BB
NULL    NULL    3       CC
```

Summary

Table of similarities, differences, and key migration considerations.

SQL Server	Aurora PostgreSQL	Comments
INNER JOIN with ON clause or commas	Supported	
OUTER JOIN with ON cluase	Supported	
OUTER JOIN with commas	Not supported	Requires T-SQL rewrite post SQL Server 2008R2.
CROSS JOIN or using commas	Supported	
CROSS APPLY and OUTER APPLY	Not Supported	Rewrite required.

For more information, see:

- *https://www.postgresql.org/docs/13/static/explicit-joins.html*
- *https://www.postgresql.org/docs/13/static/tutorial-join.html*

SQL Server Temporal Tables vs. PostgreSQL Triggers (Temporal Tables alternative)

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	

SQL Server Usage

Temporal database tables were introduced in ANSI SQL 2011. T-SQL began supporting system versioned temporal tables in SQL Server 2016.

Each temporal table has two explicitly defined DATETIME2 columns known as *period columns*. The system uses these columns to record the period of availability for each row when it is modified. An additional *history table* retains the previous version of the data. The system can automatically create the history table, or a user can specify an existing table.

To query the history table, use FOR SYSTEM TIME after the table name in the FROM clause and combine it with the following options:

- **ALL:** All changes
- **CONTAINED IN:** Change is valid only within a period
- **AS OF:** Change was valid somewhere in a specific period
- **BETWEEN:** change was valid from a time range

Temporal Tables are mostly used when to track data change history as described in the scenarios below.

Anomaly Detection

Use this option when searching for data with unusual values. For example, detecting when a customer returns items too often.

```
CREATE TABLE Products_returned
    (
       ProductID int NOT NULL PRIMARY KEY CLUSTERED,
       ProductName varchar(60) NOT NULL,
       return_count INT NOT NULL,
       ValidFrom datetime2(7) GENERATED ALWAYS AS ROW START NOT NULL,
       ValidTo datetime2(7) GENERATED ALWAYS AS ROW END NOT NULL,
       PERIOD FOR SYSTEM_TIME (ValidFrom, ValidTo)
    )
    WITH( SYSTEM_VERSIONING = ON (HISTORY_TABLE = dbo.ProductHistory,
        DATA_CONSISTENCY_CHECK = ON ))
```

Query the Product table and run calculations on the data.

```
SELECT
     ProductId,
     LAG (return_count, 1, 1)
     over (partition by ProductId order by ValidFrom) as PrevValue,
     return_count,
     LEAD (return_count, 1, 1)
     over (partition by ProductId order by ValidFrom) as NextValue ,
     ValidFrom, ValidTo from Product
FOR SYSTEM_TIME ALL
```

Audit

Track changes to critical data such as salaries or medical data.

```
CREATE TABLE Employee
(
  EmployeeID int NOT NULL PRIMARY KEY CLUSTERED,
  Name nvarchar(60) NOT NULL,
  Salary decimal (6,2) NOT NULL,
  ValidFrom datetime2 (2) GENERATED ALWAYS AS ROW START,
  ValidTo datetime2 (2) GENERATED ALWAYS AS ROW END,
  PERIOD FOR SYSTEM_TIME (ValidFrom, ValidTo)
 )
 WITH (SYSTEM_VERSIONING = ON (HISTORY_TABLE = dbo.EmployeeTrackHistory));
```

Use FOR SYSTEM_TIME ALL to retrieve changes from the history table.

```
SELECT * FROM Employee
    FOR SYSTEM_TIME ALL WHERE
        EmployeeID = 1000 ORDER BY ValidFrom;
```

Other Scenarios

Additional scenarios include:

- Fixing row-level corruption
- Slowly Changing Dimension
- Over time changes analysis

For more information, see https://docs.microsoft.com/en-us/sql/relational-databases/tables/temporal-tables?view=sql-server-ver15

PostgreSQL Usage

(Temporal Tables alternative)

PostgreSQL provides an extension for supporting temporal tables, but it's not supported by Amazon Aurora. A workaround will be to create table triggers to update a custom history table to track changes to data. For additional information, see PostgreSQL triggers.

SQL Server Views vs. PostgreSQL Views

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Indexed and Partitioned view are not supported

SQL Server Usage

Views are schema objects that provide stored definitions for virtual tables. Similar to tables, views are data sets with uniquely named columns and rows. With the exception of indexed views, view objects do not store data. They consist only of a query definition and are reevaluated for each invocation.

Views are used as abstraction layers and security filters for the underlying tables. They can JOIN and UNION data from multiple source tables and use aggregates, window functions, and other SQL features as long as the result is a semi-proper set with uniquely identifiable columns and no order to the rows. You can use Distributed Views to query other databases and data sources using linked servers.

As an abstraction layer, a view can decouple application code from the database schema. The underlying tables can be changed without the need to modify the application code as long as the expected results of the view do not change. You can use this approach to provide backward compatible views of data.

As a security mechanism, a view can screen and filter source table data. You can perform permission management at the view level without explicit permissions to the base objects, provided the ownership chain is maintained. For more information on ownership chains in SQL Server, see https://docs.microsoft.com/en-us/dotnet/framework/data/adonet/sql/overview-of-sql-server-security.

View definitions are evaluated when they are created and are not affected by subsequent changes to the underlying tables. For example, a view that uses SELECT * does not display columns that were added later to the base table. Similarly, if a column was dropped from the base table, invoking the view results in an error. Use the SCHEMABINDING option to prevent changes to base objects.

Modifying Data Through Views

Updatable Views can both SELECT and modify data. For a view to be updatable, the following conditions must be met:

- The DML targets only one base table.
- Columns being modified must be directly referenced from the underlying base tables. Computed columns, set operators, functions, aggregates, or any other expressions are not permitted.
- If a view is created with the CHECK OPTION, rows being updated can not be filtered out of the view definition as the result of the update.

Special View Types

SQL Server also provides three types of specialized views:

- **Indexed Views** (also known as materialized views or persisted views) are standard views that have been evaluated and persisted in a unique clustered index, much like a normal clustered primary key table. Each time the source data changes, SQL Server re-evaluates the indexed views automatically and updates them. Indexed views are typically used as a means to optimize performance by pre-processing operators such as aggregations, joins, and others. Queries needing this pre-processing don't have to wait for it to be reevaluated on every query execution.
- **Partitioned Views** are views that rejoin horizontally partitioned data sets from multiple underlying tables, each containing only a subset of the data. The view uses a UNION ALL query where the underlying tables can reside locally or in other databases (or even other servers). These types of views are called Distributed Partitioned Views (DPV).
- **System Views** are used to access server and object meta data. SQL Server also supports a set of standard INFORMATION_SCHEMA views for accessing object meta data.

Syntax

```
CREATE [OR ALTER] VIEW [<Schema Name>.] <View Name> [(<Column Aliases> ])]
[WITH [ENCRYPTION][SCHEMABINDING][VIEW_METADATA]]
AS <SELECT Query>
[WITH CHECK OPTION][;]
```

Examples

Create a view that aggregates items for each customer.

```
CREATE TABLE Orders
(
OrderID INT NOT NULL PRIMARY KEY,
OrderDate DATETIME NOT NULL
 DEFAULT GETDATE()
);
```

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL
 REFERENCES Orders(OrderID),
```

```
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
CREATE VIEW SalesView
AS
SELECT O.Customer,
       OI.Product,
       SUM(CAST(OI.Quantity AS BIGINT)) AS TotalItemsBought
FROM Orders AS O
     INNER JOIN
     OrderItems AS OI
      ON O.OrderID = OI.OrderID;
```

Create an indexed view that pre-aggregates items for each customer.

```
CREATE VIEW SalesViewIndexed
AS
SELECT O.Customer,
       OI.Product,
       SUM_BIG(OI.Quantity) AS TotalItemsBought
FROM Orders AS O
     INNER JOIN
     OrderItems AS OI
      ON O.OrderID = OI.OrderID;
```

```
CREATE UNIQUE CLUSTERED INDEX IDX_SalesView
ON SalesViewIndexed (Customer, Product);
```

Create a Partitioned View.

```
CREATE VIEW dbo.PartitioneView
WITH SCHEMABINDING
AS
SELECT *
FROM Table1
UNION ALL
SELECT *
FROM Table2
UNION ALL
SELECT *
FROM Table3
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/views/views?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/views/modify-data-through-a-view?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-view-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

The basic form of Views is similar between PostgreSQL and SQL Server. A view defines a stored query based on one or more physical database tables that executes every time the view is accessed.

More complex option such as Indexed Views or Partitioned Views are not supported, and may require a redesign or might application rewrite.

> RDS ONLY: Starting with PostgreSQL 13 it is now possible to rename view columns using ALTER VIEW command, this will help the DBA to avoid dropping and recreating the view in order to change a column name.
> The following syntax was added to the ALTER VIEW:
>
> `ALTER VIEW [ IF EXISTS ] name RENAME [ COLUMN ] column_name TO new_column_name`

Prior to PostgreSQL 13 the capability was there but in order to change the view's column name the DBA had to use the ALTER TABLE command.

PostgreSQL View Privileges

A Role or User must be granted SELECT and DML privileges on the base tables or views in order to create a view. For additional details, see https://www.postgresql.org/docs/13/static/sql-grant.html

PostgreSQL View Parameters

CREATE [OR REPLACE] VIEW

When re-creating an existing view, the new view must have the same column structure as generated by the original view (column names, column order, and data types). It is sometimes preferable to drop the view and use the CREATE VIEW statement instead.

```
hr=# CREATE [OR REPLACE] VIEW VW_NAME AS
     SELECT COLUMNS
     FROM TABLE(s)
     [WHERE CONDITIONS];


hr=# DROP VIEW [IF EXISTS] VW_NAME;
```

> Note: The IF EXISTS parameter is optional.

WITH [CASCADED | LOCAL] CHECK OPTION

DML INSERT and UPDATE operations are verified against the view-based tables to ensure new rows satisfy the original structure conditions or the view-defining condition. If a conflict is detected, the DML operation fails.

CHECK OPTION

- **LOCAL:** Verifies the view without a hierarchical check.
- **CASCADED:** Verifies all underlying base views using a hierarchical check.

Executing DML Commands On views

PostgreSQL simple views are automatically updatable. No restrictions exist when performing DML operations on views. An updatable view may contain a combination of updatable and non-updatable columns. A column is updatable if it references an updatable column of the underlying base table. If not, the column is read-only and an error is raised if an INSERT or UPDATE statement is attempted on the column.

Syntax

```
CREATE [ OR REPLACE ] [ TEMP | TEMPORARY ] [ RECURSIVE ] VIEW name [ ( column_name [,
...] ) ]
    [ WITH ( view_option_name [= view_option_value] [, ... ] ) ]
    AS query
    [ WITH [ CASCADED | LOCAL ] CHECK OPTION ]
```

Examples

Create and update a view without the CHECK OPTION parameter.

```
CREATE OR REPLACE VIEW VW_DEP AS
     SELECT DEPARTMENT_ID, DEPARTMENT_NAME, MANAGER_ID, LOCATION_ID
     FROM DEPARTMENTS
     WHERE LOCATION_ID=1700;

view VW_DEP created.

UPDATE VW_DEP SET LOCATION_ID=1600;

21 rows updated.
```

Create and update a view with the LOCAL CHECK OPTION parameter.

```
CREATE OR REPLACE VIEW VW_DEP AS
     SELECT DEPARTMENT_ID, DEPARTMENT_NAME, MANAGER_ID, LOCATION_ID
     FROM DEPARTMENTS
     WHERE LOCATION_ID=1700
     WITH LOCAL CHECK OPTION;

view VW_DEP created.

UPDATE VW_DEP SET LOCATION_ID=1600;

SQL Error: ERROR: new row violates check option for view "vw_dep"
```

Summary

Feature	SQL Server	Aurora PostgreSQL
Indexed Views	Supported	N/A
Partitioned Views	Supported	N/A
Updateable Views	Supported	Supported
Prevent schema conflicts	SCHEMABINDING option	N/A
Triggers on views	INSTEAD OF	INSTEAD OF
Temporary Views	CREATE VIEW #View...	CREATE [OR REPLACE] [TEMP | TEMPORARY] VIEW
Refresh view definition	sp_refreshview / ALTER VIEW	ALTER VIEW

For more information, see:

- *https://www.postgresql.org/docs/13/static/tutorial-views.html*
- *https://www.postgresql.org/docs/13/static/sql-createview.html*

SQL Server Window Functions vs. PostgreSQL Window Functions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	

SQL Server Usage

Windowed functions use an OVER clause to define the window and frame for a data set to be processed. They are part of the ANSI standard and are typically compatible among various SQL dialects. However, most RDBMS do not yet support the full ANSI specification.

Windowed functions are a relatively new, advanced, and efficient T-SQL programming tool. They are highly utilized by developers to solve numerous programming challenges.

SQL Server currently supports the following windowed functions:

- **Ranking functions:** ROW_NUMBER, RANK, DENSE_RANK, and NTILE
- **Aggregate functions:** AVG, MIN, MAX, SUM, COUNT, COUNT_BIG, VAR, STDEV, STDEVP, STRING_AGG, GROUPING, GROUPING_ID, VAR, VARP, and CHECKSUM_AGG
- **Analytic functions:** LAG, LEAD, FIRST_Value, LAST_VALUE, PERCENT_RANK, PERCENTILE_CONT, PERCENTILE_DISC, and CUME_DIST
- **Other functions:** NEXT_VALUE_FOR (See the *Identity and Sequences* section)

Syntax

```
<Function()>
OVER
(
[ <PARTITION BY clause> ]
[ <ORDER BY clause> ]
[ <ROW or RANGE clause> ]
)
```

Examples

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Locking Nut', 300);
```

Use a windowed ranking function to rank items based on the ordered quantity.

```
SELECT  Item,
        Quantity,
        RANK() OVER(ORDER BY Quantity) AS QtyRank
FROM    OrderItems;
```

```
Item           Quantity  QtyRank
----           --------  -------
M8 Bolt        100       1
M8 Nut         100       1
M8 Washer      200       3
M6 Locking Nut 300       4
```

Use a partitioned windowed aggregate function to calculate the total quantity per order (without using a GROUP BY clause).

```
SELECT  Item,
        Quantity,
        OrderID,
        SUM(Quantity)
         OVER (PARTITION BY OrderID) AS TotalOrderQty
FROM    OrderItems;
```

```
Item           Quantity  OrderID  TotalOrderQty
----           --------  -------  -------------
M8 Bolt        100       1        100
M8 Nut         100       2        100
M6 Locking Nut 300       3        500
M8 Washer      200       3        500
```

Use an analytic LEAD function to get the next largest quantity for the order.

```
SELECT  Item,
       Quantity,
       OrderID,
       LEAD(Quantity)
        OVER (PARTITION BY OrderID ORDER BY Quantity) AS NextQtyOrder
FROM   OrderItems;
```

```
Item           Quantity OrderID NextQtyOrder
----           -------- ------- ------------
M8 Bolt        100     1        NULL
M8 Nut         100     2        NULL
M8 Washer      200     3        300
M6 Locking Nut 300     3        NULL
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/queries/select-over-clause-transact-sql?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL refers to ANSI SQL analytical functions as “Window Functions”. They provide the same core functionality as SQL Analytical Functions. Window functions in PostgreSQL operate on a logical “partition” or "window" of the result set and return a value for rows in that “window”.

From a database migration perspective, you should examine PostgreSQL Window Functions by type and compare them with the equivalent SQL Server window functions to verify compatibility of syntax and output.

> **Note:** Even if a PostgreSQL window function provides the same functionality of a specific SQL Server window function, the returned data type may be different and require application changes.

PostgreSQL provides support for two main types of Window Functions: Aggregation functions and Ranking functions.

PostgreSQL Window Functions by Type

Function Type	Related Functions
Aggregate	avg, count, max, min, sum, string_agg
Ranking	row_number, rank, dense_rank, percent_rank, cume_dist, ntile, lag, lead, first_value, last_value, nth_value

PostgreSQL Window Functions

PostgreSQL Window Function	Returned Data Type	Compatible Syntax
Count	bigint	Yes
Max	numeric, string, date/time, network or enum type	Yes
Min	numeric, string, date/time, network or enum type	Yes
Avg	numeric, double, otherwise same datatype as the argument	Yes
Sum	bigint, otherwise same datatype as the argument	Yes
rank()	bigint	Yes
row_number()	bigint	Yes
dense_rank()	bigint	Yes
percent_rank()	double	Yes
cume_dist()	double	Yes
ntile()	integer	Yes
lag()	same type as value	Yes
lead()	same type as value	Yes
first_value()	same type as value	Yes
last_value()	same type as value	Yes

Examples

Use the PostgreSQL rank() function.

```
SELECT department_id, last_name, salary, commission_pct,
     RANK() OVER (PARTITION BY department_id
     ORDER BY salary DESC, commission_pct) "Rank"
     FROM employees WHERE department_id = 80;

    DEPARTMENT_ID LAST_NAME                  SALARY COMMISSION_PCT       Rank
    ------------- ------------------------- ---------- -------------- ----------
               80 Russell                   14000.00           0.40          1
               80 Partners                  13500.00           0.30          2
               80 Errazuriz                 12000.00           0.30          3
```

Note: The returned formatting for certain numeric data types is different.

Query the total salary for department 80.

```
SELECT SUM(salary)
     FROM employees WHERE department_id = 80;

  SUM(SALARY)
  ----------
  39500.00
```

```
```

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Locking Nut', 300);
```

Use a windowed ranking function to rank items based on the ordered quantity.

```
SELECT  Item,
        Quantity,
        RANK() OVER(ORDER BY Quantity) AS QtyRank
FROM    OrderItems;

Item           Quantity  QtyRank
----           --------  -------
M8 Bolt        100       1
M8 Nut         100       1
M8 Washer      200       3
M6 Locking Nut 300       4
```

Use a partitioned windowed aggregate function to calculate the total quantity per order (without using a GROUP BY clause).

```
SELECT  Item,
        Quantity,
        OrderID,
        SUM(Quantity)
         OVER (PARTITION BY OrderID) AS TotalOrderQty
FROM    OrderItems;

Item           Quantity  OrderID  TotalOrderQty
----           --------  -------  -------------
M8 Bolt        100       1        100
M8 Nut         100       2        100
M6 Locking Nut 300       3        500
M8 Washer      200       3        500
```

Use an analytic LEAD function to get the next largest quantity for the order.

```
SELECT  Item,
       Quantity,
       OrderID,
```

```
       LEAD(Quantity)
        OVER (PARTITION BY OrderID ORDER BY Quantity) AS NextQtyOrder
FROM   OrderItems;

Item           Quantity OrderID NextQtyOrder
----           -------- ------- ------------
M8 Bolt        100      1       NULL
M8 Nut         100      2       NULL
M8 Washer      200      3       300
M6 Locking Nut 300      3       NULL
```

For more information see https://www.postgresql.org/docs/13/static/tutorial-window.html

T-SQL

SQL Server Service Broker Essentials vs. PostgreSQL AWS Lambda or DB links

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Broker	Use Amazon Lambda for similar functionality

SQL Server Usage

SQL Server Service Broker provides native support for messaging and queuing applications. It's makes it easier for developers to create complex applications that use the Database Engine components to communicate between several SQL Server databases. Developers can use Service Broker to easily build distributed and more reliable applications.

Benefits of using messaging queues:

- Decouple dependencies between applications by communicating through messages.
- Scale out your architecture by moving queues / message processors to separate servers as needed.
- Maintain individual parts with a minimal impact to the end users.
- Control when the messages are processed (for example: off-peak hours).
- Process queued messages on multiple servers / processes / threads.

The following sections describe the Service Broker commands.

CREATE MESSAGE TYPE

Create a message with name and structure.

```
CREATE MESSAGE TYPE message_type_name
    [ AUTHORIZATION owner_name ]
```

```
    [ VALIDATION = {  NONE
                    | EMPTY
                    | WELL_FORMED_XML
                    | VALID_XML WITH SCHEMA COLLECTION schema_collection_name
                   } ]
[ ; ]
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/create-message-type-transact-sql?view=sql-server-ver15

CREATE QUEUE

Create a queue to store messages.

```
CREATE QUEUE <object>
   [ WITH
     [ STATUS = { ON | OFF }  [ , ] ]
     [ RETENTION = { ON | OFF } [ , ] ]
     [ ACTIVATION (
         [ STATUS = { ON | OFF } , ]
           PROCEDURE_NAME = <procedure> ,
           MAX_QUEUE_READERS = max_readers ,
           EXECUTE AS { SELF | 'user_name' | OWNER }
            ) [ , ] ]
     [ POISON_MESSAGE_HANDLING (
         [ STATUS = { ON | OFF } ] ) ]
    ]
     [ ON { filegroup | [ DEFAULT ] } ]
[ ; ]

<object> ::=
{
    [ database_name. [ schema_name ] . | schema_name. ]
        queue_name
}

<procedure> ::=
{
    [ database_name. [ schema_name ] . | schema_name. ]
        stored_procedure_name
}
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/create-queue-transact-sql?view=sql-server-ver15

CREATE CONTRACT

Specify the role and what type of messages a service can handle.

```
CREATE CONTRACT contract_name
   [ AUTHORIZATION owner_name ]
      (  {   { message_type_name | [ DEFAULT ] }
          SENT BY { INITIATOR | TARGET | ANY }
       } [ ,...n] )
[ ; ]
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/create-contract-transact-sql?view=sql-server-ver15

CREATE SERVICE

Create a named Broker Service for a specified task or set of tasks.

```
CREATE SERVICE service_name
   [ AUTHORIZATION owner_name ]
   ON QUEUE [ schema_name. ]queue_name
   [ ( contract_name | [DEFAULT][ ,...n ] ) ]
[ ; ]
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/create-service-transact-sql?view=sql-server-ver15

BEGIN DIALOG CONVERSATION

Start the interaction between Broker Services.

```
BEGIN DIALOG [ CONVERSATION ] @dialog_handle
   FROM SERVICE initiator_service_name
   TO SERVICE 'target_service_name'
       [ , { 'service_broker_guid' | 'CURRENT DATABASE' }]
   [ ON CONTRACT contract_name ]
   [ WITH
   [  { RELATED_CONVERSATION = related_conversation_handle
      | RELATED_CONVERSATION_GROUP = related_conversation_group_id } ]
   [ [ , ] LIFETIME = dialog_lifetime ]
   [ [ , ] ENCRYPTION = { ON | OFF }  ] ]
[ ; ]
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/begin-dialog-conversation-transact-sql?view=sql-server-ver15

WAITFOR(RECEIVE TOP(1))

Specify that a code block to wait until one message is received.

```
[ WAITFOR ( ]
    RECEIVE [ TOP ( n ) ]
```

```
        <column_specifier> [ ,...n ]
        FROM <queue>
        [ INTO table_variable ]
        [ WHERE {   conversation_handle = conversation_handle
                  | conversation_group_id = conversation_group_id } ]
[ ) ] [ , TIMEOUT timeout ]
[ ; ]

<column_specifier> ::=
{     *
  |   { column_name | [ ] expression } [ [ AS ] column_alias ]
  |   column_alias = expression
}      [ ,...n ]

<queue> ::=
{
    [ database_name . [ schema_name ] . | schema_name . ]
        queue_name
}
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/statements/receive-transact-sql?view=sql-server-ver15

All of the above commands can be combined in to achieve your architecture goals.

For more information see:
https://docs.microsoft.com/en-us/sql/database-engine/configure-windows/sql-server-service-broker?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL does not provide a compatible solution to the SQL Server Service Broker. However, you can use DB Links and AWS Lambda to achieve similar functionality.

AWS Lambda can be combined with AWS SQS in order to reduce costs and remove some loads from the database into the AWS Lambda and SQS (this will be much more efficient), for more information see: https://docs.aws.amazon.com/lambda/latest/dg/with-sqs.html

For example, you can create a table in each database and connect each database with a DB link to read the tables and process the data. For more information, see DB Links.

You can also use AWS Lambda to query a table from the database, process the data, and insert it to another database (even another database type). This approach is the best option for moving workloads out of the database to a less expensive instance type.

For even more decoupling and reducing workloads from the database SQS can be used with Lambda, SQS is the Amazon messages queues service.

For more information see AWS Lambda for sending mails

SQL Server Cast and Convert vs. PostgreSQL CAST and CONVERSION

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
			CONVERT is used only to convert between collations CAST uses different syntax

SQL Server Usage

The CAST and CONVERT functions are commonly used to convert one data type to another. CAST and CONVERT behave mostly the same (they share the same topic in MSDN) , but there are few differences :

- CAST is part of the ANSI-SQL specification, but CONVERT is not.
- CONVERT accepts an optional style parameter used for formatting.

For more information about styles, see https://docs.microsoft.com/en-us/sql/t-sql/functions/cast-and-convert-transact-sql?view=sql-server-ver15#date-and-time-styles

Conversion matrix

To view all conversion data types available, see https://docs.microsoft.com/en-us/sql/t-sql/functions/cast-and-convert-transact-sql?view=sql-server-ver15#implicit-conversions

Syntax

```
-- CAST Syntax:
CAST ( expression AS data_type [ ( length ) ] )

-- CONVERT Syntax:
CONVERT ( data_type [ ( length ) ] , expression [ , style ] )
```

Examples

Cast a string to int and int to decimal.

```
SELECT CAST('23.7' AS varchar) AS int, CAST(23.7 AS int) AS decimal;
```

Convert string to int and int to decimal.

```
SELECT CONVERT(VARCHAR, '23.7') AS int, CONVERT(int, 23.7) AS decimal;
```

In both examples above, the results will be:

```
int  |decimal |
-----|--------|
23.7 |23       |
```

Convert a date with option style input (109 - mon dd yyyy hh:mi:ss:mmmAM (or PM))

```
SELECT CONVERT(nvarchar(30), GETDATE(), 109);

                               |
-------------------------------|
Jul 25 2018  5:20:10.8975085PM |
```

For more information, see:
https://docs.microsoft.com/en-us/sql/t-sql/functions/cast-and-convert-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL provides the same CAST function as SQL Server for conversion between data types. It also provides a CONVERSION function, but it is not equivalent to SQL Server's CONVERT.
PostgreSQL CONVERSION is used to convert between character set encoding.

CREATE A CAST defines a new cast on how to convert between two data types.

Cast can be EXPLICITLY or IMPLICIT.

The behavior is similar to SQL Server's casting, but in PostgreSQL, you can also create your own casts to change the default behavior. For example, checking if a string is a valid credit card number by creating the CAST with the WITHOUT FUNCTION clause.

CREATE CONVERSION is used to convert between encoding such as UTF8 and LATIN. If CONVERT is currently in use in SQL Server code, it must be rewritten to use CAST instead.

> **Note:** Not all SQL Server's data types are supported on Aurora PostgreSQL, besides changing the CAST or CONVERT commands, you might need to also change the source of the target data type, for more information about supported data types, see: Data Types

Another way to convert between data types in PostgreSQL will be to use the '::' characters, this option is useful and can make your pgsql code look cleaner and simpler, see examples below.

Syntax

```
CREATE CAST (source_type AS target_type)
WITH FUNCTION function_name (argument_type [, ...]) [ AS ASSIGNMENT | AS IMPLICIT ]

CREATE CAST (source_type AS target_type)
WITHOUT FUNCTION [ AS ASSIGNMENT | AS IMPLICIT ]

CREATE CAST (source_type AS target_type)
WITH INOUT [ AS ASSIGNMENT | AS IMPLICIT ]
```

Examples

Convert a numeric value to float.

```
SELECT 23 + 2.0;

or

SELECT CAST ( 23 AS numeric ) + 2.0;
```

Convert a date with format input ('mon dd yyyy hh:mi:ss:mmmAM (or PM)').

```
SELECT TO_CHAR(NOW(),'Mon DD YYYY HH:MI:SS:MSAM');

                                |
--------------------------------|
Jul 25 2018  5:20:10.8975085PM |
```

Use '::' characters

```
SELECT '2.35'::DECIMAL + 4.5 AS results;

results |
--------|
6.85    |
```

Summary

Option	SQL Server	Aurora PostgreSQL
Explicit CAST	SELECT CAST('23.7' AS varchar) AS int	SELECT CAST('23.7' AS varchar) AS int
Explicit CONVERT	SELECT CONVERT (VARCHAR, '23.7')	Need to use CAST: SELECT CAST('23.7' AS varchar) AS int
Implicit casting	SELECT 23 + 2.0	SELECT 23 + 2.0
Convert to a specific date format: 'mon dd yyyy hh:mi:ss:mmmAM'	SELECT CONVERT(nvarchar (30), GETDATE(), 109)	SELECT TO_CHAR(NOW(),'Mon DD YYYY HH:MI:SS:MSAM')

For more information, see:

- *https://www.postgresql.org/docs/13/static/sql-createcast.html*
- *https://www.postgresql.org/docs/13/static/typeconv.html*
- *https://www.postgresql.org/docs/13/static/sql-createconversion.html*

SQL Server Common Library Runtime (CLR) vs. PostgreSQL PL/Perl

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Migrating CLR objects will require a full code rewrite

SQL Server Usage

SQL Server provides the capability of implementing .NET objects in the database using the Common Runtime Library (CLR). The CLR enables development of functionality that would be complicated using T-SQL.

The CLR provides robust solutions for string manipulation, date manipulation, and calling external services such as Windows Communication Foundation (WCF) services and web services.

The objects that can be created with the EXTERNAL NAME clause are:

- Procedures - For more information, see: https://msdn.microsoft.com/en-us/library/ms131094.aspx
- Functions - For more information, see: https://docs.microsoft.com/en-us/sql/relational-databases/user-defined-functions/create-clr-functions?view=sql-server-ver15
- Triggers - For more information, see: https://docs.microsoft.com/en-us/sql/relational-databases/triggers/create-clr-triggers?view=sql-server-ver15
- Types - For more information, see: https://docs.microsoft.com/en-us/sql/relational-databases/clr-integration-database-objects-user-defined-types/clr-user-defined-types?view=sql-server-ver15
- Aggregates - user-defined aggregate function. For more information, see: https://docs.microsoft.com/en-us/sql/relational-databases/clr-integration-database-objects-user-defined-functions/clr-user-defined-aggregates?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL does not support .NET code. However, you can create Perl functions. You must convert all C# code to PL/pgSQL or PL/Perl.

In order to use PL/Perl language you must install the perl extension:

```
CREATE EXTENSION plperl;
```

After it is installed, you can create functions using perl code. Specify plperl in the the LANGUAGE clause.

The objects that can be created with Perl are:

- Functions
- Void functions (procedures)
- Triggers

- Event Triggers
- Values for session level

Examples

Create a function that returns the greater value of two integers.

```
CREATE FUNCTION perl_max (integer, integer) RETURNS integer AS $$
    if ($_[0] > $_[1]) { return $_[0]; }
    return $_[1];
$$ LANGUAGE plperl;
```

For more information see: https://www.postgresql.org/docs/13/static/plperl.html

SQL Server Collations vs. PostgreSQL Encoding

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Collation	UTF16 and NCHAR/NVARCHAR data types are not supported

SQL Server Usage

SQL Server collations define the rules for string management and storage in terms of sorting, case sensitivity, accent sensitivity, and code page mapping. SQL Server supports both ASCII and UCS-2 UNICODE data.

UCS-2 UNICODE data uses a dedicated set of UNICODE data types denoted by the prefix "N": Nchar and Nvarchar. Their ASCII counterparts are CHAR and VARCHAR.

Choosing a collation and a character set has significant implications on data storage, logical predicate evaluations, query results, and query performance.

> **Note:** To view all collations supported by SQL Server, use the fn_helpcollations function: SELECT * FROM sys.fn_helpcollations().

Collations define the actual bitwise binary representation of all string characters and the associated sorting rules. SQL Server supports multiple collations down to the column level. A table may have multiple string columns that use different collations. Collations for non-UNICODE character sets determine the code page number representing the string characters.

> **Note:** UNICODE and non-UNICODE data types in SQL Server are not compatible. A predicate or data modification that introduces a type conflict is resolved using predefined collation precedence rules. For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/collation-precedence-transact-sql?view=sql-server-ver15

Collations define sorting and matching sensitivity for the following string characteristics:

- Case
- Accent

- Kana
- Width
- Variation selector

SQL Server uses a suffix naming convention that appends the option name to the collation name. For example, the collation Azeri_Cyrillic_100_CS_AS_KS_WS_SC, is an Azeri-Cyrillic-100 collation that is case-sensitive, accent-sensitive, kana type-sensitive, width-sensitive, and has supplementary characters.

SQL Server supports three types of collation sets:

- **Windows Collations** use the rules defined for collations by the operating system locale where UNICODE and non-UNICODE data use the same comparison algorithms.
- **Binary Collations** use the binary bit-wise code for comparison. Therefore, the locale does not affect sorting.
- **SQL Server Collations** provide backward compatibility with previous SQL Server versions. They are not compatible with the windows collation rules for non-UNICODE data.

Collations can be defined at various levels:

- **Server Level Collations** determine the collations used for all system databases and is the default for future user databases. While the system databases collation can not be changed, an alternative collation can be specified as part of the CREATE DATABASE statement.
- **Database Level Collations** inherit the server default unless the CREATE DATABASE statement explicitly sets a different collation. This collation is used as a default for all CREATE TABLE and ALTER TABLE statements.
- **Column Level Collations** can be specified as part of the CREATE TABLE or ALTER TABLE statements to override the database's default collation setting.
- **Expression Level Collations** can be set for individual string expressions using the COLLATE function. For example, SELECT * FROM MyTable ORDER BY StringColumn COLLATE Latin1_General_CS_AS.

Note: SQL Server supports UCS-2 UNICODE only.

SQL Server 2019 adds support for UTF-8 for import and export encoding, and as database-level or column-level collation for string data. Support includes PolyBase external tables, and Always Encrypted (when not used with Enclaves). For more information see Collation and Unicode Support.

Syntax

```
CREATE DATABASE <Database Name>
[ ON   <File Specifications> ]
  COLLATE <Collation>
[ WITH  <Database Option List> ];
```

```
CREATE TABLE <Table Name>
(
<Column Name> <String Data Type>
COLLATE <Collation> [ <Column Constraints> ]...
);
```

Examples

Create a database with a default Bengali_100_CS_AI collation.

```
CREATE DATABASE MyBengaliDatabase
ON
( NAME = MyBengaliDatabase_Datafile,
    FILENAME = 'C:\Program Files\Microsoft SQL Server-
\MSSQL13.MSSQLSERVER\MSSQL\DATA\MyBengaliDatabase.mdf',
    SIZE = 100)
LOG ON
( NAME = MyBengaliDatabase_Logfile,
    FILENAME = 'C:\Program Files\Microsoft SQL Server-
\MSSQL13.MSSQLSERVER\MSSQL\DATA\MyBengaliDblog.ldf',
    SIZE = 25)
COLLATE Bengali_100_CS_AI;
```

Create a table with two different collations.

```
CREATE TABLE MyTable
(
Col1 CHAR(10) COLLATE Hungarian_100_CI_AI_SC NOT NULL PRIMARY KEY,
COL2 VARCHAR(100) COLLATE Sami_Sweden_Finland_100_CS_AS_KS NOT NULL
);
```

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/collations/collation-and-unicode-support?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL supports a variety of different character sets, also known as encoding, including support for both single-byte and multi-byte languages. The default character set is specified when initializing a PostgreSQL database cluster with initdb. Each individual database created on the PostgreSQL cluster supports individual character sets defined as part of database creation.

> RDS ONLY: Starting with PostgreSQL 13, Windows version now support obtaining version information for collations (ordering rules) from OS.

When querying the colllversion from pg_collation in PostgreSQL running on Windows, prior to version 13 there wasn't any value to reflect the OS collation version, for example version 11 running on Windows:

```
CREATE COLLATION german (provider = libc, locale = 'de_DE');

CREATE COLLATION

select oid,collname,collversion from pg_collation
where collprovider='c' and collname='german';

  oid  | collname | collversion
-------+----------+-------------
 16394 | german   |
(1 row)

select pg_collation_actual_version (16394);

 pg_collation_actual_version
```

```
----------------------------
(1 row)
```

RDS ONLY: Starting PostgreSQL 13 running on Windows:

```
CREATE COLLATION german (provider = libc, locale = 'de_DE');

CREATE COLLATION

select oid,collname,collversion from pg_collation
where collprovider='c' and collname='german';

  oid  | collname |  collversion
-------+----------+---------------
 32769 | german   | 1539.5,1539.5
(1 row)

select pg_collation_actual_version (32769);

 pg_collation_actual_version
----------------------------
 1539.5,1539.5
(1 row)
```

Notes:

- All supported character sets can be used by clients. However, some client-side only characters are not supported for use within the server.
- Unlike SQL Server, PostgreSQL does not natively support an NVARHCHAR data type and does not provide support for UTF-16.

Type	Function	Implementation Level
Encoding	Defines the basic rules on how alphanumeric characters are represented in binary format. For example, Unicode Encoding.	Database
Locale	A superset that includes LC_COLLATE and LC_CTYPE among others. For example, LC_COLLATE defines how strings are sorted and must be a subset supported by the database Encoding.	Table-Column

Examples

Create a database named test01 which uses the Korean EUC_KR Encoding the and the ko_KR locale.

```
CREATE DATABASE test01 WITH ENCODING 'EUC_KR' LC_COLLATE='ko_KR.euckr' LC_CTYPE='ko_
KR.euckr' TEMPLATE=template0;
```

View the character sets configured for each database by querying the System Catalog.

```
select datname, datcollate, datctype from pg_database;
```

Changing Character Sets/Encoding

In-place modification of the database encoding is not recommended nor supported. You must export all data, create a new database with the new encoding, and import the data.

Export the data using the pg_dump utility.

```
pg_dump mydb1 > mydb1_export.sql
```

Rename (or delete) a database.

```
ALTER DATABASE mydb1 TO mydb1_backup;
```

Create a new database using the modified encoding.

```
CREATE DATABASE mydb1_new_encoding WITH ENCODING 'UNICODE' TEMPLATE=template0;
```

Import data using the pg_dump file previously created. Verify that you set your client encoding to the encoding of your “old” database.

```
PGCLIENTENCODING=OLD_DB_ENCODING psql -f mydb1_export.sql mydb1_new_encoding
```

Note: The client_encoding parameter overrides the use of PGCLIENTENCODING.

Client/Server Character Set Conversions

PostgreSQL supports conversion of character sets between servers and clients for specific character set combinations as described in the pg_conversion system catalog.

PostgreSQL includes predefined conversions. For a complete list, see
https://www.postgresql.org/docs/13/static/multibyte.html#MULTIBYTE-TRANSLATION-TABLE

You can create a new conversion using the SQL command CREATE CONVERSION.

Examples

Create a conversion from UTF8 to LATIN1 using the custom myfunc1 function.

```
CREATE CONVERSION myconv FOR 'UTF8' TO 'LATIN1' FROM myfunc1;
```

Configure the PostgreSQL client character set.

```
Method 1
========
psql \encoding SJIS

Method 2
========
SET CLIENT_ENCODING TO 'value';
```

View the client character set and reset it back to the default value.

```
SHOW client_encoding;

RESET client_encoding;
```

Table Level Collation

PostgreSQL supports specifying the sort order and character classification behavior on a per-column level.

Examples

Specify specific collations for individual table columns.

```
CREATE TABLE test1 (col1 text COLLATE "de_DE", col2 text COLLATE "es_ES");
```

Summary

Feature	SQL Server	Aurora PostgreSQL
View database character set	SELECT collation_name FROM sys.databases';	select datname, pg_encoding_to_char(encoding), datcollate, datctype from pg_database;
Modify the database character set	RECRATE the database	• Export the database. • Drop or rename the database. • Re-create the database with the desired new character set. • Import database data from the exported file into the new database.
Character set granularity	Database	Database
UTF8	Supported	Supported
UTF16	Supported	Not Supported
NCHAR/NVARCHAR data types	Supported	Not Supported

For additional details, see https://www.postgresql.org/docs/13/static/multibyte.html

SQL Server Cursors vs. PostgreSQL Cursors

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Cursors	Different cursor options

SQL Server Usage

A *set* is a fundamental concept of the relation data model from which SQL is derived. SQL is a declarative language that operates on whole sets, unlike most procedural languages that operate on individual data elements. A single invocations of an SQL statements can return a whole set or modify millions of rows.

Many developers are accustomed to using procedural or imperative approaches to develop solutions that are difficult to implement using set-based querying techniques. Also, operating on row data sequentially may be a more appropriate approach in certain situations.

Cursors provide an alternative mechanism for operating on result sets. Instead of receiving a table object containing rows of data, applications can use cursors to access the data sequentially, row-by-row. Cursors provide the following capabilities:

- Positioning the cursor at specific rows of the result set using absolute or relative offsets.
- Retrieving a row, or a block of rows, from the current cursor position.
- Modifying data at the current cursor position.
- Isolating data modifications by concurrent transactions that affect the cursor's result.
- T-SQL statements can use cursors in scripts, stored procedures, and triggers.

Syntax

```
DECLARE <Cursor Name>
CURSOR [LOCAL | GLOBAL]
     [FORWARD_ONLY | SCROLL]
     [STATIC | KEYSET | DYNAMIC | FAST_FORWARD]
     [ READ_ONLY | SCROLL_LOCKS | OPTIMISTIC]
     [TYPE_WARNING]
     FOR <SELECT statement>
     [ FOR UPDATE [ OF <Column List>]][;]
```

```
FETCH [NEXT | PRIOR | FIRST | LAST | ABSOLUTE <Value> | RELATIVE <Value>]
FROM  <Cursor Name> INTO <Variable List>;
```

Examples

Process data in a cursor.

```
 DECLARE MyCursor CURSOR FOR
    SELECT *
    FROM Table1 AS T1
         INNER JOIN
         Table2 AS T2
         ON T1.Col1 = T2.Col1;
    OPEN MyCursor;
    DECLARE @VarCursor1 VARCHAR(20);
    FETCH NEXT
     FROM MyCursor INTO @VarCursor1;

    WHILE @@FETCH_STATUS = 0
```

```
    BEGIN
        EXEC MyPRocessingProcedure
             @InputParameter = @VarCursor1;
        FETCH NEXT
         FROM product_cursor INTO @VarCursor1;
    END

    CLOSE MyCursor;
    DEALLOCATE MyCursor ;
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/cursors?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/language-elements/cursors-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Similar to SQL Server's T-SQL Cursors, PostgreSQL has PL/pgSQL cursors that enable you to iterate business logic on rows read from the database. They can encapsulate the query and read the query results a few rows at a time. All access to cursors in PL/pgSQL is performed through cursor variables, which are always of the refcursor data type.

Examples

Declare a Cursor

DECLARE..CURSOR options that are Transact-SQL extended syntax have no equivalent in PostgreSQL and they are:

SQL Server's Option	Use	Comments
FORWARD_ ONLY	Defining that FETCH NEXT is the only supported fetching option	Using FOR LOOP might be a relevant solution for this option
STATIC	Cursor will make a temporary copy of the data	For small data sets temporary tables can be created and declare a cursor that will select these tables
KEYSET	Determining that membership and order of rows in the cursor are fixed	N/A
DYNAMIC	Cursor will reflect all data changes made on the selected rows	Default for PostgreSQL
FAST_ FORWARD	Will use FORWARD_ONLY and READ_ONLY for optimizing performance	N/A
SCROLL_ LOCKS	Determine that positioned updates or deletes made by the cursor are guaranteed to succeed	N/A
OPTIMISTIC	Determine that positioned updates or deletes made by the cursor will not succeed if the rows has been updated.	N/A

SQL Server's Option	Use	Comments
TYPE_ WARNING	Will send warning messages to the client if the cursor is implicitly converted from the requested type	N/A

Declare a Cursor in PL/pgSQL to be used with any query. The variable c1 is "unbounded" because it is not bound to any particular query.

```
DECLARE c1 refcursor;
```

Declare a Cursor in PL/pgSQL with a bounded query.

```
DECLARE c2 CURSOR FOR SELECT * FROM employees;
```

Declare a Cursor with a parametrized bound query:

- The id variable is replaced by an integer parameter value when the cursor is opened.
- When declaring a Cursor with SCROLL specified, the Cursor can scroll backwards.
- If NO SCROLL is specified, backward fetches are rejected.

```
DECLARE c3 CURSOR (var1 integer) FOR SELECT * FROM employees where id = var1;
```

Declare a backward-scrolling compatible Cursor using the SCROLL option.

- SCROLL specifies that rows can be retrieved backwards. NO SCROLL specifies that rows cannot be retrieved backwards.
- Depending upon the complexity of the execution plan for the query, SCROLL might create performance issues.
- Backward fetches are not allowed when the query includes FOR UPDATE or FOR SHARE.

```
DECLARE c3 SCROLL CURSOR FOR SELECT id, name FROM employees;
```

Open a Cursor

The OPEN command is fully compatible between SQL Server and PostgreSQL.

Open a Cursor variable that was declared as Unbound and specify the query to execute.

```
OPEN c1 FOR SELECT * FROM employees WHERE id = emp_id;
```

Open a Cursor variable that was declared as Unbound and specify the query to execute as a string expression. This approach provides greater flexibility.

```
OPEN c1 FOR EXECUTE format('SELECT * FROM %I WHERE col1 = $1',tabname) USING keyvalue;
```

Parameter values can be inserted into the dynamic command with format() and USING. For example, the table name is inserted into the query with format(). The comparison value for col1 is inserted with a USING parameter.

Open a Cursor that was bound to a query when the Cursor was declared and was declared to take arguments.

```
DO $$
DECLARE
        c3 CURSOR (var1 integer) FOR SELECT * FROM employees where id = var1;
```

```
BEGIN
        OPEN c3(var1 := 42);
END$$;
```

For the c3 Cursor, supply the argument value expressions.

If the Cursor was not declared to take arguments, the arguments can be specified outside the Cursor.

```
DO $$
DECLARE
         var1 integer;
         c3 CURSOR FOR SELECT * FROM employees where id = var1;
BEGIN
         var1 := 1;
         OPEN c3;
END$$;
```

Fetch a Cursor

Syntax

```
FETCH [ direction [ FROM | IN ] ] cursor_name
```

PostgreSQL has few more options as a *direction* for the FETCH command:

PostgreSQL's Option	Use
ALL	Get all remaining rows
FORWARD	Same as NEXT
FORWARD (n)	Fetch the next *n* rows
FORWARD ALL	Same as ALL
BACKWARD	Same as PRIOR
BACKWARD (n)	Fetch the prior *n* rows
BACKWARD ALL	Fetch all prior rows

The PL/pgSQL FETCH command retrieves the next row from the Cursor into a variable.

Fetch the values returned from the c3 Cursor into a row variable.

```
DO $$
DECLARE
      c3 CURSOR FOR SELECT * FROM employees;
      rowvar employees%ROWTYPE;
BEGIN
      OPEN c3;
      FETCH c3 INTO rowvar;
END$$;
```

Fetch the values returned from the c3 Cursor into two scalar data types.

```
DO $$
DECLARE
     c3 CURSOR FOR SELECT id, name FROM employees;
     emp_id integer;
     emp_name varchar;
BEGIN
     OPEN c3;
     FETCH FROM c3 INTO emp_id, emp_name;
END$$;
```

PL/pgSQL supports a special direction clause when fetching data from a Cursor using the NEXT, PRIOR, FIRST, LAST, ABSOLUTE count, RELATIVE count, FORWARD, or BACKWARD arguments. Omitting direction is equivalent to specifying NEXT. For example, fetch the last row from the Cursor into the declared variables.

```
DO $$
DECLARE
     c3 CURSOR FOR SELECT id, name  FROM employees;
     emp_id integer;
     emp_name varchar;
BEGIN
     OPEN c3;
     FETCH LAST FROM c3 INTO emp_id, emp_name;
END$$;
```

Summary

Feature	SQL Server	Aurora PostgreSQL
Cursor options	[FORWARD_ONLY | SCROLL] [STATIC | KEYSET | DYNAMIC | FAST_FORWARD] [READ_ONLY | SCROLL_LOCKS | OPTIMISTIC]	[BINARY] [INSENSITIVE] [[NO] SCROLL] CURSOR [{ WITH | WITHOUT } HOLD]
Updateable cursors	DECLARE CURSOR... FOR UPDATE	DECLARE cur_name CURSOR... FOR UPDATE
Cursor declaration	DECLARE CURSOR	DECLARE cur_name CURSOR
Cursor open	OPEN	OPEN
Cursor fetch	FETCH NEXT | PRIOR | FIRST | LAST | ABSOLUTE | RELATIVE	FETCH [direction [FROM | IN]] cursor_name where direction can be empty or one of: NEXT, PRIOR, FIRST, LAST, ABSOLUTE count, RELATIVE count, count , ALL FORWARD, FORWARD count, FORWARD ALL, BACKWARD, BACKWARD count, BACKWARD ALL
Cursor close	CLOSE	CLOSE
Cursor Deallocate	DEALLOCATE	Same effect as CLOSE (not required)

Feature	SQL Server	Aurora PostgreSQL
Cursor end condition	@@FETCH_STATUS system variable	Not Supported

For additional details, see https://www.postgresql.org/docs/13/static/sql-fetch.html

SQL Server Date and Time Functions vs. PostgreSQL Date and Time Functions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Date Time Functions	PostgreSQL is using different function names

SQL Server Usage

Date and Time Functions are scalar functions that perform operations on temporal or numeric input and return temporal or numeric values.

System date and time values are derived from the operating system of the server on which SQL Server is running.

> **Note:** This section does not address timezone considerations and timezone aware functions. For more information about time zone handling, see Data Types.

Syntax and Examples

The following table lists the most commonly used Date and Time Functions.

Function	Purpose	Example	Result	Comments
`GETDATE and GETUTCDATE`	Return a datetime value that contains the current local or UTC date and time	`SELECT GETDATE ()`	2018-04-05 15:53:01.380	
`DATEPART, DAY, MONTH, and YEAR`	Return an integer value representing the specified datepart of a specified date	`SELECT MONTH (GETDATE()), YEAR(GETDATE ())`	4, 2018	
`DATEDIFF`	Returns an integer value of datepart boundaries that are crossed between two dates	`SELECT DATEDIFF(DAY, GETDATE(), EOMONTH (GETDATE()))`	25	How many days left until end of the month
`DATEADD`	Returns a datetime value that is calculated with an offset interval to	`SELECT DATEADD (DAY, 25, GETDATE())`	2018-04-30 15:55:52.147	

Function	Purpose	Example	Result	Comments
	the specified datepart of a date.			
CAST and CONVERT	Converts datetime values to and from string literals and to and from other datetime formats	SELECT CAST (GETDATE() AS DATE) SELECT CONVERT (VARCHAR(20), GETDATE(), 112)	2018-04-05 20180405	Default date format Style 112 (ISO) with no seprartors

For more information, see
https://docs.microsoft.com/en-us/sql/t-sql/functions/date-and-time-data-types-and-functions-transact-sql?view=sql-server-ver15#DateandTimeFunctions

PostgreSQL Usage

Aurora PostgreSQL provides a very rich set of scalar date and time functions; more than SQL Server.

> **Note:** While some of the functions appear to be similar to those in SQL Server, the functionality can be significantly different. Take extra care when migrating temporal logic to Aurora PostgreSQL paradigms.

Functions and definition

PostgreSQL Function	Function Definition
AGE	Subtract from current_date
CLOCK_ TIMESTAMP	Current date and time
CURRENT_DATE	Current date
CURRENT_TIME	Current time of day
CURRENT_ TIMESTAMP	Current date and time (start of current transaction)
DATE_PART	Get subfield (equivalent to extract)
DATE_TRUNC	Truncate to specified precision
EXTRACT	Get subfield
ISFINITE	Test for finite interval
JUSTIFY_DAYS	Adjust interval so 30-day time periods are represented as months
JUSTIFY_HOURS	Adjust interval so 24-hour time periods are represented as days
JUSTIFY_ INTERVAL	Adjust interval using justify_days and justify_hours, with additional sign adjustments
LOCALTIME	Current time of day
MAKE_DATE	Create date from year, month and day fields

PostgreSQL Function	Function Definition
MAKE_INTERVAL	Create interval from years, months, weeks, days, hours, minutes and seconds fields
MAKE_TIME	Create time from hour, minute and seconds fields
MAKE_ TIMESTAMP	Create timestamp from year, month, day, hour, minute, and seconds fields
MAKE_ TIMESTAMPTZ	Create timestamp with time zone from year, month, day, hour, minute, and seconds fields. If timezone is not specified, the current time zone is used
NOW	Current date and time
STATEMENT_ TIMESTAMP	Current date and time
TIMEOFDAY	Current date and time (like clock_timestamp, but as a text string)
TRANSACTION_ TIMESTAMP	Current date and time
TO_TIMESTAMP	Convert Unix epoch (seconds since 1970-01-01 00:00:00+00) to timestamp

Summary

SQL Server Function	Aurora PostgerSQL Function
GETDATE, CURRENT_ TIMESTAMP	NOW, CURRENT_DATE, CURRENT_TIME, CURRENT_ TIMESTAMP
GETUTCDATE	current_timestamp at time zone 'utc'
DAY, MONTH, and YEAR	EXTRACT(DAY/MONTH/YEAR FROM TIMESTAMP timestamp_ value)
DATEPART	EXTRACT, DATE_PART
DATEDIFF	DATE_PART
DATEADD	+ INTERVAL 'X days/months/years'
CAST and CONVERT	CAST

For more information, see https://www.postgresql.org/docs/13/static/functions-datetime.html

SQL Server String Functions vs. PostgreSQL String Functions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Syntax and option differences

SQL Server Usage

String Functions are typically scalar functions that perform an operation on string input and return a string or a numeric value.

Syntax and Examples

The following table lists the most commonly used string functions.

Function	Purpose	Example	Result	Comments
ASCII and UNICODE	Convert an ASCII or UNICODE character to its ASCII or UNICODE code	SELECT ASCII ('A')	65	Returns a numeric integer value
CHAR and NCHAR	Convert between ASCII or UNICODE code to a string character	SELECT CHAR(65)	'A'	Numeric integer value as input
CHARINDEX and PATINDEX	Find the starting position of one string expression (or string pattern) within another string expression	SELECT CHARINDEX('ab', 'xabcdy')	2	Returns a numeric integer value
CONCAT and CONCAT_WS	Combine multiple string input expressions into a single string with, or without, a separator character (WS)	SELECT CONCAT ('a','b'), CONCAT_WS (',','a','b')	'ab', 'a,b'	
LEFT, RIGHT, and SUBSTRING	Return a partial string from another string expression based on position and length	SELECT LEFT ('abs',2), SUBSTRING ('abcd',2,2)	'ab', 'bc'	
LOWER and UPPER	Return a string with all characters in lower or upper case. Use for presentation or to handle case insensitive expressions	SELECT LOWER ('ABcd')	'abcd'	
LTRIM, RTRIM and TRIM	Remove leading and trailing spaces	SELECT LTRIM (' abc d ')	'abc d '	
STR	Convert a numeric value to a string	SELECT STR (3.1415927,5,3)	3.142	Numeric expressions as input
REVERSE	Return a string in reverse order	SELECT REVERSE ('abcd')	'dcba'	
REPLICATE	Return a string that consists of zero or more concatenated copies of	SELECT REPLICATE ('abc', 3)	'abcabcabc'	

Function	Purpose	Example	Result	Comments
	another string expression			
REPLACE	Replace all occurrences of a string expression with another	SELECT REPLACE ('abcd', 'bc', 'xy')	'axyd'	
STRING_SPLIT	Parse a list of values with a separator and return a set of all individual elements	SELECT * FROM STRING_ SPLIT('1,2', ',') AS X(C)	1 2	STRING_ SPLIT is a table valued function
STRING_AGG	Return a string that consists of concatenated string values in row groups	SELECT STRING_ AGG(C, ',') FROM VALUES(1, 'a'), (1, 'b'), (2,'c') AS X (ID,C) GROUP BY I	1 'ab' 2 'c'	STRING_ AGG is an aggregate function

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/functions/string-functions-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Most of SQL Server's String Functions are supported in PostgreSQL, there are few which are not:

- UNICODE - this function will return the integer value of the first character as defined by the Unicode standard, if you will use UTF8 input ASCII can be used in order to get the same results.
- PATINDEX - returns the starting position of the first occurrence of a pattern in a specified expression, or zeros if the pattern is not found, there is no equivalent function for that but you can create the same function with the same name so it will be fully compatible.

Some functions are not supported but they have an equivalent function in PostgreSQL that can be used in order to get the some functionality.

Some of the functions such as regular expressions do not exist in SQL Server and may be useful for your application.

Syntax and Examples

The following table lists the most commonly used string functions.

PostgreSQL Function	Function Definition
CONCAT	Concatenate the text representations of all the arguments: concat('a', 1) --> a1 Also, can use the (||) operators: select 'a' ||' '|| 'b' --> a b
LOWER / UPPER	Returns char, with all letters lowercase or uppercase: lower ('MR. Smith') --> mr. smith
LPAD / RPAD	Returns expr1, left or right padded to length n characters with the sequence of characters in expr2: LPAD('Log-1',10,'*') --> *****Log-1

PostgreSQL Function	Function Definition
REGEXP_ REPLACE	Replace substring(s) matching a POSIX regular expression: regexp_replace('John', '[hn].', '1') --> Jo1
REGEXP_ MATCHES OR SUBSTRING	Return all captured substrings resulting from matching a POSIX regular expression against the string: REGEXP_MATCHES ('http://www.aws.com/products', '(http://[[: alnum:]]+.*/)') --> {http://www.aws.com/} OR SUBSTRING ('http://www.aws.com/products', '(http://[[: alnum:]]+.*/)') --> http://www.aws.com/
REPLACE	Returns char with every occurrence of search string replaced with a replacement string: replace ('abcdef', 'abc', '123') --> 123def
LTRIM / RTRIM	Remove the longest string containing only characters from characters (a space by default) from the start of string: ltrim('zzzyaws', 'xyz') --> aws
SUBSTRING	Extract substring: substring ('John Smith', 6 ,1) --> S
TRIM	Remove the longest string containing only characters from characters (a space by default) from the start, end, or both ends: trim (both from 'yxJohnxx', 'xyz') --> John
ASCII	Returns the decimal representation in the database character set of the first character of char: ascii('a') --> 97
LENGTH	Return the length of char: length ('John S.') --> 7

In order to create the PATINDEX function, you should use the code snippet below, note the 0 means that the expression does not exist so the first position will be 1:

```
CREATE OR REPLACE FUNCTION "patindex"( "pattern" VARCHAR, "expression" VARCHAR )
RETURNS INT AS $BODY$
SELECT COALESCE(STRPOS($2,(
  SELECT(REGEXP_MATCHES($2,'(' ||
     REPLACE( REPLACE(TRIM( $1, '%' ), '%', '.*?' ), '_', '.' )
         || ')','i') )[ 1 ] LIMIT 1)),0);
$BODY$ LANGUAGE 'sql' IMMUTABLE;

SELECT patindex( 'Lo%', 'Long String' );

patindex |
---------|
1        |

SELECT patindex( '%rin%', 'Long String' );

patindex |
---------|
8        |

SELECT patindex( '%g_S%', 'Long String' );

patindex |
```

```
---------|
4        |
```

Summary

SQL Server function	Aurora PostgreSQL equivalent function
ASCII	ASCII
UNICODE	For UTF8 inputs only ASCII can be used
CHAR and NCHAR	CHR
CHARINDEX	POSITION
PATINDEX	see examples
CONCAT and CONCAT_WS	CONCAT and CONCAT_WS
LEFT, RIGHT, and SUBSTRING	LEFT, RIGHT, and SUBSTRING
LOWER and UPPER	LOWER and UPPER
LTRIM, RTRIM and TRIM	LTRIM, RTRIM and TRIM
STR	TO_CHAR
REVERSE	REVERSE
REPLICATE	LPAD
REPLACE	REPLACE
STRING_SPLIT	regexp_split_to_array or regexp_split_to_table
STRING_AGG	CONCAT_WS

For more information, see https://www.postgresql.org/docs/13/static/functions-string.html

SQL Server Databases and Schemas vs. PostgreSQL Databases and Schemas

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	

SQL Server Usage

Databases and Schemas are logical containers for security and access control. Administrators can grant permissions collectively at both the databases and the schema levels. SQL Server instances provide security at three levels: Individual Objects, Schemas (collections of objects), and Databases (collections of schemas). For more information, see Data Control Language.

> **Note:** In previous versions of SQL server, the term *user* was interchangeable with the term *schema*. For backward compatibility, each database has several built-in security schemas including guest, dbo,

db_datareaded, sys, INFORMATION_SCHEMA, and others. You most likely will not need to migrate these schemas.

Each SQL Server instance can host and manage a collection of databases, which consists of SQL Server processes and the Master, Model, TempDB, and MSDB system databases.

The most common SQL Server administrator tasks at the database level are:

- Managing Physical Files: Add, remove, change file growth settings, and re-size files.
- Managing Filegroups: Partition schemes, object distribution, and read-only protection of tables.
- Managing default options.
- Creating database snapshots.

Unique object identifiers within an instance use three-part identifiers: <Database name>.<Schema name>.<Object name>.

The recommended way to view database object meta data, including schemas, is to use the ANSI standard Information Schema views. In most cases, these views are compatible with other ANSI compliant Relational Database Management Systems (RDBMS).

To view a list of all databases on the server, use the sys.databases table.

Syntax

Simplified syntax for CREATE DATABASE:

```
CREATE DATABASE <database name>
[ ON [ PRIMARY ] <file specifications>[,<filegroup>]
[ LOG ON <file specifications>
[ WITH  <options specification> ] ;
```

Simplified syntax for CREATE SCHEMA:

```
CREATE SCHEMA <schema name> | AUTHORIZATION <owner name>;
```

Examples

Add a file to a database and create a table using the new file.

```
USE master;
```

```
ALTER DATABASE NewDB
ADD FILEGROUP NewGroup;
```

```
ALTER DATABASE NewDB
ADD FILE (
          NAME = 'NewFile',
          FILENAME = 'D:\NewFile.ndf',
          SIZE = 2 MB
         )
TO FILEGROUP NewGroup;
```

```
USE NewDB;
```

```
CREATE TABLE NewTable
(
Col1 INT PRIMARY KEY
)
ON NewGroup;
```

```
SELECT Name
FROM sys.databases
WHERE database_id > 4;
```

Create a table within a new schema and database.

```
USE master
CREATE DATABASE NewDB;

USE NewDB;
CREATE SCHEMA NewSchema;

CREATE TABLE NewSchema.NewTable
(
NewColumn VARCHAR(20) NOT NULL PRIMARY KEY
);
```

Note: This example uses default settings for the new database and schema.

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/system-catalog-views/sys-databases-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-schema-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-database-sql-server-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL supports both the CREATE SCHEMA and CREATE DATABASE statements.

As with SQL Server, Aurora PostgreSQL does have the concept of an instance hosting multiple databases, which in turn contain multiple schemas. Objects in Aurora PostgreSQL are referenced as a three part name: <database>.<schema>.<object>.

A schema is essentially a namespace that contains named objects.

When database is created, it is cloned from a template.

Syntax

Syntax for CREATE DATABASE:

```
CREATE DATABASE name
    [ [ WITH ] [ OWNER [=] user_name ]
           [ TEMPLATE [=] template ]
```

```
            [ ENCODING [=] encoding ]
            [ LC_COLLATE [=] lc_collate ]
            [ LC_CTYPE [=] lc_ctype ]
            [ TABLESPACE [=] tablespace_name ]
            [ ALLOW_CONNECTIONS [=] allowconn ]
            [ CONNECTION LIMIT [=] connlimit ]
            [ IS_TEMPLATE [=] istemplate ] ]
```

Syntax for CREATE SCHEMA:

```
CREATE SCHEMA schema_name [ AUTHORIZATION role_specification ] [ schema_element [ ...
] ]
CREATE SCHEMA AUTHORIZATION role_specification [ schema_element [ ... ] ]
CREATE SCHEMA IF NOT EXISTS schema_name [ AUTHORIZATION role_specification ]
CREATE SCHEMA IF NOT EXISTS AUTHORIZATION role_specification

where role_specification can be:

    user_name
  | CURRENT_USER
  | SESSION_USER
```

Migration Considerations

Unlike SQL Server, Aurora PostgreSQL does not support the USE command to specify the default database (schema) for missing object qualifiers. To use a different database, you must use a new connection, have the required permissions, and refer to the object using the database name.

For applications using a single database and multiple schemas, the migration path is the same and requires fewer rewrites because two-part names are already being used.

Query the postgres.pg_catalog.pg_database table to view databases in Aurora PostgreSQL.

```
SELECT datname, datcollate, datistemplate, datallowconn
FROM postgres.pg_catalog.pg_database;

datname   |datcollate  |datistemplate |datallowconn |
----------|------------|--------------|-------------|
template0 |en_US.UTF-8 |true          |false        |
rdsadmin  |en_US.UTF-8 |false         |true         |
template1 |en_US.UTF-8 |true          |true         |
postgres  |en_US.UTF-8 |false         |true         |
```

Examples

Create a new database.

```
CREATE DATABASE NewDatabase;
```

Create a schema for user testing.

```
CREATE SCHEMA AUTHORIZATION joe;
```

Create a schema, a table and a view.

```
CREATE SCHEMA world_flights
    CREATE TABLE flights (flight_id VARCHAR(10), departure DATE, airport VARCHAR(30))
    CREATE VIEW us_flights AS
        SELECT flight_id, departure FROM flights WHERE airport='United States';
```

For more information, see:

- *https://www.postgresql.org/docs/13/static/sql-createdatabase.html*
- *https://www.postgresql.org/docs/13/static/sql-createschema.html*

SQL Server Dynamic SQL vs. PostgreSQL EXECUTE and PREPARE

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Different paradigm and syntax will require rewriting the application

SQL Server Usage

Dynamic SQL is a feature that helps minimize hard-coded SQL. The SQL Engine optimizes code, which leads to less "hard" parses.

Dynamic SQL allows developers to construct and execute SQL queries at run time as a string, using some logic in SQL to construct varying query strings, without having to pre-construct them during development.

There are two options for running Dynamic SQL: use the EXECUTE command or the sp_executesql function.

EXECUTE Command

This option enables executing a command string within a T-SQL block, procedure, or function. The EXECUTE command can also be used with linked servers. Meta-data for the result set can be defined by using the WITH RESULT SETS options.

For parameters, use either the value or @parameter_name=value.

> **Note:** It's important to validate the structure of the string command before running it with the EXECUTE statement

Syntax

```
-- Syntax for SQL Server

Execute a stored procedure or function
[ { EXEC | EXECUTE } ]
    {
```

```
      [ @return_status = ]
      { module_name [ ;number ] | @module_name_var }
        [ [ @parameter = ] { value
                           | @variable [ OUTPUT ]
                           | [ DEFAULT ]
                           }
        ]
      [ ,...n ]
      [ WITH <execute_option> [ ,...n ] ]
    }
[;]

Execute a character string
{ EXEC | EXECUTE }
    ( { @string_variable | [ N ]'tsql_string' } [ + ...n ] )
    [ AS { LOGIN | USER } = ' name ' ]
[;]

Execute a pass-through command against a linked server
{ EXEC | EXECUTE }
    ( { @string_variable | [ N ] 'command_string [ ? ]' } [ + ...n ]
        [ { , { value | @variable [ OUTPUT ] } } [ ...n ] ]
    )
    [ AS { LOGIN | USER } = ' name ' ]
    [ AT linked_server_name ]
[;]

<execute_option>::=
{
        RECOMPILE
    | { RESULT SETS UNDEFINED }
    | { RESULT SETS NONE }
    | { RESULT SETS ( <result_sets_definition> [,...n ] ) }
}

<result_sets_definition> ::=
{
    (
         { column_name
           data_type
         [ COLLATE collation_name ]
         [ NULL | NOT NULL ] }
         [,...n ]
    )
    | AS OBJECT
        [ db_name . [ schema_name ] . | schema_name . ]
        {table_name | view_name | table_valued_function_name }
    | AS TYPE [ schema_name.]table_type_name
    | AS FOR XML
}
```

Example

EXECUTE a 'tsql_string' with a variable.

```
DECLARE @scm_name sysname;
DECLARE @tbl_name sysname;
EXECUTE ('DROP TABLE ' + @scm_name + '.' + @tbl_name + ';');
```

Use EXECUTE AS USER to switch context to another user.

```
DECLARE @scm_name sysname;
DECLARE @tbl_name sysname;
EXECUTE ('DROP TABLE ' + @scm_name + '.' + @tbl_name + ';') AS USER = 'SchemasAdmin';
```

Use EXECUTE with a result set.

```
EXEC GetMaxSalByDeptID 23
WITH RESULT SETS
(
   ([Salary] int NOT NULL)
);
```

sp_executesql system stored procedure

This option executes a T-SQL command or block that can be executed several times and built dynamically. It also can be used with embedded parameters.

Syntax

```
-- Syntax for SQL Server, Azure SQL Database, Azure SQL Data Warehouse, Parallel Data
Warehouse

sp_executesql [ @stmt = ] statement
[
  { , [ @params = ] N'@parameter_name data_type [ OUT | OUTPUT ][ ,...n ]' }
     { , [ @param1 = ] 'value1' [ ,...n ] }
]
```

Examples

Executing a SELECT statement.

```
EXECUTE sp_executesql
          N'SELECT * FROM HR.Employees
          WHERE DeptID = @DID',
          N'@DID int',
          @DID = 23;
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/system-stored-procedures/sp-executesql-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/language-elements/execute-transact-sql?view=sql-server-ver15*

PostgreSQL Overview

EXECUTE

The PostgreSQL EXECUTE command prepares and executes commands dynamically. The EXECUTE command can also run DDL statements and retrieve data using SQL commands. Similar to SQL Server, the PostgreSQL EXECUTE command can be used with bind variables.

Note that Converting SQL Server Dynamic SQL to PostgreSQL requires significant effort.

Examples

Execute a SQL SELECT query with the table name as a dynamic variable using bind variables. This query returns the number of employees under a manager with a specific ID.

```
DO $$DECLARE
Tabname  varchar(30) := 'employees';
num             integer := 1;
cnt             integer;
BEGIN
EXECUTE format('SELECT count(*) FROM %I WHERE manager = $1', tabname)
INTO cnt USING num;
RAISE NOTICE 'Count is % int table %', cnt, tabname;
END$$;
;
```

Execute a DML command; first with no variables and then with variables.

```
DO $$DECLARE
BEGIN
EXECUTE 'INSERT INTO numbers (a) VALUES (1)';
EXECUTE format('INSERT INTO numbers (a) VALUES (%s)', 42);
END$$;
;
```

> **Note:** %s formats the argument value as a simple string. A null value is treated as an empty string. %I treats the argument value as an SQL identifier and double-quotes it if necessary. It is an error for the value to be null.

Execute a DDL command.

```
DO $$DECLARE
BEGIN
EXECUTE 'CREATE TABLE numbers (num integer)';
END$$;
;
```

For additional details, see https://www.postgresql.org/docs/13/static/functions-string.html

PREPARE

Using a PREPARE statement can improve performance of reusable SQL statements.

The PREPARE command can receive a SELECT, INSERT, UPDATE, DELETE, or VALUES statement and parse it with a user-specified qualifying name so the EXECUTE command can be used later without the need to re-parse the SQL statement for each execution.

- When using PREPARE to create a prepared statement, it will be viable for the scope of the current session.
- If a DDL command is executed on a database object referenced by the prepared SQL statement, the next EXECUTE command requires a hard parse of the SQL statement.

Example

Use PREPARE and EXECUTE commands in tandem: The SQL command is prepared with a user-specified qualifying name.The SQL command is executed several times, without the need for re-parsing.

```
PREPARE numplan (int, text, bool) AS
INSERT INTO numbers VALUES($1, $2, $3);

EXECUTE numplan(100, 'New number 100', 't');
EXECUTE numplan(101, 'New number 101', 't');
EXECUTE numplan(102, 'New number 102', 'f');
EXECUTE numplan(103, 'New number 103', 't');
```

Summary

Functionality	SQL Server - Dynamic SQL	PostgerSQL- EXECUTE & PREPARE
Execute SQL with results and bind variables	DECLARE @sal int; EXECUTE getSalary @sal OUTPUT;	EXECUTE format('select salary from employees WHERE %I = $1', col_name) INTO amount USING col_val;
Execute DML with variables and bind variables	DECLARE @amount int DECLARE @col_val int DECLARE @col_name carchar(70) DECLARE @sqlCommand varchar (1000) SET @sqlCommand = 'UPDATE employees SET salary=salary' + @amount + ' WHERE ' + @col_name + '=' + @col_val EXECUTE (@sqlCommand)	EXECUTE format('UPDATE employees SET salary = salary + $1 WHERE %I = $2', col_name) USING amount, col_val;
Execute DDL	EXECUTE ('CREATE TABLE link_emp (idemp1 integer, idemp2 integer);');	EXECUTE 'CREATE TABLE link_emp (idemp1 integer, idemp2 integer)';
Execute Anonymous block	BEGIN ... END;	DO $$DECLARE BEGIN ... END$$;

For additional details, see https://www.postgresql.org/docs/13/static/plpgsql-statements.html

SQL Server Transactions vs. PostgreSQL Transactions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Transactions	Nested transactions are not supported and syntax differences for initializing a transaction

SQL Server Usage

A Transaction is a unit of work performed on a database and typically represents a change in the database. Transactions serve the following purposes:

- Provide units of work that enable recovery from logical or physical system failures while keeping the database in a consistent state.
- Provide units of work that enable recovery from failures while keeping a database in a consistent state when a logical or physical system failure occurs.
- Provide isolation between users and programs accessing a database concurrently.

Transactions are an "all-or-nothing" unit of work. Each transactional unit of work must either complete, or it must rollback all data changes. Also, transactions must be isolated from other transactions. The results of the "view of data" for each transaction must conform to the defined database isolation level.

Database transactions must comply with ACID properties:

- **Atomic:** Transactions are "all or nothing". If any part of the transaction fails, the entire transaction fails and the database remains unchanged.

  Note: There are exceptions to this rule. For example, some constraint violations, per ANSI definitions, should not cause a transaction rollback.

- **Consistent:** All transactions must bring the database from one valid state to another valid state. Data must be valid according to all defined rules, constraints, triggers, etc.
- **Isolation:** Concurrent execution of transactions must result in a system state that would occur if transactions were executed sequentially.

  Note: There are several exceptions to this rule based on the lenience of the required isolation level.

- **Durable:** After a transaction commits successfully and is acknowledged to the client, the engine must guarantee that its changes are persisted in the event of power loss, system crashes, or any other errors.

  Note: By default, SQL Server uses the "auto commit" (also known as "implicit transactions") mode set to ON. Every statement is treated as a transaction on its own unless a transaction was explicitly defined. This behavior is different than other engines like Oracle where, by default, every DML requires an explicit COMMIT statement to be persisted.

Syntax

Simplified syntax for the commands defining transaction boundaries:

Define the beginning of a transaction.

```
BEGIN  TRAN | TRANSACTION  [<transaction name>]
```

Committing work and the end of a transaction.

```
COMMIT WORK | [ TRAN | TRANSACTION [<transaction name>]]
```

Rollback work at the end of a transaction.

```
ROLLBACK WORK | [ TRAN | TRANSACTION [<transaction name>]]
```

SQL Server supports the standard ANSI isolation levels defined by the ANSI/ISO SQL standard (SQL92):

> **Note:** Each level provides a different approach for managing the concurrent execution of transactions. The main purpose of a transaction isolation level is to manage the visibility of changed data as seen by other running transactions. Additionally, when concurrent transactions access the same data, the level of transaction isolation affects the way they interact with each other.

- **Read Uncommitted:** A current transaction can see uncommitted data from other transactions. If a transaction performs a rollback, all data is restored to its previous state.
- **Read Committed:** A transaction only sees data changes that were committed. Therefore, dirty reads are not possible. However, after issuing a commit, it would be visible to the current transaction (while it's still in a running state).
- **Repeatable Read:** A transaction sees data changes made by the other transactions only after both transactions issue a commit or are rolled back.
- **Serializable:** This isolation level is the strictest because it does not permit transaction overwrites of another transaction's actions. Concurrent execution of a set of serializable transactions is guaranteed to produce the same effect as running them sequentially in the same order.

The main difference between isolation levels is the phenomena they prevent from appearing. The three preventable phenomena are:

- **Dirty Reads:** A transaction can read data written by another transaction but not yet committed.
- **Non-Repeatable (fuzzy) Reads:** When reading the same data several times, a transaction can find the data has been modified by another transaction that has just committed. The same query executed twice can return different values for the same rows.
- **Phantom (ghost) Reads:** Similar to a non-repeatable read, but it is related to new data created by another transaction. The same query executed twice can return different numbers of records.

The following table summarizes the four ANSI/ISO SQL standard (SQL92) isolation levels and indicates which phenomena are allowed (√) or disallowed (X).

Transaction Isolation Level	Dirty Reads	Non Repeatable Reads	Phantom Reads
Read Uncommitted	√	√	√
Read Committed	X	√	√
Repeatable Read	X	X	√

Transaction Isolation Level	Dirty Reads	Non Repeatable Reads	Phantom Reads
Serializable	X	X	X

There are two common implementations for transaction isolation:

- **Pessimistic Isolation (Locking):** Resources accessed by a transaction are locked for the duration of the transaction. Depending on the operation, resource, and transaction isolation level, other transactions can "see" changes made by the locking transaction, or they must wait for it to complete. With this mechanism, there is only one copy of the data for all transactions, which minimizes memory and disk resource consumption at the expense of transaction lock waits.
- **Optimistic Isolation (MVCC):** Every transaction owns a set of the versions of the resources (typically rows) that it accessed. In this mode, transactions don't have to wait for one another at the expense of increased memory and disk utilization. In this isolation mechanism, there is a chance that conflicts will arise when transactions attempt to commit. In case of a conflict, the application needs to be able to handle the rollback, and attempt a retry.

SQL Server implements both mechanisms; they can be used concurrently.

For Optimistic Isolation, SQL Server introduced two additional isolation levels: Read Committed Snapshot and Snapshot. For more details see the links at end of this section.

Set the transaction isolation level using SET command. It affects the current execution scope only.

```
SET TRANSACTION ISOLATION LEVEL { READ UNCOMMITTED | READ COMMITTED | REPEATABLE READ
| SNAPSHOT | SERIALIZABLE }
```

Examples

Execute two DML statements within a serializable transaction.

```
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;
BEGIN TRANSACTION;
INSERT INTO Table1
VALUES (1, 'A');
UPDATE Table2
 SET Column1 = 'Done'
WHERE KeyColumn = 1;
COMMIT TRANSACTION;
```

For more information, see
https://docs.microsoft.com/en-us/sql/odbc/reference/develop-app/transaction-isolation-levels?view=sql-server-ver15 and
https://docs.microsoft.com/en-us/sql/t-sql/statements/set-transaction-isolation-level-transact-sql?view=sql-server-ver15

PostgreSQL Usage

As with SQL Server, the same ANSI/ISO SQL (SQL92) isolation levels apply to PostgreSQL, but with several similarities and some differences.

Isolation Level	Dirty Reads	Non-Repeatable Reads	Phantom Reads
Read Uncom-	Permitted but not imple-	Permitted	Permitted

Isolation Level	Dirty Reads	Non-Repeatable Reads	Phantom Reads
mitted	mented in PostgreSQL		
Read Committed	Not permitted	Permitted	Permitted
Repeatable Read	Not permitted	Not permitted	Permitted but not implemented in PostgreSQL
Serializable	Not permitted	Not permitted	Not permitted

PostgreSQL technically supports the use of any of the above four transaction isolation levels, but only three can practically be used. The Read-Uncommitted isolation level serves as Read-Committed.

The way the Repeatable-Read isolation-level is implemented does not allow for phantom reads, which is similar to the Serializable isolation-level. The primary difference between Repeatable-Read and Serializable is that Serializable guarantees that the result of concurrent transactions are precisely the same as if they were executed serially, which is not always true for Repeatable-Reads.

Starting with PostgreSQL 12 option AND CHAIN can be added to COMMIT or ROLLBACK commands to immediately start another transaction with the same parameters as preceding transaction.

Multiversion Concurrency Control (MVCC)

In PostgreSQL, the MVCC mechanism allows transactions to work with a consistent snapshot of data ignoring changes made by other transactions that have not yet committed or rolled back. Each transaction “sees” a snapshot of accessed data accurate to its execution start time regardless of what other transactions are doing concurrently.

Isolation Levels

PostgreSQL supports the Read-Committed, Repeatable-Reads, and Serializable isolation levels. Read-Committed is the default isolation level.

- **Read-Committed:** The default PostgreSQL transaction isolation level. It prevents sessions from “seeing” data from concurrent transactions until it is committed. Dirty reads are not permitted.
- **Repeatable-Read:** Queries can only see rows committed before the first query or DML statement was executed in the transaction.
- **Serializable:** Provides the strictest transaction isolation level. The Serializable isolation level assures that the result of the concurrent transactions will be the same as if they were executed serially. This is not always the case for the Repeatable-Read isolation level.

Setting Isolation Levels in Aurora PostgreSQL

Isolation levels can be configured at several levels:

- Session level
- Transaction level
- Instance level using Aurora “Parameter Groups”.

Syntax

```
SET TRANSACTION transaction_mode [...]
SET TRANSACTION SNAPSHOT snapshot_id
SET SESSION CHARACTERISTICS AS TRANSACTION transaction_mode [...]

where transaction_mode is one of:

ISOLATION LEVEL {
SERIALIZABLE | REPEATABLE READ | READ COMMITTED | READ UNCOMMITTED
}
READ WRITE | READ ONLY [ NOT ] DEFERRABLE
```

Examples

Configure the isolation level for a specific transaction.

```
SET TRANSACTION ISOLATION LEVEL READ COMMITTED;
SET TRANSACTION ISOLATION LEVEL REPEATABLE READ;
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;
```

Configure the isolation level for a specific session.

```
SET SESSION CHARACTERISTICS AS TRANSACTION ISOLATION LEVEL READ COMMITTED;
SET SESSION CHARACTERISTICS AS TRANSACTION ISOLATION LEVEL REPEATABLE READ;
```

View the current isolation level.

```
SELECT CURRENT_SETTING('TRANSACTION_ISOLATION'); -- Session
SHOW DEFAULT_TRANSACTION_ISOLATION;              -- Instance
```

Modifying instance-level parameters for Aurora PostgreSQL is done using “Parameter Groups”. For example altering the default_transaction_isolation parameter using the AWS Console or the AWS CLI.

For additional details, see: http://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_WorkingWithParamGroups.html#USER_WorkingWithParamGroups.Modifying

Comparison table of relevant database features related to transactions

Database Feature	SQL Server	PostgreSQL
AutoCommit	Off	Depends Autocommit is turned off by default, however, some client tools like psql and more are setting this to ON by default. Check your client tool defaults or run the following command to check current configuration in psql:

Database Feature	SQL Server	PostgreSQL
		`\echo :AUTOCOMMIT`
MVCC	Yes	Yes
Default Isolation Level	Read Committed	Read Committed
Supported Isolation Levels	REPEATABLE READ | READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE	Repeatable Reads Serializable Read-only
Configure Session Isolation Levels	Yes	Yes
Configure Transaction Isolation Levels	Yes	Yes

Read-Committed Isolation Level

TX1	TX2	Comment
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	select employee_id, salary from EMPLOYEES where employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	Same results returned from both sessions
begin; UPDATE employees SET salary=27000 WHERE employee_id=100;	begin; set transaction isolation level read committed;	**TX1** starts a transaction; performs an update. **TX2** starts a transaction with read-committed isolation level
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 27000.00	SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	**TX1** will “see” the modified results (27000.00) while **TX2** “sees” the original data (24000.00)
	UPDATE employees SET salary=29000 WHERE employee_id=100;	Waits as **TX2** is blocked by **TX1**
Commit;		**TX1** issues a commit, and the lock is released
	Commit;	**TX2** issues a commit
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------+----------	SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+----------	Both queries return the value - 29000.00

TX1	TX2	Comment
100 | 29000.00	100 | 29000.00	

Serializable Isolation Level

TX1	TX2	Comment
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	Same results returned from both sessions
begin; UPDATE employees SET salary=27000 WHERE employee_id=100;	begin; set transaction isolation level serializable;	**TX1** starts a transaction; performs an update. **TX2** starts a transaction with isolation level of read committed
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 27000.00	SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 24000.00	**TX1** will "see" the modified results (27000.00) while **TX2** "sees" the original data (24000.00)
	update employees set salary=29000 where employee_id=100;	Waits as **TX2** is blocked by **TX1**
Commit;		**TX1** issues a commit, and the lock is released
	ERROR: could not serialize access due to concurrent update	**TX2** received an error message
	Commit; ROLLBACK	**TX2** trying to issue a commit but receives a rollback message, the transaction failed due to the serializable isolation level
SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 27000.00	SELECT employee_id, salary FROM EMPLOYEES WHERE employee_id=100; employee_id | salary ------------------+---------- 100 | 27000.00	Both queries will return the data updated according to **TX1**

Summary

The following table summarizes the key differences in transaction support and syntax when migrating from SQL Server to Aurora PostgreSQL.

Transaction Property	SQL Server	Aurora PostgreSQL
Default isolation level	READ COMMITTED	READ COMMITED
initialize transaction syntax	BEGIN TRAN|TRANSACTION	SET TRANSACTION
Default isolation mechanism	Pessimistic lock based	Lock based for writes, consistent read for SELECTs
Commit transaction	COMMIT [WORK|TRAN|TRANSACTION]	COMMIT [WORK | TRANSACTION]
Rollback transaction	ROLLBACK [WORK |[TRAN | TRANSACTION]	ROLLBACK [WORK | TRANSACTION]
Set autocommit off/on	SET IMPLICIT_ TRANSACTIONS OFF | ON	SET AUTOCOMMIT { = | TO } { ON | OFF }
ANSI Isolation	REPEATABLE READ | READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE	REPEATABLE READ | READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE
MVCC	SNAPSHOT and READ COMMITTED SNAPSHOT	READ COMMITTED SNAPSHOT
Nested transactions	Supported, view level with @@trancount	Not Supported

For additional details, see:

- *https://www.postgresql.org/docs/13/static/tutorial-transactions.html*
- *https://www.postgresql.org/docs/13/static/transaction-iso.html*
- *https://www.postgresql.org/docs/13/static/sql-set-transaction.html*

SQL Server Synonyms vs. PostgreSQL Views, Types & Functions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	PostgreSQL does not support Synony - there is an available workaround

SQL Server Usage

Synonyms are database objects that serve as alternative identifiers for other database objects. The referenced database object is called the 'base object' and may reside in the same database, another database on the same instance, or a remote server.

Synonyms provide an abstraction layer to isolate client application code from changes to the name or location of the base object.

In SQL Server, Synonyms are often used to simplify the use of four-part identifiers when accessing remote instances.

For Example, table A resides on Server A, and the client application accesses it directly. For scale out reasons, Table A needs to be moved to server B to offload resource consumption on Server A. Without synonyms, the client application code must be rewritten to access Server B. Instead, you can create a synonym called Table A and it will transparently redirect the calling application to Server B without any code changes.

Synonyms can be created for the following objects:

- Assembly (CLR) stored procedures, table-valued functions, scalar functions, and aggregate functions
- Replication-filter-procedures
- Extended stored procedures
- SQL scalar functions, table-valued functions, inline-tabled-valued functions, views, and stored procedures
- User defined tables including local and global temporary tables

Syntax

```
CREATE SYNONYM [ <Synonym Schema> ] . <Synonym Name>
FOR [ <Server Name> ] . [ <Database Name> ] . [ Schema Name> ] . <Object Name>
```

Examples

Create a synonym for a local object in a separate database.

```
CREATE TABLE DB1.Schema1.MyTable
(
KeyColumn INT IDENTITY PRIMARY KEY,
DataColumn VARCHAR(20) NOT NULL
);

USE DB2;
CREATE SYNONYM Schema2.MyTable
FOR DB1.Schema1.MyTable
```

Create a synonym for a remote object.

```
-- On ServerA
CREATE TABLE DB1.Schema1.MyTable
(
 KeyColumn INT IDENTITY PRIMARY KEY,
DataColumn VARCHAR(20) NOT NULL
);

-- On Server B
```

```
USE DB2;
CREATE SYNONYM Schema2.MyTable
FOR ServerA.DB1.Schema1.MyTable;
```

Note: This example assumes a linked server named ServerA exists on Server B that points to Server A.

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/create-synonym-transact-sql?view=sql-server-ver15

PostgreSQL Usage

SQL Server's Synonym often being used to give another name for an object, PostgreSQL does not provide a feature comparable to SQL Server Synonyms. However, you can achieve similar functionality by using a few PostgreSQL objects.

This lack of functionality will add a manual dimension to migration process wherever SQL Server Synonyms are involved. The user using these objects must have privileges on the base object and relevant PostgreSQL options should be used.

Example

In order to create a Synonym of a table in PostgreSQL, views should be used.

The first step is to create a table that will be used as the base object, and on top of it, a view that will be used as Synonym.

```
CREATE TABLE DB1.Schema1.MyTable
(
KeyColumn NUMERIC PRIMARY KEY,
DataColumn VARCHAR(20) NOT NULL
);

CREATE VIEW DB2.Schema2.MyTable_Syn
AS SELECT * FROM DB1.Schema1.MyTable
```

For more information see: Views

In order to create a Synonym of a User Defined Type in PostgreSQL, another User-Defined-Type should be used to wrap the source Type.

The first step is to create the User-Defined-Type that will be used as the base object, and on top of it, a User-Defined-Type that will be used as the Synonym.

```
CREATE TYPE DB1.Schema1.MyType AS (
ID NUMERIC,
name CHARACTER VARYING(100));

CREATE TYPE DB2.Schema2.MyType_Syn AS (
udt DB1.Schema1.MyT);
```

For more information see: User Define Types

In order to create a Synonym for a function in PostgreSQL, another Function should be used to wrap the source Type.

As before, the first step is to create the Function that will the used as the base object, and on top of it, a Function that will be used as the Synonym.

```
CREATE OR REPLACE FUNCTION DB1.Schema1.MyFunc (P_NUM NUMERIC)
RETURNS numeric AS $$
begin
       RETURN P_NUM * 2;
END; $$
LANGUAGE PLPGSQL;

CREATE OR REPLACE FUNCTION DB2.Schema2.MyFunc_Syn (P_NUM NUMERIC)
RETURNS numeric AS $$
begin
       RETURN DB1.Schema1.MyFunc(P_NUM);
END; $$
LANGUAGE PLPGSQL;
```

For more information see: User Define Function

SQL Server DELETE and UPDATE FROM vs. PostgreSQL DELETE and UPDATE FROM

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	DELETE...FROM from_list is not supported - rewrite to use subqueries

SQL Server Usage

SQL Server supports an extension to the ANSI standard that allows using an additional FROM clause in UPDATE and DELETE statements.

This additional FROM clause can be used to limit the number of modified rows by joining the table being updated, or deleted from, to one or more other tables. This functionality is similar to using a WHERE clause with a derived table sub-query. For UPDATE, you can use this syntax to set multiple column values simultaneously without repeating the sub-query for every column.

However, these statements can introduce logical inconsistencies if a row in an updated table is matched to more than one row in a joined table. The current implementation chooses an arbitrary value from the set of potential values and is non-deterministic.

Syntax

```
UPDATE <Table Name>
SET <Column Name> = <Expression> ,...
FROM <Table Source>
WHERE <Filter Predicate>;
```

```
DELETE FROM <Table Name>
FROM <Table Source>
WHERE <Filter Predicate>;
```

Examples

Delete customers with no orders.

```
CREATE TABLE Customers
(
Customer VARCHAR(20) PRIMARY KEY
);
```

```
INSERT INTO Customers
VALUES
('John'),
('Jim'),
('Jack')
```

```
CREATE TABLE Orders
(
OrderID INT NOT NULL PRIMARY KEY,
Customer VARCHAR(20) NOT NULL,
OrderDate DATE NOT NULL
);
```

```
INSERT INTO Orders (OrderID, Customer, OrderDate)
VALUES
(1, 'Jim', '20180401'),
(2, 'Jack', '20180402');
```

```
DELETE FROM Customers
FROM   Customers AS C
       LEFT OUTER JOIN
       Orders AS O
       ON O.Customer = C.Customer
WHERE  O.OrderID IS NULL;
```

```
SELECT *
FROM Customers;
```

```
Customer
--------
Jim
Jack
```

Update multiple columns in Orders based on the values in OrderCorrections.

```
CREATE TABLE OrderCorrections
(
OrderID INT NOT NULL PRIMARY KEY,
Customer VARCHAR(20) NOT NULL,
OrderDate DATE NOT NULL
);
```

```
INSERT INTO OrderCorrections
VALUES (1, 'Jack', '20180324');
```

```
UPDATE O
SET Customer = OC.Customer,
       OrderDate = OC.OrderDate
FROM   Orders AS O
       INNER JOIN
       OrderCorrections AS OC
       ON O.OrderID = OC.OrderID;
```

```
SELECT *
FROM Orders;
```

```
Customer   OrderDate
---------  ---------
Jack       2018-03-24
Jack       2018-04-02
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/t-sql/queries/update-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/delete-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/queries/from-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL does not support DELETE..FROM syntax, but it does support UPDATE FROM syntax.

Syntax

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
UPDATE [ ONLY ] table_name [ * ] [ [ AS ] alias ]
    SET { column_name = { expression | DEFAULT } |
          ( column_name [, ...] ) = ( { expression | DEFAULT } [, ...] ) |
          ( column_name [, ...] ) = ( sub-SELECT )
        } [, ...]
    [ FROM from_list ]
    [ WHERE condition | WHERE CURRENT OF cursor_name ]
    [ RETURNING * | output_expression [ [ AS ] output_name ] [, ...] ]
```

Migration Considerations

You can easily rewrite the DELETE statements as subqueries. Place the subqueries in the WHERE clause. This workaround is simple and, in most cases, easier to read and understand.

Examples

Delete customers with no orders.

```
CREATE TABLE Customers
(
Customer VARCHAR(20) PRIMARY KEY
);

INSERT INTO Customers
VALUES
('John'),
('Jim'),
('Jack')

CREATE TABLE Orders
(
OrderID INT NOT NULL PRIMARY KEY,
Customer VARCHAR(20) NOT NULL,
OrderDate DATE NOT NULL
);

INSERT INTO Orders (OrderID, Customer, OrderDate)
VALUES
(1, 'Jim', '20180401'),
(2, 'Jack', '20180402');

DELETE FROM Customers
WHERE Customer NOT IN (
                        SELECT Customer
                        FROM Orders
                       );

SELECT *
FROM Customers;

Customer
--------
Jim
Jack
```

Update.

```
CREATE TABLE OrderCorrections
(
OrderID INT NOT NULL PRIMARY KEY,
Customer VARCHAR(20) NOT NULL,
OrderDate DATE NOT NULL
```

```
);

INSERT INTO OrderCorrections
VALUES (1, 'Jack', '20180324');

UPDATE orders
SET Customer = OC.Customer,
       OrderDate = OC.OrderDate
FROM   Orders AS O
       INNER JOIN
       OrderCorrections AS OC
       ON O.OrderID = OC.OrderID;

SELECT *
FROM Orders;

Customer   OrderDate
---------  ---------
Jack       2018-03-24
Jack       2018-04-02
```

Summary

The following table identifies similarities, differences, and key migration considerations.

Feature	SQL Server	Aurora PostgreSQL
Join as part of DELETE	DELETE FROM ... FROM	N/A - Rewrite to use WHERE clause with a sub-query.
Join as part of UPDATE	UPDATE ... FROM	UPDATE ... FROM

For more information, see:

- *https://www.postgresql.org/docs/13/static/sql-delete.html*
- *https://www.postgresql.org/docs/13/static/sql-update.html*

SQL Server Stored Procedures vs. PostgreSQL Stored Procedures

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Stored Procedures	Syntax and option differences

SQL Server Usage

Stored Procedures are encapsulated, persisted code modules that you can execute using the EXECUTE T-SQL statement. They may have multiple input (IN) and output (OUT) parameters. Table valued user defined types can be used as input parameters. IN is the default direction for parameters, but OUT must be explicitly specified. You can specify parameters as both IN and OUT.

SQL Server allows you to run stored procedures in any security context using the EXECUTE AS option. They can be explicitly recompiled for every execution using the RECOMPILE option and can be encrypted in the database using the ENCRYPTION option to prevent unauthorized access to the source code.

SQL Server provides a unique feature that allows you to use a stored procedure as an input to an INSERT statement. When using this feature, only the first row in the data set returned by the stored procedure is evaluated.

Syntax

```
CREATE [ OR ALTER ] { PROC | PROCEDURE } <Procedure Name>
[<Parameter List>
[ WITH [ ENCRYPTION ]|[ RECOMPILE ]|[ EXECUTE AS ...]]
AS {
[ BEGIN ]
<SQL Code Body>
[ END ] }[;]
```

Examples

Creating and Executing a Stored Procedure

Create a simple parameterized Stored Procedure to validate the basic format of an Email.

```
CREATE PROCEDURE ValidateEmail
@Email VARCHAR(128), @IsValid BIT = 0 OUT
AS
BEGIN
IF @Email LIKE N'%@%' SET @IsValid = 1
ELSE SET @IsValid = 0
RETURN @IsValid
END;
```

Execute the procedure.

```
DECLARE @IsValid BIT
EXECUTE [ValidateEmail]
 @Email = 'X@y.com', @IsValid = @IsValid OUT;
SELECT @IsValid;

-- Returns 1
```

```
EXECUTE [ValidateEmail]
 @Email = 'Xy.com', @IsValid = @IsValid OUT;
SELECT @IsValid;
```

```
-- Returns 0
```

Create a stored procedure that uses RETURN to pass an error value to the application.

```
CREATE PROCEDURE ProcessImportBatch
@BatchID INT
AS
BEGIN
 BEGIN TRY
  EXECUTE Step1 @BatchID
  EXECUTE Step2 @BatchID
  EXECUTE Step3 @BatchID
 END TRY
 BEGIN CATCH
  IF ERROR_NUMBER() = 235
   RETURN -1 -- indicate special condition
  ELSE
   THROW -- handle error normally
 END CATCH
END
```

Using a Table-Valued Input Parameter

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Washer', 100);
```

Create a tabled valued type for the OrderItem table valued parameter.

```
CREATE TYPE OrderItems
AS TABLE
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

Create a procedure to process order items.

```
CREATE PROCEDURE InsertOrderItems
@OrderItems AS OrderItems READONLY
```

```
AS
BEGIN
    INSERT INTO OrderItems(OrderID, Item, Quantity)
    SELECT OrderID,
           Item,
           Quantity
    FROM @OrderItems
END;
```

Instantiate and populate the table valued variable and pass the data set to the stored procedure.

```
DECLARE @OrderItems AS OrderItems;

INSERT INTO @OrderItems ([OrderID], [Item], [Quantity])
VALUES
(1, 'M8 Bolt', 100),
(1, 'M8 Nut', 100),
(1, M8 Washer, 200);

EXECUTE [InsertOrderItems]
 @OrderItems = @OrderItems;

(3 rows affected)
   Item                Quantity
   ------------        ------------
 1      M8 Bolt          100
 2      M8 Nut           100
 3      M8 Washer        200
```

INSERT... EXEC Syntax

```
INSERT INTO <MyTable>
EXECUTE <MyStoredProcedure>;
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/create-procedure-transact-sql?view=sql-server-ver15

PostgreSQL Overview

PostgreSQL version 10 provides support for both stored procedures and stored functions using the CREATE FUNCTION statement. To emphasize, only the CREATE FUNCTION is supported by the procedural statements used by PostgreSQL version 10. The CREATE PROCEDURE statement is not supported.

PL/pgSQL is the main database programming language used for migrating from SQL Server's T-SQL code. PostgreSQL supports these additional programming languages, also available in Amazon Aurora PostgreSQL:

- PL/pgSQL
- PL/Tcl
- PL/Perl

Use the show.rds.extensions command to view all available Amazon Aurora extensions.

PostgreSQL Create Function Privileges

To create a function, a user must have USAGE privilege on the language. When creating a function, a language parameter can be specified as shown in the examples below.

Examples

Create a new function named FUNC_ALG.

```
CREATE OR REPLACE FUNCTION FUNC_ALG(P_NUM NUMERIC)
RETURNS NUMERIC
AS $$
BEGIN
   RETURN P_NUM * 2;
END; $$
LANGUAGE PLPGSQL;
```

- The CREATE OR REPLACE statement creates a new function or replaces an existing function with these limitations:
  - You cannot change the function name or argument types.
  - The statement does not allow changing the existing function return type.
  - The user must own the function to replace it.
- INPUT parameter (P_NUM) is implemented similar to SQL Server T-SQL INPUT parameter.
- The $$ signs alleviate the need to use single-quoted string escape elements. With the $$ sign, there is no need to use escape characters in the code when using single quotation marks ('). The $$ sign appears after the keyword AS and after the function keyword END.
- Use the LANGUAGE PLPGSQL parameter to specify the language for the created function.

Create a function with PostgreSQL PL/pgSQL.

```
CREATE OR REPLACE FUNCTION EMP_SAL_RAISE
(IN P_EMP_ID DOUBLE PRECISION, IN SAL_RAISE DOUBLE PRECISION)
RETURNS VOID
AS $$
DECLARE
V_EMP_CURRENT_SAL DOUBLE PRECISION;
BEGIN
SELECT SALARY INTO STRICT V_EMP_CURRENT_SAL
FROM EMPLOYEES WHERE EMPLOYEE_ID = P_EMP_ID;

UPDATE EMPLOYEES SET SALARY = V_EMP_CURRENT_SAL + SAL_RAISE WHERE EMPLOYEE_ID = P_EMP_
ID;

RAISE DEBUG USING MESSAGE := CONCAT_WS('', 'NEW SALARY FOR EMPLOYEE ID: ', P_EMP_ID, '
IS ', (V_EMP_CURRENT_SAL + SAL_RAISE));
EXCEPTION
WHEN OTHERS THEN
RAISE USING ERRCODE := '20001', MESSAGE := CONCAT_WS('', 'AN ERROR WAS ENCOUNTERED -
', SQLSTATE, ' -ERROR-', SQLERRM);
END; $$
LANGUAGE  PLPGSQL;
```

```
select emp_sal_raise(200, 1000);
```

Note: In the example above, the RAISE command can be replaced with RETURN in order to inform the application that an error occurred.

Create a function with PostgreSQL PL/pgSQL.

```
CREATE OR REPLACE FUNCTION EMP_PERIOD_OF_SERVICE_YEAR (IN P_EMP_ID DOUBLE PRECISION)
RETURNS DOUBLE PRECISION
AS $$
DECLARE
V_PERIOD_OF_SERVICE_YEARS DOUBLE PRECISION;
BEGIN
SELECT
EXTRACT (YEAR FROM NOW()) - EXTRACT (YEAR FROM (HIRE_DATE))
INTO STRICT V_PERIOD_OF_SERVICE_YEARS
FROM EMPLOYEES
WHERE EMPLOYEE_ID = P_EMP_ID;
RETURN V_PERIOD_OF_SERVICE_YEARS;
END; $$
LANGUAGE  PLPGSQL;

SELECT EMPLOYEE_ID,FIRST_NAME, EMP_PERIOD_OF_SERVICE_YEAR(EMPLOYEE_ID) AS
PERIOD_OF_SERVICE_YEAR
FROM EMPLOYEES;
```

There is a new behavior in PostgreSQL version 10 for a set-returning function, used by LATERAL FROM-clause.

Previous

```
CREATE TABLE emps (id int, manager int);
INSERT INTO tab VALUES (23, 24), (52, 23), (21, 65);
SELECT x, generate_series(1,5) AS g FROM tab;


id |g
---|--
23 |1
23 |2
23 |3
23 |4
23 |5
52 |1
52 |2
52 |3
52 |4
52 |5
21 |1
21 |2
21 |3
21 |4
21 |5
```

New

```
SELECT id, g FROM emps, LATERAL generate_series(1,5) AS g;

id |g
---|--
23 |1
23 |2
23 |3
23 |4
23 |5
52 |1
52 |2
52 |3
52 |4
52 |5
21 |1
21 |2
21 |3
21 |4
21 |5
```

In the above example, you could put the set-return function on the outside of the nested loop join, since it has no actual lateral dependency on emps table.

Summary

The following table summarizes the differences between SQL Server Stored Procedures and PostgreSQL Stored Procedures.

	SQL Server	Aurora PostgreSQL	Workaround
General CREATE Syntax differences	CREATE PROC|PROCEDURE <Procedure Name> @Parameter1 <Type>, ...n AS <Body>	CREATE [OR REPLACE] FUNCTION <Function Name> (Parameter1 <Type>, ...n) AS $$ <body>	Rewrite stored procedure creation scripts to use FUNCTION instead of PROC or PROCEDURE. Rewrite stored procedure creation scripts to omit the AS $$ pattern. Rewrite stored procedure parameters to not use the @ symbol in parameter names. Add parentheses around the parameter declaration.
Security Context	{ EXEC | EXECUTE } AS { CALLER | SELF | OWNER | 'user_name' }	SECURITY INVOKER | SECURITY DEFINER	For stored procedures that use an explicit user name, rewrite the code from EXECUTE AS 'user' to SECURITY DEFINER and recreate the functions with this user. For stored procedures that use the CALLER option, rewrite the code to include SECURITY INVOKER. For stored procedures that use the SELF option, rewrite the code to SECURITY DEFINER.

	SQL Server	Aurora PostgreSQL	Workaround
Encryption	Use WITH ENCRYPTION option	Not supported in Aurora PostgreSQL	
Parameter direction	IN and OUT|OUTPUT, by default OUT can be used as IN as well.	IN, OUT, INOUT, or VARIADIC	Although the functionality of these parameters is the same for SQL Server and PostgreSQL, you must rewrite the code for syntax compliance: Use OUT instead of OUTPUT. USE INOUT instead of OUT for bidirectional parameters.
Recompile	Use WITH RECOMPILE option	Not supported in Aurora PostgreSQL	
Table Valued Parameters	Use declared table type user defined parameters	Use declared table type user defined parameters	
Additional restrictions	Use BULK INSERT to load data from text file	Not supported in Aurora PostgreSQL	

For additional details, see:

- *https://www.postgresql.org/docs/13/static/sql-createfunction.html*
- *https://www.postgresql.org/docs/13/static/plpgsql.html*
- *https://www.postgresql.org/docs/13/static/xplang.html*
- *https://www.postgresql.org/docs/13/static/xfunc-sql.html*

SQL Server Error Handling vs. PostgreSQL Error Handling

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Different paradigm and syntax will require rewrite of error handling code

SQL Server Usage

SQL Server error handling capabilities have significantly improved throughout the years. However, previous features are retained for backward compatibility.
Before SQL Server 2008, only very basic error handling features were available. RAISERROR was the primary statement used for error handling.

Since SQL 2008, SQL Server has added extensive ".Net like" error handling capabilities including TRY/CATCH blocks, THROW statements, the FORMATMESSAGE function, and a set of system functions that return metadata for the current error condition.

TRY/CATCH Blocks

TRY/CATCH blocks implement error handling similar to Microsoft Visual C# and Microsoft Visual C++. TRY ... END TRY statement blocks can contain T-SQL statements .

If an error is raised by any of the statements within the TRY ... END TRY block, execution stops and is moved to the nearest set of statements that are bounded by a CATCH ... END CATCH block.

Syntax

```
BEGIN TRY
<Set of SQL Statements>
END TRY
BEGIN CATCH
<Set of SQL Error Handling Statements>
END CATCH
```

THROW

The THROW statement raises an exception and transfers execution of the TRY ... END TRY block of statements to the associated CATCH ... END CATCH block of statements.

Throw accepts either constant literals or variables for all parameters.

Syntax

```
THROW [Error Number>, <Error Message>, < Error State>] [;]
```

Examples

Use TRY/CATCH error blocks to handle key violations.

```
CREATE TABLE ErrorTest (Col1 INT NOT NULL PRIMARY KEY);
```

```
BEGIN TRY
 BEGIN TRANSACTION
   INSERT INTO ErrorTest(Col1) VALUES(1);
   INSERT INTO ErrorTest(Col1) VALUES(2);
   INSERT INTO ErrorTest(Col1) VALUES(1);
 COMMIT TRANSACTION;
END TRY
BEGIN CATCH
  THROW; -- Throw with no parameters = RETHROW
END CATCH;
```

```
(1 row affected)
(1 row affected)
(0 rows affected)
Msg 2627, Level 14, State 1, Line 7
```

```
Violation of PRIMARY KEY constraint 'PK__ErrorTes__A259EE54D8676973'.
Cannot insert duplicate key in object 'dbo.ErrorTest'. The duplicate key value is (1).
```

> **Note:** Contrary to what many SQL developers believe, the values 1 and 2 are indeed inserted into ErrorTestTable in the above example. This behavior is in accordance with ANSI specifications stating that a constraint violation should not roll back an entire transaction.

Use THROW with variables

```
BEGIN TRY
BEGIN TRANSACTION
INSERT INTO ErrorTest(Col1) VALUES(1);
INSERT INTO ErrorTest(Col1) VALUES(2);
INSERT INTO ErrorTest(Col1) VALUES(1);
COMMIT TRANSACTION;
END TRY
BEGIN CATCH
DECLARE @CustomMessage VARCHAR(1000),
               @CustomError INT,
               @CustomState INT;
SET @CustomMessage = 'My Custom Text ' + ERROR_MESSAGE();
SET @CustomError = 54321;
SET @CustomState = 1;
THROW @CustomError, @CustomMessage, @CustomState;
END CATCH;
```

```
(0 rows affected)
Msg 54321, Level 16, State 1, Line 19
My Custom Text Violation of PRIMARY KEY constraint 'PK__ErrorTes__A259EE545CBDBB9A'.
Cannot insert duplicate key in object 'dbo.ErrorTest'. The duplicate key value is (1).
```

RAISERROR

The RAISERROR statement is used to explicitly raise an error message, similar to THROW. It causes an error state for the executing session and forwards execution to either the calling scope or, if the error occurred within a TRY ... END TRY block, to the associated CATCH ... END CATCH block. RAISERROR can reference a user-defined message stored in the sys.messages system table or can be used with dynamic message text.

The key differences between THROW and RAISERROR are:

- Message IDs passed to RAISERROR must exist in the sys.messages system table. The error number parameter passed to THROW does not.
- RAISERROR message text may contain printf formatting styles. The message text of THROW may not.
- RAISERROR uses the severity parameter for the error returned. For THROW, severity is always 16.

Syntax

```
RAISERROR (<Message ID>|<Message Text> ,<Message Severity> ,<Message State>
[WITH option [<Option List>]])
```

Examples

Raise a custom error.

```
RAISERROR (N'This is a custom error message with severity 10 and state 1.', 10, 1)
```

FORMATMESSAGE

FORMATMESSAGE returns a sting message consisting of an existing error message in the sys.messages system table, or from a text string, using the optional parameter list replacements. The FORMATMESSAGE statement is similar to the RAISERROR statement.

Syntax

```
FORMATMESSAGE (<Message Number> | <Message String>, <Parameter List>)
```

Error State Functions

SQL Server provides the following error state functions:

- ERROR_LINE
- ERROR_MESSAGE
- ERROR_NUMBER
- ERROR_PROCEDURE
- ERROR_SEVERITY
- ERROR_STATE
- @@ERROR

Examples

Use Error State Functions within a CATCH block.

```
CREATE TABLE ErrorTest (Col1 INT NOT NULL PRIMARY KEY);
```

```
BEGIN TRY;
 BEGIN TRANSACTION;
   INSERT INTO ErrorTest(Col1) VALUES(1);
   INSERT INTO ErrorTest(Col1) VALUES(2);
   INSERT INTO ErrorTest(Col1) VALUES(1);
 COMMIT TRANSACTION;
END TRY
BEGIN CATCH
  SELECT        ERROR_LINE(),
                ERROR_MESSAGE(),
                ERROR_NUMBER(),
                ERROR_PROCEDURE(),
                ERROR_SEVERITY(),
                ERROR_STATE(),
                @@Error;
THROW;
END CATCH;
```

```
6
Violation of PRIMARY KEY constraint 'PK__ErrorTes__A259EE543C8912D8'. Cannot insert
duplicate key in object 'dbo.ErrorTest'. The duplicate key value is (1).
2627
```

```
NULL
14
1
2627
```

```
(1 row affected)
(1 row affected)
(0 rows affected)
(1 row affected)
Msg 2627, Level 14, State 1, Line 25
Violation of PRIMARY KEY constraint 'PK__ErrorTes__A259EE543C8912D8'. Cannot insert
duplicate key in object 'dbo.ErrorTest'. The duplicate key value is (1).
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/t-sql/language-elements/raiserror-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/language-elements/try-catch-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/language-elements/throw-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL does not provide native replacement for SQL Server error handling features and options, but it has many comparable options.

To trap the errors, use the BEGIN.. EXCEPTION.. END. By default, any error raised in a PL/pgSQL function block aborts execution and the surrounding transaction. You can trap and recover from errors using a BEGIN block with an EXCEPTION clause. The syntax is an extension to the normal syntax for a BEGIN block.

Syntax

```
[ <<label>> ]
[ DECLARE
    declarations ]
BEGIN
    statements
EXCEPTION
    WHEN condition [ OR condition ... ] THEN
        handler_statements
    [ WHEN condition [ OR condition ... ] THEN
          handler_statements
      ... ]
END;
```

"condition" is related to the error or the code. For example:

- WHEN interval_field_overflow THEN..
- WHEN SQLSTATE '22015' THEN...

For all error codes, see https://www.postgresql.org/docs/13/static/errcodes-appendix.html

Throw errors

The PostgreSQL RAISE statement can be used to throw errors. You can combine RAISE with several levels of severity including:

Severity	Usage
DEBUG1..DEBUG5	Provides successively more detailed information for use by developers.
INFO	Provides information implicitly requested by the user.
NOTICE	Provides information that might be helpful to users.
WARNING	Provides warnings of likely problems.
ERROR	Reports an error that caused the current command to abort.
LOG	Reports information of interest to administrators. For example, checkpoint activity.
FATAL	Reports an error that caused the current session to abort.
PANIC	Reports an error that caused all database sessions to abort.

Examples

Use RAISE DEBUG (where DEBUG is the configurable severity level).

```
SET CLIENT_MIN_MESSAGES = 'debug';

DO $$
BEGIN
RAISE DEBUG USING MESSAGE := 'hello world';
END $$;

DEBUG:  hello world
DO
```

Use the client_min_messages parameter to control the level of messages sent to the client. The default is NOTICE. Use the log_min_messages parameter to control which message levels are written to the server log. The default is WARNING.

```
SET CLIENT_MIN_MESSAGES = 'deb
```

Use EXCEPTION..WHEN...THEN inside BEGIN and END block to handle dividing by zero violations.

```
CREATE TABLE ErrorTest (Col1 INT NOT NULL PRIMARY KEY);
```

```
INSERT INTO employee values ('John',10);
BEGIN
       SELECT 5/0;
EXCEPTION
    WHEN division_by_zero THEN
        RAISE NOTICE 'caught division_by_zero';
       return 0;
END;
```

Summary

The following table identifies similarities, differences, and key migration considerations.

SQL Server Error Handling Feature	Aurora PostgreSQL equivalent
TRY ... END TRY and CATCH ... END CATCH blocks	Inner BEGIN ... EXCEPTION WHEN ... THEN END
THROW and RAISERROR	RAISE
FORMATMESSAGE	RAISE [level] 'format' or ASSERT
Error state functions	GET STACKED DIAGNOSTICS
Proprietary error messages in sys.messages system table	RAISE

For more information, see

- *https://www.postgresql.org/docs/13/static/ecpg-errors.html*
- *https://www.postgresql.org/docs/13/static/plpgsql-errors-and-messages.html*
- *https://www.postgresql.org/docs/13/static/runtime-config-logging.html#GUC-LOG-MIN-MESSAGES*

SQL Server Flow Control vs. PostgreSQL Control Structures

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Flow Control	Postgres does not support GOTO and WAITFOR TIME

SQL Server Usage

Although SQL is a mostly declarative language, it does support flow control commands, which provide run time dynamic changes in script execution paths.

> **Note:** Before SQL/PSM was introduced in SQL:1999, the ANSI standard did not include flow control constructs. Therefore, there are significant syntax differences among RDBMS engines.

SQL Server provides the following flow control keywords.

- **BEGIN... END:** Define boundaries for a block of commands that are executed together.
- **RETURN:** Exit a server code module (stored procedure, function, etc.) and return control to the calling scope. RETURN <value> can be used to return an INT value to the calling scope.
- **BREAK:** Exit WHILE loop execution.

- **THROW:** Raise errors and potentially return control to the calling stack.
- **CONTINUE:** Restart a WHILE loop.
- **TRY... CATCH:** Error handling (see Error Handling).
- **GOTO label:** Moves the execution point to the location of the specified label.
- **WAITFOR:** Delay.
- **IF... ELSE:** Conditional flow control.
- **WHILE <condition>:** Continue looping while <condition> returns TRUE.

  Note: WHILE loops are commonly used with cursors and use the system variable @@FETCH_STATUS to determine when to exit (see the Cursors section for more details).

For more information about TRY-CATCH and THROW, see Error Handling.

Examples

The following example demonstrates a solution for executing different processes based on the number of items in an order:

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200);
```

Declare a cursor for looping through all OrderItems and calculating the total quantity per order.

```
DECLARE  OrderItemCursor CURSOR FAST_FORWARD
FOR
SELECT  OrderID,
        SUM(Quantity) AS NumItems
FROM    OrderItems
GROUP BY OrderID
ORDER BY OrderID;

DECLARE @OrderID INT, @NumItems INT;

-- Instantiate the cursor and loop through all orders.
OPEN OrderItemCursor;

FETCH NEXT FROM OrderItemCursor
INTO @OrderID, @NumItems

WHILE @@Fetch_Status = 0
```

```
BEGIN;

 IF     @NumItems > 100
  PRINT 'EXECUTING LogLargeOrder - '
  + CAST(@OrderID AS VARCHAR(5))
  + ' ' + CAST(@NumItems AS VARCHAR(5));
 ELSE
  PRINT 'EXECUTING LogSmallOrder - '
  + CAST(@OrderID AS VARCHAR(5))
  + ' ' + CAST(@NumItems AS VARCHAR(5));

FETCH NEXT FROM OrderItemCursor
INTO @OrderID, @NumItems;
END;

-- Close and deallocate the cursor.
CLOSE OrderItemCursor;
DEALLOCATE OrderItemCursor;
```

The above code displays the following results:

```
EXECUTING LogSmallOrder - 1 100
EXECUTING LogSmallOrder - 2 100
EXECUTING LogLargeOrder - 3 200
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/language-elements/control-of-flow?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL provides the following flow control constructs:

- **BEGIN... END:** Define boundaries for a block of commands executed together.
- **CASE:** Execute a set of commands based on a predicate (not to be confused with CASE expressions).
- **IF... ELSE:** Perform conditional flow control.
- **ITERATE:** Restart a LOOP or WHILE statement.
- **LEAVE:** Exit a server code module (stored procedure, function etc.) and return control to the calling scope.
- **LOOP:** Loop indefinitely.
- **REPEAT... UNTIL:** Loop until the predicate is true.
- **RETURN:** Terminate execution of the current scope and return to the calling scope.
- **WHILE:** Continue looping while the condition returns TRUE.

Examples

The following example demonstrates a solution for executing different logic based on the number of items in an order. It provides the same functionality as the example for SQL Server flow control. However, unlike the SQL Server example executed as a batch script, Aurora PostgreSQL variables can only be used in stored routines (procedures and functions).

Create and populate an OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200);
```

Create a procedure to declare a cursor and loop through the order items.

```
CREATE OR REPLACE FUNCTION P()
 RETURNS numeric
 LANGUAGE plpgsql
AS $function$
DECLARE
 done int default false;
 var_OrderID int;
 var_NumItems int;
 OrderItemCursor CURSOR FOR SELECT     OrderID, SUM(Quantity) AS NumItems
 FROM  OrderItems
 GROUP BY OrderID
 ORDER BY OrderID;

 BEGIN
    OPEN OrderItemCursor;
   LOOP
       fetch from OrderItemCursor INTO var_OrderID, var_NumItems;
    EXIT WHEN NOT FOUND;
   IF var_NumItems > 100 THEN
   RAISE NOTICE 'EXECUTING LogLargeOrder -  %s',var_OrderID;
   RAISE NOTICE 'Num Items: %s', var_NumItems;
 ELSE
 RAISE NOTICE 'EXECUTING LogSmallOrder - %s',var_OrderID;
   RAISE NOTICE 'Num Items: %s', var_NumItems;
 END IF;
       END LOOP;

   done = TRUE;

    CLOSE OrderItemCursor;

 END; $function$
```

Summary

While there are some syntax differences between SQL Server and Aurora PostgreSQL flow control statements, most rewrites should be straightforward. The following table summarizes the differences and identifies how to modify T-SQL code to support similar functionality in Aurora PostgreSQL PL/pgSQL.

COMMAND	SQL Server	Aurora PostgreSQL
BEGIN... END	Define command block boundaries	Define command block boundaries.
RETURN	Exit the current scope and return to caller Supported for both scripts and stored code (procedures and functions).	Exit a stored function and return to caller.
BREAK	Exit WHILE loop execution	EXIT WHEN
THROW	Raise errors and potentially return control to the calling stack	Raise errors and potentially return control to the calling stack.
TRY - CATCH	Error handling	Error handling - See Error Handling for more details.
GOTO	Move execution to specified label	Consider rewriting the flow logic using either CASE statements or nested stored procedures. You can use nested stored procedures to circumvent this limitation by separating code sections and encapsulating them in sub-procedures. Use IF <condition> EXEC <stored procedure> in place of GOTO.
WAITFOR	Delay	pg_sleep - see: https://www.postgresql.org/docs/13/static/functions-datetime.html
IF... ELSE	Conditional flow control	Conditional flow control
WHILE	Continue execution while condition is TRUE	Continue execution while condition is TRUE

For more information, see https://www.postgresql.org/docs/13/static/plpgsql-control-structures.html

SQL Server Full-Text Search vs. PostgreSQL Full-Text Search

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Full Text Search	Different paradigm and syntax will require rewriting the application

SQL Server Usage

SQL Server supports an optional framework for executing Full-Text search queries against character-based data in SQL Server tables using an integrated, in-process Full-Text engine and a filter daemon host process (fdhost.exe).

To run Full-Text queries, a Full-Text catalog must first be created, which in turn may contain one or more Full-Text indexes. A Full-Text index is comprised of one or more textual columns of a table.

Full-text queries perform smart linguistic searches against Full-Text indexes by identifying words and phrases based on specific language rules. The searches can be for simple words, complex phrases, or multiple forms of a word or a phrase. They can return ranking scores for matches (also known as "hits").

Full-Text Indexes

A Full-Text index can be created on one of more columns of a table or view for any of the following data types:

- **CHAR:** Fixed size ASCII string column data type
- **VARCHAR:** Variable size ASCII string column data type
- **NCHAR:** Fixed size UNICODE string column data type
- **NVARCHAR:** Variable size UNICODE string column data type
- **TEXT:** ASCII BLOB string column data type (deprecated)
- **NTEXT:** UNICODE BLOB string column data type (deprecated)
- **IMAGE:** Binary BLOB data type (deprecated)
- XML: XML structured BLOB data type
- **VARBINARY(MAX):** Binary BLOB data type
- **FILESTREAM:** File based storage data type

Note: For more information about data types, see Data Types.

Full-text indexes are created using the CREATE FULLTEXT INDEX statement. A Full-Text index may contain up to 1024 columns from a single table or view.

When creating Full-Text indexes on BINARY type columns, documents such as Microsoft Word can be stored as a binary stream and parsed correctly by the Full-Text engine.

Full-Text catalogs

Full-text indexes are contained within Full-Text catalog objects. A Full-Text catalog is a logical container for one or more Full-Text indexes and can be used to collectively administer them as a group for tasks such as back-up, restore, refresh content, etc.

Full-text catalogs are created using the `CREATE FULLTEXT CATALOG` statement. A Full-Text catalog may contain zero or more Full-Text indexes and is limited in scope to a single database.

Full-Text queries

After a Full-Text catalog and index have been create and populated, users can perform Full-Text queries against these indexes to query for:

- Simple term match for one or more words or phrases
- Prefix term match for words that begin with a set of characters
- Generational term match for inflectional forms of a word
- Proximity term match for words or phrases that are close to another word or phrase
- Thesaurus search for synonymous forms of a word
- Weighted term match for finding words or phrases with weighted proximity values

Full-text queries are integrated into T-SQL and use the following predicates and functions:

- CONTAINS predicate
- FREETEXT predicate
- CONTAINSTABLE table valued function
- FREETEXTTABLE table valued function

> **Note:** Do not confuse Full-Text functionality with the LIKE predicate, which is used for pattern matching only.

Updating Full-Text Indexes

By default, Full-Text indexes are automatically updated when the underlying data is modified, similar to a normal B-Tree or Columnstore index. However, large changes to the underlying data may inflict a performance impact for the Full-Text indexes update because it is a resource intensive operation. In these cases, you can disable the automatic update of the catalog and update it manually, or on a schedule, to keep the catalog up to date with the underlying tables.

> **Note:** You can monitor the status of Full-Text catalog by using the FULLTEXTCATALOGPROPERTY (<Full-text Catalog Name>, 'Populatestatus') function.

Examples

Create a ProductReviews table.

```
CREATE TABLE ProductReviews
(
ReviewID INT NOT NULL
 IDENTITY(1,1),
CONSTRAINT PK_ProductReviews PRIMARY KEY(ReviewID),
ProductID INT NOT NULL
 /*REFERENCES Products(ProductID)*/,
ReviewText VARCHAR(4000) NOT NULL,
ReviewDate DATE NOT NULL,
UserID INT NOT NULL
/*REFERENCES Users(UserID)*/
);
```

```
INSERT INTO ProductReviews
( ProductID, ReviewText, ReviewDate, UserID)
VALUES
(1, 'This is a review for product 1, it is excellent and works as expected',
'20180701', 2),
(1, 'This is a review for product 1, it is not that great and failed after two days',
```

```
'20180702', 2),
(2, 'This is a review for product 3, it has exceeded my expectations. A+++',
'20180710', 2);
```

Create a Full-Text catalog for product reviews.

```
CREATE FULLTEXT CATALOG ProductFTCatalog;
```

Create a Full-Text index for ProductReviews.

```
CREATE FULLTEXT INDEX
ON ProductReviews (ReviewText)
KEY INDEX PK_ProductReviews
ON ProductFTCatalog;
```

Query the Full-Text index for reviews containing the word 'excellent'.

```
SELECT *
FROM ProductReviews
WHERE CONTAINS(ReviewText, 'excellent');
```

```
ReviewID  ProductID     ReviewText
                                                    ReviewDate      UserID
--------  ---------     ----------
                                                      ----------      ------
1         1             This is a review for product 1, it is excellent and works as expected
2018-07-01      2
```

For more information, see https://docs.microsoft.com/en-us/sql/2014/relational-databases/search/Full-Text-search?view-w=sql-server-ver15

PostgreSQL Usage

Full-Text indexes are used to speed up textual searches performed against textual data by using the Full-Text @@ predicate.

Full-Text indexes can be created on almost any column data type, it depends on the operator class used when the index is created. All classes can be queried from the pg_opclass table and defaults can be defined.

The default class uses index tsvector data types. The most common use is to create one column with text or other data type, and use triggers to convert it to a tsvector.

There are two index types for full-text searches: GIN and GiST.

GIN is slowler when building the index because it iscomplete (no false positive results), but it's faster when query-ing.

GIN performance on creation can be improved by increasing the maintenance_work_mem parameter.

When creating GIN indexes, they can be combined with these parameters:

- **fastupdate:** puts updates on the index on a waiting list so they will occur in VACUUM or related scenarios (default is ON)
- **gin_pending_list_limit:** the maximum size of a waiting list (in KB, the default is 4MB)

GIN cannot be used as composite index (multi columns) unless you add the btree_gin extension (which is supported in Aurora).

```
CREATE EXTENSION btree_gin;
CREATE INDEX reviews_idx ON reviews USING GIN (title, body);
```

Full-Text Search Functions

Boolean Search

You can use to_tsquery(), which accepts a list of words is checked against the normalized vector created with to_tsvector(). To do this, use the @@ operator to check if tsquery matches tsvector. For example, the following statement returns 't' because the column contains the word 'boy'. This search also returns 't' for 'boys' but not for 'boyser'.

```
SELECT to_tsvector('The quick young boy jumped over the fence')
    @@ to_tsquery('boy');
```

Operators Search

The following example shows how to use the AND (&), OR (|), and NOT (!) operators. The example below returns 't'.

```
SELECT to_tsvector('The quick young boy jumped over the fence')
    @@ to_tsquery('young & (boy | guy) & !girl');
```

Phase Search

When using to_tsquery, you can also search for a similar term if you replace boy with boys and add the laungauge to be used.

```
SELECT to_tsvector('The quick young boy jumped over the fence')
    @@ to_tsquery('english', 'young & (boys | guy) & !girl');
```

Search words within a specific distance ('-' is equal to 1). Theses examples return true.

```
SELECT to_tsvector('The quick young boy jumped over the fence') @@
       to_tsquery('young <-> boy'),
       to_tsvector('The quick young boy jumped over the fence') @@
       to_tsquery('quick <3> jumped');
```

Migration Considerations

Migrating Full-Text indexes from SQL Server to Aurora PostgreSQL requires a full rewrite of the code that addresses creating, managing, and querying of Full-Text searches.

Although the Aurora PostgreSQL full-text engine is significantly less comprehensive than SQL Server, it is also much simpler to create and manage, and it is sufficiently powerful for most common, basic full-text requirements.

A text search dictionary can be created. For more information see: https://www.postgresql.org/docs/13/static/sql-createtsdictionary.html

For more complex full-text workloads, Amazon RDS offers CloudSearch, a managed service in the AWS Cloud that makes it simple and cost-effective to set up, manage, and scale an enterprise grade search solution. Amazon CloudSearch supports 34 languages and advanced search features such as highlighting, autocomplete, and geo-spatial search.

Currently, there is no direct tooling integration with Aurora PostgreSQL and, therefore, you must create a custom application to synchronize the data between RDS instances and the CloudSearch Service.

For more information on CloudSearch, see https://aws.amazon.com/cloudsearch/

Examples

```
CREATE TABLE ProductReviews
(
ReviewID SERIAL PRIMARY KEY,
ProductID INT NOT NULL
ReviewText TEXT NOT NULL,
ReviewDate DATE NOT NULL,
UserID INT NOT NULL
);
```

```
INSERT INTO ProductReviews
(ProductID, ReviewText, ReviewDate, UserID)
VALUES
(1, 'This is a review for product 1, it is excellent and works as expected',
'20180701', 2),
(1, 'This is a review for product 1, it is not that great and failed after two days',
'20180702', 2),
(2, 'This is a review for product 3, it has exceeded my expectations. A+++',
'20180710', 2);
```

Create Full-Text search index.

```
CREATE INDEX gin_idx ON ProductReviews USING gin (ReviewText gin_trgm_ops);
```

Note: gin_trgm_ops allows indexing a TEXT data type.

Query the full-text index for reviews containing the word 'excellent'.

```
SELECT * FROM ProductReviews where ReviewText @@ to_tsquery('excellent');
```

For more information, see:

- *https://www.postgresql.org/docs/13/static/textsearch.html*
- *https://www.postgresql.org/docs/13/static/textsearch-features.html*

SQL Server Graph vs. PostgreSQL Apache AGE extension

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
			No native support requires rewriting the application

SQL Server Usage

SQL Server offers graph database capabilities to model many-to-many relationships. The graph relationships are integrated into Transact-SQL and receive the benefits of using SQL Server as the foundational database management system.

A graph database is a collection of nodes (or vertices) and edges (or relationships). A node represents an entity (for example, a person or an organization) and an edge represents a relationship between the two nodes that it connects (for example, likes or friends). Both nodes and edges may have properties associated with them. Here are some features that make a graph database unique:

- Edges or relationships are first class entities in a Graph Database and can have attributes or properties associated with them.
- A single edge can flexibly connect multiple nodes in a Graph Database.
- You can express pattern matching and multi-hop navigation queries easily.
- You can express transitive closure and polymorphic queries easily.

A relational database can achieve anything a graph database can. However, a graph database makes it easier to express certain kinds of queries. Also, with specific optimizations, certain queries may perform better. Your decision to choose either a relational or graph database is based on following factors:

- Your application has hierarchical data. The HierarchyID datatype can be used to implement hierarchies, but it has some limitations. For example, it does not allow you to store multiple parents for a node.
- Your application has complex many-to-many relationships; as application evolves, new relationships are added.
- You need to analyze interconnected data and relationships.

SQL Server 2017 adds new graph database capabilities for modeling graph many-to-many relationships. They include new CREATE TABLE syntax for creating node and edge tables, and the keyword MATCH for queries. See Graph Processing with SQL Server 2017

CREATE TABLE example:

```
CREATE TABLE Person (ID INTEGER PRIMARY KEY, Name VARCHAR(100), Age INT) AS NODE;

CREATE TABLE friends (StartDate date) AS EDGE;
```

New MATCH clause is introduced to support pattern matching and multi-hop navigation through the graph. The MATCH function uses ASCII-art style syntax for pattern matching. For example:

```
-- Find friends of John

SELECT Person2.Name
FROM Person Person1, Friends, Person Person2
WHERE MATCH(Person1-(Friends)->Person2)
AND Person1.Name = 'John';
```

SQL Server 2019 adds ability to define cascaded delete actions on an edge constraint in a graph database. Edge constraints enable users to add constraints to their edge tables, thereby enforcing specific semantics and also maintaining data integrity. For more information see Edge Cnostraints

In SQL Server 2019 graph tables now have support for table and index partitioning. For more information see Partitioned Tables and Indexes.

PostgreSQL Usage

Currently PostgreSQL does not provide native Graph Database feature, but it is possible to implement some of them using recursive CTE queries, serializing graphs to regular relations or using various extensions, such as Apache AGE. For more information see Postgres as Graph Database.

Apache AGE is a PostgreSQL extension that provides graph database functionality. AGE is an acronym for A Graph Extension, and is inspired by Bitnine's fork of PostgreSQL 10, AgensGraph, which is a multi-model database. The goal of the project is to create single storage that can handle both relational and graph model data so that users can use standard ANSI SQL along with openCypher, the Graph query language.

- AGE is currently being developed for the PostgreSQL 11 release and will support PostgreSQL 12 and 13 in 2021 and all the future releases of PostgreSQL.
- AGE supports the openCypher graph query language and label hierarchy.
- AGE enables querying multiple graphs at the same time. This will allow a user to query two or more graphs at once with cypher, decide how to merge them and get the desired query outputs.
- AGE will be enhanced with an aim to support all of the key features of AgensGraph (PostgreSQL fork extended with graph DB functionality).

Unfortunately, Aurora PostgreSQL is not supporting Apache AGE extension. So if you want to use Graphs in PostgreSQL you should consider to use RDS for PostgreSQL.

For more information see Apache AGE (incubating)

SQL Server JSON and XML vs. PostgreSQL JSON and XML

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		XML	Syntax and option differences, similar functionality Missing FOR XML clause

SQL Server Usage

Java Script Object Notation (JSON) and eXtensible Markup Language (XML) are the two most common types of semi-structured data documents used by a variety of data interfaces and NoSQL databases. Most REST web service APIs support JSON as their native data transfer format. XML is an older, more mature framework that is still widely used. It provides many extensions such as XQuery, name spaces, schemas, and more.

The following example is a JSON document:

```
[{
    "name": "Robert",
    "age": "28"
}, {
    "name": "James",
    "age": "71"
    "lastname": "Drapers"
}]
```

It's XML counterpart is:

```
<?xml version="1.0" encoding="UTF-16" ?>
<root>
        <Person>
                <name>Robert</name>
                <age>28</age>
       </Person>
       <Person>
                <name>James</name>
                <age>71</age>
                <lastname>Drapers</lastname>
       </Person>
</root>
```

SQL Server provides native support for both JSON and XML in the database using the familiar and convenient T-SQL interface.

XML Data

SQL Server provides extensive native support for working with XML data including XML Data Types, XML Columns, XML Indexes, and XQuery.

XML Data Types and Columns

XML data can be stored using the following data types:

- The **Native XML Data Type** uses a BLOB structure but preserves the XML Infoset, which consists of the containment hierarchy, document order, and element/attribute values. An XML typed document may differ from the original text; white space is removed and the order of objects may change. XML Data stored as a native XML data type has the additional benefit of schema validation.
- An **Annotated Schema** (AXSD) can be used to distribute XML documents to one or more tables. Hierarchical structure is maintained, but element order is not.

- **CLOB or BLOB** such as VARCHAR(MAX) and VARBINARY(MAX) can be used to store the original XML document.

XML Indexes

SQL Server allows creation of PRIMARY and SECONDARY XML indexes on columns with a native XML data type. Secondary indexes can be created for PATH, VALUE, or PROPERTY, which are helpful for various types of workload queries.

XQuery

SQL Server supports a subset of the W3C XQUERY language specification. It allows executing queries directly against XML data and using them as expressions or sets in standard T-SQL statements.

For example:

```
DECLARE @XMLVar XML = '<Root><Data>My XML Data</Data></Root>';
SELECT @XMLVar.query('/Root/Data');
```

```
Result: <Data>My XML Data</Data>
```

JSON Data

SQL Server does not support a dedicated JSON data type. However, you can store JSON documents in an NVARCHAR column. For more information about BLOBS, see Data Types.

SQL Server provides a set of JSON functions that can be used for the following tasks:

- Retrieve and modify values in JSON documents.
- Convert JSON objects to a set (table) format.
- Use standard T-SQL queries with converted JSON objects.
- Convert tabular results of T-SQL queries to JSON format.

The functions are:

- **ISJSON**: Tests if a string contains a valid JSON string. Use in WHERE clause to avoid errors.
- **JSON_VALUE:** Retrieves a scalar value from a JSON document.
- **JSON_QUERY:** Retrieves a whole object or array from a JSON document.
- **JSON_MODIFY:** Modifies values in a JSON document.
- **OPENJSON**: Converts a JSON document to a SET that can be used in the FROM clause of a T-SQL query.

The FOR JSON clause of SELECT queries can be used to convert a tabular set to a JSON document.

Examples

Create a table with a native typed XML column.

```
CREATE TABLE MyTable
(
```

```
XMLIdentifier INT NOT NULL PRIMARY KEY,
XMLDocument XML NULL
);
```

Query a JSON document.

```
DECLARE @JSONVar NVARCHAR(MAX);
SET @JSONVar = '{"Data":{"Person":[{"Name":"John"},{"Name":"Jane"},
{"Name":"Maria"}]}}';
SELECT JSON_QUERY(@JSONVar, '$.Data');
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/json/json-data-sql-server?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/xml/xml-data-sql-server?view=sql-server-ver15*

PostgreSQL Usage

PostgreSQL provides native JSON Document support using the JSON data types JSON and JSONB.

JSON stores an exact copy of the input text that processing functions must re-parse on each execution. It also preserves semantically-insignificant white space between tokens and the order of keys within JSON objects.

JSONB stores data in a decomposed binary format causing slightly slower input performance due to added conversion to binary overhead. But it is significantly faster to process, since no re-parsing is needed on reads.

- Does not preserve white space.
- Does not preserve the order of object keys.
- Does not keep duplicate object keys. If duplicate keys are specified in the input, only the last value is retained.

Most applications store JSON data as JSONB unless there are specialized needs. For additional information about the differences between JSON and JSOB datatypes, see https://www.postgresql.org/docs/13/static/datatype-json.html

In order to comply with the full JSON specification, database encoding must be set to UTF8. If the database code page is not set to UTF8, then non-UTF8 characters are allowed and the database encoding will be non-compliant with the full JSON specification.

> **Note:** Starting with PostgreSQL 10, both JSON and JSONB are compatible with full-text search.

Examples

Querying JSON data in PostgreSQL uses different syntax than SQL Server.

Return the JSON document stored in the emp_data column associated with emp_id=1.

```
SELECT emp_data FROM employees WHERE emp_id = 1;
```

Return all JSON documents stored in the emp_data column having a key named address.

```
SELECT emp_data FROM employees WHERE emp_data ? ' address';
```

Return all JSON items that have an address key or a hobbies key.

```
SELECT * FROM employees WHERE emp_data ?| array['address', 'hobbies'];
```

Return all JSON items that have both an address key and a hobbies key.

```
SELECT * FROM employees WHERE emp_data ?& array['a', 'b'];
```

Return the value of home key in the phone numbers array.

```
SELECT emp_data ->'phone numbers'->>'home' FROM employees;
```

Return all JSON documents where the address key is equal to a specified value and return all JSON documents where address key contains a specific string (using like).

```
SELECT * FROM employees WHERE emp_data->>'address' = '1234 First Street, Capital
City';

SELECT * FROM employees WHERE emp_data->>'address' like '%Capital City%';
```

Removing keys from JSON (removing more than one key is available in PostgreSQL 10 only).

```
select '{"id":132, "fname":"John", "salary":999999, "bank_account":1234}'::jsonb
              - '{salary,bank_account}'::text[];
```

For additional details, see https://www.postgresql.org/docs/13/static/functions-json.html

Indexing and Constraints with JSONB Columns

You can use the CREATE UNIQUE INDEX statement to enforce constraints on values inside JSON documents. For example, you can create a unique index that forces values of the address key to be unique.

```
CREATE UNIQUE INDEX employee_address_uq ON employees( (emp_data->>'address') ) ;
```

This index allows the first SQL insert statement to work and causes the second to fail.

```
INSERT INTO employees VALUES
(2, 'Second Employee','{ "address": "1234 Second Street, Capital City"}');

INSERT INTO employees VALUES
(3, 'Third Employee', '{ "address": "1234 Second Street, Capital City"}');

ERROR: duplicate key value violates unique constraint "employee_address_uq" SQL state:
23505 Detail: Key ((emp_data ->> 'address'::text))=(1234 Second Street, Capital City)
already exists.
```

For JSON data, PostgreSQL Supports B-Tree, HASH, and Generalized Inverted Indexes (GIN). A GIN index is a special inverted index structure that is useful when an index must map many values to a row (such as indexing JSON documents).

When using GIN indexes, you can efficiently and quickly query data using only the following JSON operators: @>, ?, ?&, ?|

Without indexes, PostgreSQL is forced to perform a full table scan when filtering data. This condition applies to JSON data and will most likely have a negative impact on performance since Postgres has to step into each JSON document.

Create an index on the address key of emp_data.

```
CREATE  idx1_employees ON employees ((emp_data->>'address'));
```

Create a GIN index on a specific key or the entire emp_data column.

```
CREATE INDEX idx2_employees ON cards USING gin ((emp_data->'tags'));
CREATE INDEX idx3_employees ON employees USING gin (emp_data);
```

XML

PostgreSQL provides an XML data type for table columns. The primary advantage of using XML columns, rather than placing XML data in text columns, is that the XML data is type checked when inserted. Additionally, there are support functions to perform type-safe operations.

XML can store well-formed “documents” as defined by the XML standard or “content” fragments that defined by the production XMLDecl. Content fragments can have more than one top-level element or character node.

IS DOCUMENT can be used to evaluate whether a particular XML value is a full document or only a content fragment.

Examples

The following example demonstrates how to create XML data and insert it into a table:

Insert a document, and then insert a content fragment. Both types of XML data can be inserted into the same column. If the XML is incorrect (such as a missing tag), the insert fails with the relevant error. The query retrieves only document records.

```
CREATE TABLE test (a xml);

insert into test values (XMLPARSE (DOCUMENT '<?xml ver-
sion="1.0"?><Series><title>Simpsons</title><chapter>...</chapter></Series>'));

insert into test values (XMLPARSE (CONTENT 'note<tag>value</tag><tag>value</tag>'));

select * from test where a IS DOCUMENT;
```

Converting XML data to rows was a feature added in PostgreSQL 10. This can be very helpful reading XML data using a table equivalent:

```
CREATE TABLE xmldata_sample AS SELECT
xml $$
<ROWS>
  <ROW id="1">
    <EMP_ID>532</EMP_ID>
    <EMP_NAME>John</EMP_NAME>
  </ROW>
  <ROW id="5">
    <EMP_ID>234</EMP_ID>
    <EMP_NAME>Carl</EMP_NAME>
    <EMP_DEP>6</EMP_DEP>
    <SALARY unit="dollars">10000</SALARY>
  </ROW>
  <ROW id="6">
    <EMP_ID>123</EMP_ID>
    <EMP_DEP>8</EMP_DEP>
    <SALARY unit="dollars">5000</SALARY>
  </ROW>
</ROWS>
$$ AS data;

SELECT xmltable.*
  FROM xmldata_sample,
       XMLTABLE('//ROWS/ROW'
                PASSING data
                COLUMNS id int PATH '@id',
                       ordinality FOR ORDINALITY,
                       "EMP_NAME" text,
                       "EMP_ID" text PATH 'EMP_ID',
                       SALARY_USD float PATH 'SALARY[@unit = "dollars"]',
                       MANAGER_NAME text PATH 'MANAGER_NAME' DEFAULT 'not specified');

id |ordinality |EMP_NAME |EMP_ID |salary_usd |manager_name
---|-----------|---------|-------|-----------|--------------
1  |1          |John     |532    |           |not specified
5  |2          |Carl     |234    |10000      |not specified
6  |3          |         |123    |5000       |not specified
```

Summary

The following table identifies similarities, differences, and key migration considerations.

Feature	SQL Server	Aurora PostgreSQL
XML and JSON native data types	XML with schema collections	JSON
JSON functions	IS_JSON, JSON_VALUE, JSON_QUERY, JSON_MODFIY, OPEN_JSON, FOR JSON	A set of more than 20 dedicated JSON functions. See: https://www.postgresql.org/docs/13/static/functions-json.html
XML functions	XQUERY and XPATH, OPEN_XML, FOR XML	Many XML functions, see: https://www.postgresql.org/docs/13/static/functions-xml.html Missing the FOR XML cluase, can use string_agg instead.
XML and JSON Indexes	Primary and Secondary PATH, VALUE and PROPERTY indexes	Supported

For additional information on PostgresSQL XML Types & Functions, see:

- *https://www.postgresql.org/docs/13/static/datatype-xml.html*
- *https://www.postgresql.org/docs/13/static/functions-xml.html*

For additional information on the JSON data type & functions, see:

- *https://www.postgresql.org/docs/13/static/datatype-json.html*
- *https://www.postgresql.org/docs/13/static/functions-json.html*

SQL Server MERGE vs. PostgreSQL MERGE

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - MERGE	Rewrite to use INSERT… ON CONFLICT

SQL Server Usage

MERGE is a complex , hybrid DML/DQL statement for performing INSERT, UPDATE, or DELETE operations on a target table based on the results of a logical join of the target table and a source data set.

MERGE can also return row sets similar to SELECT using the OUTPUT clause, which gives the calling scope access to the actual data modifications of the MERGE statement.

The MERGE statement is most efficient for non-trivial conditional DML. For example, inserting data if a row key value does not exist and updating the existing row if the key value already exists.

You can easily manage additional logic such as deleting rows from the target that don't appear in the source. For simple, straightforward updates of data in one table based on data in another, it is typically more efficient to use simple INSERT, DELETE, and UPDATE statements. All MERGE functionality can be replicated using INSERT, DELETE, and UPDATE statements, but not necessarily less efficiently.

The SQL Server MERGE statement provides a wide range of functionality and flexibility and is compatible with ANSI standard SQL:2008. SQL Server has many extensions to MERGE that provide efficient T-SQL solutions for synchronizing data.

Syntax

```
MERGE [INTO] <Target Table> [AS] <Table Alias>]
USING <Source Table>
ON <Merge Predicate>
[WHEN MATCHED [AND <Predicate>]
THEN UPDATE SET <Column Assignments...> | DELETE]
[WHEN NOT MATCHED [BY TARGET] [AND <Predicate>]
THEN INSERT [(<Column List>)]
VALUES (<Values List>) | DEFAULT VALUES]
[WHEN NOT MATCHED BY SOURCE [AND <Predicate>]
THEN UPDATE SET <Column Assignments...> | DELETE]
OUTPUT [<Output Clause>]
```

Examples

Perform a simple one-way synchronization of two tables.

```
CREATE TABLE SourceTable
(
Col1 INT NOT NULL PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
);
```

```
CREATE TABLE TargetTable
(
Col1 INT NOT NULL PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
);
```

```
INSERT INTO SourceTable (Col1, Col2)
VALUES
(2, 'Source2'),
(3, 'Source3'),
(4, 'Source4');
```

```
INSERT INTO TargetTable (Col1, Col2)
VALUES
(1, 'Target1'),
(2, 'Target2'),
(3, 'Target3');
```

```
MERGE INTO TargetTable AS TGT
USING SourceTable AS SRC ON TGT.Col1 = SRC.Col1
WHEN MATCHED
 THEN UPDATE SET TGT.Col2 = SRC.Col2
WHEN NOT MATCHED
 THEN INSERT (Col1, Col2)
 VALUES (SRC.Col1, SRC.Col2);
```

```
SELECT * FROM TargetTable;
```

```
Col1    Col2
-----   -----
1       Target1
2       Source2
3       Source3
4       Source4
```

Perform a conditional two-way synchronization using NULL for "no change" and DELETE from the target when the data is not found in the source.

```
TRUNCATE TABLE SourceTable;
INSERT INTO SourceTable (Col1, Col2) VALUES (3, NULL), (4, 'NewSource4'), (5,
'Source5');
```

```
MERGE INTO TargetTable AS TGT
USING SourceTable AS SRC ON TGT.Col1 = SRC.Col1
WHEN MATCHED AND SRC.Col2 IS NOT NULL
 THEN UPDATE SET TGT.Col2 = SRC.Col2
WHEN NOT MATCHED
 THEN INSERT (Col1, Col2)
 VALUES (SRC.Col1, SRC.Col2)
WHEN NOT MATCHED BY SOURCE
 THEN DELETE;
```

```
SELECT *
FROM TargetTable;
```

```
Col1    Col2
-----   -----
3       Source3
4       NewSource4
5       Source5
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/merge-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Currently, PostgreSQL version 10 does not support the use of the MERGE SQL command. As an alternative, consider using the INSERT… ON CONFLICT clause, which can handle cases where insert clauses might cause a conflict, and then redirect the operation as an update.

Examples

Using the ON ONFLICT clause:

```
CREATE TABLE EMP_BONUS (
EMPLOYEE_ID NUMERIC,
BONUS_YEAR VARCHAR(4),
SALARY NUMERIC,
BONUS NUMERIC,
PRIMARY KEY (EMPLOYEE_ID, BONUS_YEAR));

INSERT INTO EMP_BONUS (EMPLOYEE_ID, BONUS_YEAR, SALARY)
        SELECT EMPLOYEE_ID, EXTRACT(YEAR FROM NOW()), SALARY
        FROM   EMPLOYEES
        WHERE  SALARY < 10000
        ON CONFLICT (EMPLOYEE_ID, BONUS_YEAR)
        DO UPDATE SET BONUS = EMP_BONUS.SALARY * 0.5;

SELECT * FROM EMP_BONUS;
employee_id | bonus_year | salary  |  bonus
------------+------------+---------+----------
103 | 2017       | 9000.00 | 4500.000
104 | 2017       | 6000.00 | 3000.000
105 | 2017       | 4800.00 | 2400.000
106 | 2017       | 4800.00 | 2400.000
107 | 2017       | 4200.00 | 2100.000
109 | 2017       | 9000.00 | 4500.000
110 | 2017       | 8200.00 | 4100.000
111 | 2017       | 7700.00 | 3850.000
112 | 2017       | 7800.00 | 3900.000
113 | 2017       | 6900.00 | 3450.000
115 | 2017       | 3100.00 | 1550.000
116 | 2017       | 2900.00 | 1450.000
117 | 2017       | 2800.00 | 1400.000
118 | 2017       | 2600.00 | 1300.000
```

Running the same operation multiple times using the ON CONFLICT clause does not generate an error because the existing records are redirected to the update clause.

For more information, see:
https://www.postgresql.org/docs/13/static/sql-insert.html

https://www.postgresql.org/docs/13/static/unsupported-features-sql-standard.htm

SQL Server PIVOT and UNPIVOT vs. PostgreSQL PIVOT and UNPIVOT

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - PIVOT	Straight forward rewrite to use traditional SQL syntax

SQL Server Usage

PIVOT and UNPIVOT are relational operations used to transform a set by rotating rows into columns and columns into rows.

PIVOT

The PIVOT operator consists of several clauses and implied expressions.

The "Anchor" column is the column that is not be pivoted and results in a single row per unique value, similar to GROUP BY.

The pivoted columns are derived from the PIVOT clause and are the row values transformed into columns. The values for these columns are derived from the source column defined in the PIVOT clause.

Syntax

```
SELECT <Anchor column>,
       [Pivoted Column 1] AS <Alias>,
       [Pivoted column 2] AS <Alias>
       ...n
FROM
    (<SELECT Statement of Set to be Pivoted>)
    AS <Set Alias>
PIVOT
(
    <Aggregate Function>(<Aggregated Column>)
FOR
[<Column With the Values for the Pivoted Columns Names>]
    IN ( [Pivoted Column 1], [Pivoted column 2] ...)
) AS <Pivot Table Alias>;
```

PIVOT Examples

Create and populate the Orders Table.

```
CREATE TABLE Orders
(
       OrderID INT NOT NULL
       IDENTITY(1,1) PRIMARY KEY,
       OrderDate DATE NOT NULL,
       Customer VARCHAR(20) NOT NULL
);
```

```
INSERT INTO Orders (OrderDate, Customer)
VALUES
('20180101', 'John'),
('20180201', 'Mitch'),
('20180102', 'John'),
('20180104', 'Kevin'),
('20180104', 'Larry'),
```

```
('20180104', 'Kevin'),
('20180104', 'Kevin');
```

Create a simple PIVOT for the number of orders per day (days of month 5-31 omitted for example simplicity).

```
SELECT  'Number of Orders Per Day' AS DayOfMonth,
               [1], [2], [3], [4]  /*...[31]*/
FROM  (
       SELECT  OrderID,
               DAY(OrderDate) AS OrderDay
       FROM    Orders
      ) AS SourceSet
PIVOT
(
 COUNT(OrderID)
 FOR OrderDay IN ([1], [2], [3], [4] /*...[31]*/)
) AS PivotSet;
```

```
DayOfMonth                    1        2       3       4     /*...[31]*/
------                        -        -       -       -
Number of Orders Per Day      2        1       0       4
```

> **Note:** The result set is now oriented in rows vs. columns. The first column is the description of the columns to follow.

PIVOT for number of orders per day per customer.

```
SELECT  Customer,
       [1], [2], [3], [4] /*...[31]*/
FROM  (
       SELECT  OrderID,
               Customer,
               DAY(OrderDate) AS OrderDay
       FROM    Orders
       ) AS SourceSet
PIVOT
(
 COUNT(OrderID)
 FOR OrderDay IN ([1], [2], [3], [4] /*...[31]*/)
) AS PivotSet;
```

```
Customer        1       2       3       4
--------        -       -       -       -
John            1       1       0       0
Kevin           0       0       0       3
Larry           0       0       0       1
Mitch           1       0       0       0
```

UNPIVOT

UNPIVOT is similar to PIVOT in reverse, but spreads existing column values into rows.

The source set is similar to the result of the PIVOT with values pertaining to particular entities listed in columns. Since the result set has more rows than the source, aggregations aren't required.

It is less commonly used than PIVOT because most data in relational databases have attributes in columns; not the other way around.

UNPIVOT Examples

Create an populate the "pivot like" EmployeeSales table (in a actual scenario, this is most likely a view or a set from an external source).

```
CREATE TABLE EmployeeSales
(
SaleDate DATE NOT NULL PRIMARY KEY,
John   INT,
Kevin  INT,
Mary   INT
);
```

```
INSERT INTO EmployeeSales
VALUES
('20180101', 150, 0, 300),
('20180102', 0, 0, 0),
('20180103', 250, 50, 0),
('20180104', 500, 400, 100);
```

Unpivot employee sales per date into individual rows per employee.

```
SELECT SaleDate,
       Employee,
       SaleAmount
FROM
   (
     SELECT SaleDate, John, Kevin, Mary
     FROM EmployeeSales
   ) AS SourceSet
UNPIVOT (
         SaleAmount
         FOR Employee IN (John, Kevin, Mary)
        )AS UnpivotSet;
```

```
SaleDate        Employee        SaleAmount
--------        --------        ----------
2018-01-01      John            150
2018-01-01      Kevin           0
2018-01-01      Mary            300
2018-01-02      John            0
2018-01-02      Kevin           0
2018-01-02      Mary            0
2018-01-03      John            250
2018-01-03      Kevin           50
2018-01-03      Mary            0
2018-01-04      John            500
2018-01-04      Kevin           400
2018-01-04      Mary            100
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/queries/from-using-pivot-and-unpivot?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL does not support the PIVOT and UNPIVOT relational operators.

Functionality of both operators can be rewritten to use standard SQL syntax, as shown in the examples below.

Examples

PIVOT

Create and populate the Orders Table.

```
CREATE TABLE Orders
(
       OrderID SERIAL PRIMARY KEY,
       OrderDate DATE NOT NULL,
       Customer VARCHAR(20) NOT NULL
);
```

```
INSERT INTO Orders (OrderDate, Customer)
VALUES
('20180101', 'John'),
('20180201', 'Mitch'),
('20180102', 'John'),
('20180104', 'Kevin'),
('20180104', 'Larry'),
('20180104', 'Kevin'),
('20180104', 'Kevin');
```

Simple PIVOT for number of orders per day (days of month 5-31 omitted for example simplicity).

```
SELECT 'Number of Orders Per Day' AS DayOfMonth,
       COUNT(CASE WHEN date_part('day', OrderDate) = 1 THEN 'OrderDate' ELSE NULL END) AS
"1",
       COUNT(CASE WHEN date_part('day', OrderDate) = 2 THEN 'OrderDate' ELSE NULL END) AS
"2",
       COUNT(CASE WHEN date_part('day', OrderDate) = 3 THEN 'OrderDate' ELSE NULL END) AS
"3",
       COUNT(CASE WHEN date_part('day', OrderDate) = 4 THEN 'OrderDate' ELSE NULL END) AS
"4" /*...[31]*/
FROM   Orders AS O;
```

```
DayOfMonth                    1        2       3       4     /*...[31]*/
------                        -        -       -       -
Number of Orders Per Day      2        1       0       4
```

PIVOT for number of order per day, per customer.

```
SELECT  Customer,
COUNT(CASE WHEN date_part('day', OrderDate) = 1 THEN 'OrderDate' ELSE NULL END) AS
"1",
COUNT(CASE WHEN date_part('day', OrderDate) = 2 THEN 'OrderDate' ELSE NULL END) AS
"2",
COUNT(CASE WHEN date_part('day', OrderDate) = 3 THEN 'OrderDate' ELSE NULL END) AS
"3",
COUNT(CASE WHEN date_part('day', OrderDate) = 4 THEN 'OrderDate' ELSE NULL END) AS "4"
/*...[31]*/
FROM    Orders AS O
GROUP BY Customer;
```

```
Customer        1       2       3       4
--------        -       -       -       -
John            1       1       0       0
Kevin           0       0       0       3
Larry           0       0       0       1
Mitch           1       0       0       0
```

UNPIVOT

Create an populate the 'pivot like' EmployeeSales table.

> **Note:** in real life this will most likely be a view, or a set from an external source.

```
CREATE TABLE EmployeeSales
(
SaleDate DATE NOT NULL PRIMARY KEY,
John   INT,
Kevin  INT,
Mary   INT
);
```

```
INSERT INTO EmployeeSales
VALUES
('20180101', 150, 0, 300),
('20180102', 0, 0, 0),
('20180103', 250, 50, 0),
('20180104', 500, 400, 100);
```

Unpivot employee sales per date into individual rows per employee.

```
SELECT SaleDate, Employee, SaleAmount
FROM (
       SELECT  SaleDate,
               Employee,
               CASE
                       WHEN Employee = 'John'  THEN 'John'
                       WHEN Employee = 'Kevin' THEN 'Kevin'
                       WHEN Employee = 'Mary'  THEN 'Mary'
               END AS SaleAmount
       FROM EmployeeSales as emp
       CROSS JOIN
       (
```

```
                SELECT 'John' AS Employee
                UNION ALL
                SELECT 'Kevin'
                UNION ALL
                SELECT 'Mary'
        ) AS Employees
) AS UnpivotedSet;
```

```
SaleDate        Employee        SaleAmount
--------        --------        ----------
2018-01-01      John            150
2018-01-01      Kevin           0
2018-01-01      Mary            300
2018-01-02      John            0
2018-01-02      Kevin           0
2018-01-02      Mary            0
2018-01-03      John            250
2018-01-03      Kevin           50
2018-01-03      Mary            0
2018-01-04      John            500
2018-01-04      Kevin           400
2018-01-04      Mary            100
```

SQL Server Triggers vs. PostgreSQL Triggers

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Triggers	Syntax and option differences, similar functionality - PostgreSQL trigger calling a function

SQL Server Usage

Triggers are special types of stored procedures that execute automatically in response to events. They are most commonly used for Data Manipulation Language (DML).

SQL Server supports AFTER/FOR and INSTEAD OF triggers, which can be created on tables and views (AFTER and FOR are synonymous). SQL Server also provides an event trigger framework at the server and database levels that includes Data Definition Language (DDL), Data Control Language (DCL), and general system events such as login.

> **Note:** SQL Sever does not support FOR EACH ROW triggers in which the trigger code is executed once for each row of modified data.

Trigger Execution

AFTER triggers execute after DML statements complete execution. INSTEAD OF triggers execute code in place of the original DML statement. AFTER triggers can be created on tables only. INSTEAD OF triggers can be created on tables and views.

Only a single INSTEAD OF trigger can be created for any given object and event. When multiple AFTER triggers exist for the same event and object, you can partially set the trigger order by using the *sp_settriggerorder* system stored procedure. It allows setting the first and last triggers to be executed, but not the order of others.

Trigger Scope

SQL Server supports statement level triggers only. The trigger code is executed once per statement. The data modified by the DML statement is available to the trigger scope and is saved in two virtual tables: INSERTED and DELETED. These tables contain the entire set of changes performed by the DML statement that caused trigger execution.

SQL triggers always execute within the transaction of the statement that triggered the execution. If the trigger code issues an explicit ROLLBACK, or causes an exception that mandates a rollback, the DML statement is also rolled back. For INSTEAD OF triggers, the DML statement is not executed and does not require a rollback.

Examples

Use a DML Trigger to Audit Invoice Deletions

The following examples demonstrate how to use a trigger to log rows deleted from a table.

Create and populate an Invoices table.

```
CREATE TABLE Invoices
(
InvoiceID       INT NOT NULL PRIMARY KEY,
Customer        VARCHAR(20) NOT NULL,
TotalAmount     DECIMAL(9,2) NOT NULL
);

INSERT INTO Invoices (InvoiceID,Customer,TotalAmount)
VALUES
(1, 'John', 1400.23),
(2, 'Jeff', 245.00),
(3, 'James', 677.22);
```

Create an InvoiceAuditLog table.

```
CREATE TABLE InvoiceAuditLog
(
InvoiceID       INT NOT NULL PRIMARY KEY,
Customer        VARCHAR(20) NOT NULL,
TotalAmount     DECIMAL(9,2) NOT NULL,
DeleteDate      DATETIME NOT NULL DEFAULT (GETDATE()),
DeletedBy       VARCHAR(128) NOT NULL DEFAULT (CURRENT_USER)
);
```

Create an AFTER DELETE trigger to log deletions from the Invoices table to the audit log.

```
CREATE TRIGGER LogInvoiceDeletes
ON Invoices
AFTER DELETE
AS
BEGIN
```

```
INSERT INTO InvoiceAuditLog (InvoiceID, Customer, TotalAmount)
SELECT  InvoiceID,
        Customer,
        TotalAmount
FROM    Deleted
END;
```

Delete an invoice.

```
DELETE FROM Invoices
WHERE InvoiceID = 3;
```

Query the content of both tables.

```
SELECT *
FROM Invoices AS I
     FULL OUTER JOIN
     InvoiceAuditLog AS IAG
     ON I.InvoiceID = IAG.InvoiceID;
```

The example code above displays the following results:

```
InvoiceID   Customer   TotalAmount    InvoiceID   Customer
TotalAmount     DeleteDate       DeletedBy
---------   --------   -----------    ---------   --------     -----------     -------
---       ----------
1           John       1400.23        NULL        NULL         NULL            NULL
         NULL
2           Jeff       245.00         NULL        NULL         NULL            NULL
         NULL
NULL        NULL       NULL           3           James
677.22          20180224 13:02   Domain/JohnCortney
```

Create a DDL Trigger

Create a trigger to protect all tables in the database from accidental deletion.

```
CREATE TRIGGER PreventTableDrop
ON DATABASE FOR DROP_TABLE
AS
BEGIN
    RAISERROR ('Tables Can''t be dropped in this database', 16, 1)
    ROLLBACK TRANSACTION
END;
```

Test the trigger by attempting to drop a table.

```
DROP TABLE [Invoices];
   GO
```

The system displays the follow message explaining that the Invoices table cannot be dropped:

```
Msg 50000, Level 16, State 1, Procedure PreventTableDrop, Line 5 [Batch Start Line 56]
Tables Can't be dropped in this database
```

```
Msg 3609, Level 16, State 2, Line 57
The transaction ended in the trigger. The batch has been aborted.
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/relational-databases/triggers/dml-triggers?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/triggers/ddl-triggers?view=sql-server-ver15*

PostgreSQL Usage

Triggers provide much of the same functionality as SQL Server:

- **DML Triggers** execute based on table related events, such as DML.
- **Event Triggers** execute after certain database events, such as running DDL commands.

Unlike SQL Server triggers, PostgreSQL triggers must call a function. They do not support anonymous blocks of PL/pgSQL code as part of the trigger body. The user-supplied function is declared with no arguments and has a return type of trigger.

PostgreSQL DML Triggers

- PostgreSQL triggers can be fired BEFORE or AFTER a DML operation.
  - They execute before the operation is attempted on a row.
    - Before constraints are checked and the INSERT, UPDATE, or DELETE is attempted.
    - If the trigger executes before or instead of the event, the trigger can skip the operation for the current row or change the row being inserted (for INSERT and UPDATE operations only).
  - Triggers can execute after the operation was completed, after constraints are checked, and the INSERT, UPDATE, or DELETE command completed. If the trigger executes after the event, all changes, including the effects of other triggers, are "visible" to the trigger.
- PostgreSQL triggers can run INSTEAD OF a DML command when created on views.
- PostgreSQL triggers can run FOR EACH ROW affected by the DML statement or FOR EACH STATEMENT running only once as part of a DML statement.

When Fired	Database Event	Row-Level Trigger (FOR EACH ROW)	Statement-Level Trigger (FOR EACH STATEMENT)
BEFORE	INSERT, UPDATE, DELETE	Tables and foreign tables	Tables, views, and foreign tables
	TRUNCATE	–	Tables
AFTER	INSERT, UPDATE, DELETE	Tables and foreign tables	Tables, views, and foreign tables
	TRUNCATE	–	Tables
INSTEAD OF	INSERT, UPDATE, DELETE	Views	–
	TRUNCATE	–	–

PostgreSQL Event Triggers

An event trigger executes when a specific event associated with the trigger occurs in the database. Supported events include ddl_command_start, ddl_command_end, table_rewrite, and sql_drop.

- **ddl_command_start** occurs before the execution of a CREATE, ALTER, DROP, SECURITY LABEL, COMMENT, GRANT, REVOKE or SELECT INTO command.
- **ddl_command_end** occurs after the command completed and before the transaction commits.
- **sql_drop** executes only for the DROP DDL command, before the ddl_command_end trigger executes.

For a full list of supported PostgreSQL event trigger types, see https://www.postgresql.org/docs/13/static/event-trigger-matrix.html

PostgreSQL CREATE TRIGGER Synopsis

```
CREATE [ CONSTRAINT ] TRIGGER name { BEFORE | AFTER | INSTEAD OF } { event [ OR ... ]
}
    ON table_name
    [ FROM referenced_table_name ]
    [ NOT DEFERRABLE | [ DEFERRABLE ] [ INITIALLY IMMEDIATE | INITIALLY DEFERRED ] ]
    [ REFERENCING { { OLD | NEW } TABLE [ AS ] transition_relation_name } [ ... ] ]
    [ FOR [ EACH ] { ROW | STATEMENT } ]
    [ WHEN ( condition ) ]
    EXECUTE PROCEDURE function_name ( arguments )

where event can be one of:

    INSERT
    UPDATE [ OF column_name [, ... ] ]
    DELETE
    TRUNCATE
```

Note: REFERENCING is a new option since PostgreSQL 10. It can be used with AFTER trigger to interact with the overall view of the OLD or the NEW TABLE changed rows.

Example

Create a Trigger

Create a trigger function that stores the execution logic (this is the same as a SQL Server DML trigger).

```
CREATE OR REPLACE FUNCTION PROJECTS_SET_NULL()
 RETURNS TRIGGER
 AS $$
 BEGIN
IF TG_OP = 'UPDATE' AND OLD.PROJECTNO != NEW.PROJECTNO OR
  TG_OP = 'DELETE' THEN
UPDATE EMP
                        SET PROJECTNO = NULL
               WHERE EMP.PROJECTNO = OLD.PROJECTNO;
               END IF;
```

```
                IF TG_OP = 'UPDATE' THEN RETURN NULL;
                        ELSIF TG_OP = 'DELETE' THEN RETURN NULL;
                END IF;
 END; $$
 LANGUAGE  PLPGSQL;

CREATE FUNCTION
```

Create the trigger.

```
CREATE TRIGGER TRG_PROJECTS_SET_NULL
 AFTER UPDATE OF PROJECTNO OR DELETE
 ON PROJECTS
 FOR EACH ROW
 EXECUTE PROCEDURE PROJECTS_SET_NULL();

CREATE TRIGGER
```

Test the trigger by deleting a row from the PROJECTS table.

```
DELETE FROM PROJECTS WHERE PROJECTNO=123;
SELECT PROJECTNO FROM EMP WHERE PROJECTNO=123;

 projectno
-----------
(0 rows)
```

Create a DDL Trigger

Create an event trigger function (this is the same as a SQL Server DDL System/Schema level trigger, such as a trigger that prevents running a DDL DROP on objects in the HR schema).

Note that trigger functions are created with no arguments and must have a return type of TRIGGER or EVENT_TRIGGER.

```
CREATE OR REPLACE FUNCTION ABORT_DROP_COMMAND()
        RETURNS EVENT_TRIGGER
        AS $$
 BEGIN
               RAISE EXCEPTION 'The % Command is Disabled', tg_tag;
 END; $$
 LANGUAGE PLPGSQL;

CREATE FUNCTION
```

Create the event trigger, which executes before the start of a DDL DROP command.

```
CREATE EVENT TRIGGER trg_abort_drop_command
       ON DDL_COMMAND_START
       WHEN TAG IN ('DROP TABLE', 'DROP VIEW', 'DROP FUNCTION', 'DROP
                     SEQUENCE', 'DROP MATERIALIZED VIEW', 'DROP TYPE')
       EXECUTE PROCEDURE abort_drop_command();
```

Test the trigger by attempting to drop the EMPLOYEES table.

```
DROP TABLE EMPLOYEES;

ERROR:  The DROP TABLE Command is Disabled
CONTEXT:  PL/pgSQL function abort_drop_command() line 3 at RAISE
```

Summary

Feature	SQL Server	Aurora PostgreSQL
DML Triggers Scope	Statement level only	FOR EACH ROW and FOR EACH STATMENT
Access to change set	INSERTED and DELETED Virtual multi-row tables	OLD and NEW virtual one-row tables or the whole view of changed rows
System event triggers	DDL, DCL and other event types	Event triggers
Trigger execution phase	AFTER and INSTEAD OF	AFTER, BEFORE, and INSTEAD OF
Multi-trigger execution order	Can only set first and last using *sp_settriggerorder*	Call function within a function
Drop a trigger	DROP TRIGGER <trigger name>;	DROP TRIGGER <trigger name>;
Modify trigger code	Use the ALTER TRIGGER statement	Modify function code
Enable/Disable a trigger	Use the ALTER TRIGGER <trigger name> ENABLE; and ALTER TRIGGER <trigger name> DISABLE;	ALTER TABLE
Triggers on views	INSTEAD OF TRIGGERS only	INSTEAD OF TRIGGERS only

For additional details, see https://www.postgresql.org/docs/13/static/plpgsql-trigger.html

SQL Server TOP and FETCH vs. PostgreSQL LIMIT and OFFSET (TOP and FETCH Equivalent)

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - TOP and FETCH	TOP is not supported

SQL Server Usage

SQL Server supports two options for limiting and paging result sets returned to the client. TOP is a legacy, proprietary T-SQL keyword that is still supported due to its wide usage. The ANSI compliant syntax of FETCH and OFFSET were introduced in SQL Server 2012 and are recommended for paginating results sets.

TOP

The TOP (n) operator is used in the SELECT list and limits the number of rows returned to the client based on the ORDER BY clause.

Note: When TOP is used with no ORDER BY clause, the query is non-deterministic and may return any rows up to the number specified by the TOP operator.

TOP (n) can be used with two modifier options:

- **TOP (n) PERCENT** is used to designate a percentage of the rows to be returned instead of a fixed maximal row number limit (n). When using PERCENT, n can be any value from 1-100.
- **TOP (n) WITH TIES** is used to allow overriding the n maximal number (or percentage) of rows specified in case there are additional rows with the same ordering values as the last row.

Note: If TOP (n) is used without WITH TIES and there are additional rows that have the same ordering value as the last row in the group of n rows, the query is also non-deterministic because the last row may be any of the rows that share the same ordering value.

Syntax

```
SELECT TOP (<Limit Expression>) [PERCENT] [ WITH TIES ] <Select Expressions List>
FROM...
```

OFFSET... FETCH

OFFSET... FETCH as part of the ORDER BY clause is the ANSI compatible syntax for limiting and paginating result sets. It allows specification of the starting position and limits the number of rows returned, which enables easy pagination of result sets.

Similar to TOP, OFFSET... FETCH relies on the presentation order defined by the ORDER BY clause. Unlike TOP, it is part of the ORDER BY clause and can't be used without it.

Note: Queries using FETCH... OFFSET can still be non-deterministic if there is more than one row that has the same ordering value as the last row.

Syntax

```
ORDER BY <Ordering Expression> [ ASC | DESC ] [ ,...n ]
OFFSET  <Offset Expression> { ROW | ROWS }
[FETCH { FIRST | NEXT } <Page Size Expression> { ROW | ROWS } ONLY ]
```

Examples

Create the OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
```

```
(2, 'M8 Nut', 100),
(3, 'M8 Washer', 200),
(3, 'M6 Locking Nut', 300);
```

Retrieve the 3 most ordered items by quantity.

```
-- Using TOP
SELECT TOP (3) *
FROM OrderItems
ORDER BY Quantity DESC;

-- USING FETCH
SELECT *
FROM OrderItems
ORDER BY Quantity DESC
OFFSET 0 ROWS FETCH NEXT 3 ROWS ONLY;
```

```
OrderID Item            Quantity
------- ----            --------
3       M6 Locking Nut  300
3       M8 Washer       200
2       M8 Nut          100
```

Include rows with ties.

```
SELECT TOP (3) WITH TIES *
FROM OrderItems
ORDER BY Quantity DESC;
```

```
OrderID Item            Quantity
------- ----            --------
3       M6 Locking Nut  300
3       M8 Washer       200
2       M8 Nut          100
1       M8 Bolt         100
```

Retrieve half the rows based on quantity.

```
SELECT TOP (50) PERCENT *
FROM OrderItems
ORDER BY Quantity DESC;
```

```
OrderID Item            Quantity
------- ----            --------
3       M6 Locking Nut  300
3       M8 Washer       200
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/t-sql/queries/select-order-by-clause-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/queries/top-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL supports the non-ANSI compliant (but popular with other engines) LIMIT... OFFSET operator for paging results sets.

The LIMIT clause limits the number of rows returned and does not require an ORDER BY clause, although that would make the query non-deterministic.

The OFFSET clause is zero-based, similar to SQL Server and used for pagination.
OFFSET 0 is the same as omitting the OFFSET clause, as is OFFSET with a NULL argument.

Syntax

```
SELECT select_list
    FROM table_expression
    [ ORDER BY ... ]
    [ LIMIT { number | ALL } ] [ OFFSET number ]
```

Migration Considerations

LIMIT... OFFSET syntax can be used to replace the functionality of both TOP(n) and FETCH... OFFSET in SQL Server. It is automatically converted by the Schema Conversion Tool (SCT) except for the WITH TIES and PERCENT modifiers.

To replace the PERCENT option, you must first calculate how many rows the query returns and then calculate the fixed number of rows to be returned based on that number (see the example below).

> **Note:** Since this technique involves added complexity and accessing the table twice, consider changing the logic to use a fixed number instead of percentage.

To replace the WITH TIES option, you must rewrite the logic to add another query that checks for the existence of additional rows that have the same ordering value as the last row returned from the LIMIT clause.

> **Note:** Since this technique introduces significant added complexity and three accesses to the source table, consider changing the logic to introduce a tie-breaker into the ORDER BY clause (see the example below).

Examples

Create the OrderItems table.

```
CREATE TABLE OrderItems
(
 OrderID INT NOT NULL,
 Item VARCHAR(20) NOT NULL,
 Quantity SMALLINT NOT NULL,
 PRIMARY KEY(OrderID, Item)
);
```

```
INSERT INTO OrderItems (OrderID, Item, Quantity)
VALUES
(1, 'M8 Bolt', 100),
(2, 'M8 Nut', 100),
```

```
(3, 'M8 Washer', 200),
(3, 'M6 Locking Nut', 300);
```

Retrieve the three most ordered items by quantity.

```
SELECT *
FROM OrderItems
ORDER BY Quantity DESC
LIMIT 3 OFFSET 0;
```

```
OrderID Item            Quantity
------- ----            --------
3       M6 Locking Nut  300
3       M8 Washer       200
1       M8 Bolt         100
```

Include rows with ties.

```
SELECT *
FROM
(
 SELECT *
 FROM OrderItems
 ORDER BY Quantity DESC
 LIMIT 3 OFFSET 0
) AS X
UNION
SELECT *
FROM OrderItems
WHERE Quantity = (
                  SELECT Quantity
                  FROM OrderItems
                  ORDER BY Quantity DESC
                  LIMIT 1 OFFSET 2
                 )
ORDER BY Quantity DESC
```

```
OrderID Item            Quantity
------- ----            --------
3       M6 Locking Nut  300
3       M8 Washer       200
2       M8 Nut          100
1       M8 Bolt         100
```

Retrieve half the rows based on quantity.

```
CREATE or replace FUNCTION getOrdersPct(int) RETURNS SETOF  OrderItems AS $$
    SELECT * FROM OrderItems
    ORDER BY Quantity desc LIMIT (SELECT COUNT(*)*$1/100 FROM OrderItems) oFFSET 0;
$$ LANGUAGE SQL;
```

```
SELECT * from getOrdersPct(50);
or
SELECT getOrdersPct(50);
```

```
OrderID Item            Quantity
------- ----            --------
3        M6 Locking Nut  300
3       M8 Washer       200
```

Summary

SQL Server	Aurora PostgreSQL	Comments
TOP (n)	LIMIT n	
TOP (n) WITH TIES	Not supported	See examples for work-around
TOP (n) PERCENT	Not supported	See examples for work-around
OFFSET... FETCH	LIMIT... OFFSET	

For more information, see https://www.postgresql.org/docs/13/static/queries-limit.html

SQL Server User DefinedFunctions vs. PostgreSQL User Defined Functions

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Syntax and option differences

SQL Server Usage

User Defined Functions (UDF) are code objects that accept input parameters and return either a scalar value or a set consisting of rows and columns. SQL Server UDFs can be implemented using T-SQL or Common Language Runtime (CLR) code.

Note: This section does not cover CLR code objects.

Function invocations can not have any lasting impact on the database. They must be contained and can only modify objects and data local to their scope (for example, data in local variables). Functions are not allowed to modify data or the structure of a database.

Functions may be deterministic or non-deterministic. Deterministic functions always return the same result when executed with the same data. Non-deterministic functions may return different results each time they execute. For example, a function that returns the current date or time.

SQL Server supports three types of T-SQL UDFs: Scalar Functions, Table-Valued Functions, and Multi-Statement Table-Valued Functions.

SQL Server 2019 adds Scalar User Defined Functions (UDF) inlining. Inlining transforms functions into relational expressions and embeds them in the calling SQL query. This transformation improves the performance of workloads that take advantage of scalar UDFs. Scalar UDF inlining facilitates cost-based optimization of operations

inside UDFs. The results are efficient, set-oriented, and parallel instead of inefficient, iterative, serial execution plans. For more information see Scalar UDF Inlining

Scalar User Defined Functions

Scalar UDFs accept zero or more parameters and return a scalar value. They can be used in T-SQL expressions.

Syntax

```
CREATE FUNCTION <Function Name> ([{<Parameter Name> [AS] <Data Type> [= <Default
Value>] [READONLY]} [,...n]])
RETURNS <Return Data Type>
[AS]
BEGIN
<Function Body Code>
RETURN <Scalar Expression>
END[;]
```

Examples

Create a scalar function to change the first character of a string to upper case.

```
CREATE FUNCTION dbo.UpperCaseFirstChar (@String VARCHAR(20))
RETURNS VARCHAR(20)
AS
BEGIN
RETURN UPPER(LEFT(@String, 1)) + LOWER(SUBSTRING(@String, 2, 19))
END;
```

```
SELECT dbo.UpperCaseFirstChar ('mIxEdCasE');

---------
Mixedcase
```

User Defined Table-Valued Functions

Inline table-valued UDFs are similar to views or a Common Table Expressions (CTE) with the added benefit of parameters. They can be used in FROM clauses as subqueries and can be joined to other source table rows using the APPLY and OUTER APPLY operators. In-line table valued UDFs have many associated internal optimizer optimizations due to their simple, view-like characteristics.

Syntax

```
CREATE FUNCTION <Function Name> ([{<Parameter Name> [AS] <Data Type> [= <Default
Value>] [READONLY]} [,...n]])
RETURNS TABLE
[AS]
RETURN (<SELECT Query>)[;]
```

Examples

Create a table valued function to aggregate employee orders.

```
CREATE TABLE Orders
(
OrderID INT NOT NULL PRIMARY KEY,
EmployeeID INT NOT NULL,
OrderDate DATETIME NOT NULL
);
```

```
INSERT INTO Orders (OrderID, EmployeeID, OrderDate)
VALUES
(1, 1, '20180101 13:00:05'),
(2, 1, '20180201 11:33:12'),
(3, 2, '20180112 10:22:35');
```

```
CREATE FUNCTION dbo.EmployeeMonthlyOrders
(@EmployeeID INT)
RETURNS TABLE AS
RETURN
(
SELECT  EmployeeID,
        YEAR(OrderDate) AS OrderYear,
        MONTH(OrderDate) AS OrderMonth,
        COUNT(*) AS NumOrders
FROM    Orders AS O
WHERE   EmployeeID = @EmployeeID
GROUP BY EmployeeID,
         YEAR(OrderDate),
         MONTH(OrderDate)
);
```

```
SELECT  *
FROM    dbo.EmployeeMonthlyOrders (1)

EmployeeID      OrderYear       OrderMonth      NumOrders
----------      ---------       ----------      ---------
1               2018            1               1
1               2018            2               1
```

Multi-Statment User Defined Table-Valued Functions

Multi-statement table-valued UDFs , like In-line UDFs, are also similar to views or CTEs with the added benefit of parameters. They can be used in FROM clauses as sub queries and can be joined to other source table rows using the APPLY and OUTER APPLY operators.

The difference between multi-statement UDFs and the inline UDFs is that multi-statement UDFs are not restricted to a single SELECT statement. They can consist of multiple statements including logic implemented with flow control, complex data processing, security checks, etc.

The downside of using multi-statement UDFs is that there are far less optimizations possible and performance may suffer.

Syntax

```
CREATE FUNCTION <Function Name> ([{<Parameter Name> [AS] <Data Type> [= <Default
Value>] [READONLY]} [,...n]])
RETURNS <@Return Variable> TABLE <Table Definition>
[AS]
BEGIN
<Function Body Code>
RETURN
END[;]
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/create-function-transact-sql?view=sql-server-ver15

PostgreSQL Usage

See Stored Procedures.

Syntax

```
CREATE [ OR REPLACE ] FUNCTION
    name ( [ [ argmode ] [ argname ] argtype [ { DEFAULT | = } default_expr ] [, ...]
] )
    [ RETURNS rettype
      | RETURNS TABLE ( column_name column_type [, ...] ) ]
  { LANGUAGE lang_name
    | TRANSFORM { FOR TYPE type_name } [, ... ]
    | WINDOW
    | IMMUTABLE | STABLE | VOLATILE | [ NOT ] LEAKPROOF
    | CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT
    | [ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER
    | PARALLEL { UNSAFE | RESTRICTED | SAFE }
    | COST execution_cost
    | ROWS result_rows
    | SET configuration_parameter { TO value | = value | FROM CURRENT }
    | AS 'definition'
    | AS 'obj_file', 'link_symbol'
  } ...
    [ WITH ( attribute [, ...] ) ]
```

SQL Server User Defined Types vs. PostgreSQL User Defined Types

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
			Syntax and option differences

SQL Server Usage

SQL Server User defined Types provide a mechanism for encapsulating custom data types and for adding NULL constraints.

SQL Server also supports table-valued user defined types, which you can use to pass a set of values to a stored procedure.

User defined types can also be associated to CLR code assemblies. Beginning with SQL Server 2014, memory optimized types support memory optimized tables and code.

> **Note:** If your code uses custom rules bound to data types, Microsoft recommends discontinuing the use of this deprecated feature.

All user defined types are based on an existing system data types. They allow developers to reuse the definition, making the code and schema more readable.

Syntax

The simplified syntax for the CREATE TYPE statement is specified below.

```
CREATE TYPE <type name> {
FROM <base type> [ NULL | NOT NULL ] | AS TABLE (<Table Definition>)}
```

Examples

User Defined Types

Create a ZipCode Scalar User Defined Type.

```
CREATE TYPE ZipCode
FROM CHAR(5)
NOT NULL
```

Use the ZipCode type in a table.

```
CREATE TABLE UserLocations
(UserID INT NOT NULL PRIMARY KEY, ZipCode ZipCode);

INSERT INTO [UserLocations] ([UserID],[ZipCode]) VALUES (1, '94324');
INSERT INTO [UserLocations] ([UserID],[ZipCode]) VALUES (2, NULL);
```

The above code displays the following error message indicating NULL values for ZipCode are not allowed.

```
Msg 515, Level 16, State 2, Line 78
Cannot insert the value NULL into column 'ZipCode', table 'tempdb.dbo.UserLocations';
column does not allow nulls. INSERT fails.
The statement has been terminated.
```

Table-Valued types

The following example demonstrates how to create and use a table valued types to pass a set of values to a stored procedure:

Create the OrderItems table.

```
CREATE TABLE OrderItems
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

Create a table valued type for the OrderItems table.

```
CREATE TYPE OrderItems
AS TABLE
(
OrderID INT NOT NULL,
Item VARCHAR(20) NOT NULL,
Quantity SMALLINT NOT NULL,
PRIMARY KEY(OrderID, Item)
);
```

Create the InsertOrderItems procedure. Note that the entire set of rows from the table valued parameter is handled with one statement.

```
CREATE PROCEDURE InsertOrderItems
@OrderItems AS OrderItems READONLY
AS
BEGIN
    INSERT INTO OrderItems(OrderID, Item, Quantity)
    SELECT OrderID,
           Item,
           Quantity
    FROM @OrderItems;
END
```

Instantiate the OrderItems type, insert the values, and pass it to a stored procedure.

```
DECLARE @OrderItems AS OrderItems;

INSERT INTO @OrderItems ([OrderID], [Item], [Quantity])
VALUES
(1, 'M8 Bolt', 100),
(1, 'M8 Nut', 100),
(1, M8 Washer, 200);

EXECUTE [InsertOrderItems] @OrderItems = @OrderItems;

(3 rows affected)
```

Select all rows from the OrderItems table.

```
SELECT * FROM OrderItems;

OrderID     Item          Quantity
-------     ----          --------
1           M8 Bolt       100
1           M8 Nut        100
1           M8 Washer     200
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/create-type-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Similar to SQL Server, PostgreSQL enables creation of User Defined Types using the CREATE TYPE statement. A User Defined Type is owned by the user who creates it. If a schema name is specified, the type is created under that schema.

PostgreSQL supports the creation of several different User Defined Types:

- **Composite Types** store a single named attribute attached to a data type or multiple attributes as an attribute collection. In PostgreSQL, you can also use the CREATE TYPE statement standalone with an association to a table.
- **Enumerated Types (enum)** store a static ordered set of values. For example, product categories.

  ```
  CREATE TYPE PRODUCT_CATEGORT AS ENUM
          ('Hardware', 'Software', 'Document');
  ```

- **Range Types** store a range of values, for example, a range of timestamps used to represent the ranges of time of when a course is scheduled.

  ```
  CREATE TYPE float8_range AS RANGE
          (subtype = float8, subtype_diff = float8mi);
  ```

  For more information see https://www.postgresql.org/docs/13/static/rangetypes.html

- **Base Types** are the system core types (abstract types) and are implemented in a low-level language such as C.
- **Array Types** support definition of columns as multidimensional arrays. An array column can be created with a built-in type or a user-defined base type, enum type, or composite.

  ```
  CREATE TABLE COURSE_SCHEDULE (
          COURSE_ID         NUMERIC PRIMARY KEY,
    COURSE_NAME       VARCHAR(60),
    COURSE_SCHEDULES text[]);
  ```

  For additional details, see https://www.postgresql.org/docs/13/static/arrays.html

Syntax

```
CREATE TYPE name AS RANGE (
    SUBTYPE = subtype
```

```
    [ , SUBTYPE_OPCLASS = subtype_operator_class ]
    [ , COLLATION = collation ]
    [ , CANONICAL = canonical_function ]
    [ , SUBTYPE_DIFF = subtype_diff_function ]
)

CREATE TYPE name (
    INPUT = input_function,
    OUTPUT = output_function
    [ , RECEIVE = receive_function ]
    [ , SEND = send_function ]
    [ , TYPMOD_IN = type_modifier_input_function ]
    [ , TYPMOD_OUT = type_modifier_output_function ]
    [ , ANALYZE = analyze_function ]
    [ , INTERNALLENGTH = { internallength | VARIABLE } ]
    [ , PASSEDBYVALUE ]
    [ , ALIGNMENT = alignment ]
    [ , STORAGE = storage ]
    [ , LIKE = like_type ]
    [ , CATEGORY = category ]
    [ , PREFERRED = preferred ]
    [ , DEFAULT = default ]
    [ , ELEMENT = element ]
    [ , DELIMITER = delimiter ]
    [ , COLLATABLE = collatable ]
)
```

Examples

Create a User Define Type for storing an employee phone numbers.

```
CREATE TYPE EMP_PHONE_NUM AS (
         PHONE_NUM VARCHAR(11));

CREATE TABLE EMPLOYEES (
         EMP_ID    NUMERIC PRIMARY KEY,
         EMP_PHONE EMP_PHONE_NUM NOT NULL);

INSERT INTO EMPLOYEES VALUES(1, ROW('111-222-333'));

SELECT a.EMP_ID, (a.EMP_PHONE).PHONE_NUM FROM EMPLOYEES a;

 emp_id |  phone_num
--------+-------------
      1 | 111-222-333
(1 row)
```

Create a PostgreSQL Object Type as a collection of Attributes for the employees table.

```
CREATE OR REPLACE TYPE EMP_ADDRESS AS OBJECT (
         STATE    VARCHAR(2),
         CITY     VARCHAR(20),
         STREET   VARCHAR(20),
         ZIP_CODE NUMERIC);
```

```
CREATE TABLE EMPLOYEES (
         EMP_ID      NUMERIC PRIMARY KEY,
         EMP_NAME    VARCHAR(10) NOT NULL,
         EMP_ADDRESS EMP_ADDRESS NOT NULL);

INSERT INTO EMPLOYEES
         VALUES(1, 'John Smith',
        ('AL', 'Gulf Shores', '3033 Joyce Street', '36542'));

SELECT a.EMP_NAME,
                (a.EMP_ADDRESS).STATE,
                (a.EMP_ADDRESS).CITY,
                (a.EMP_ADDRESS).STREET,
                 (a.EMP_ADDRESS).ZIP_CODE
 FROM EMPLOYEES a;

  emp_name   | state |    city     |      street       | zip_code
-------------+-------+-------------+-------------------+----------
 John Smith | AL    | Gulf Shores | 3033 Joyce Street |    36542
```

For additional details, see:

- *https://www.postgresql.org/docs/13/static/sql-createtype.html*
- *https://www.postgresql.org/docs/13/static/rowtypes.htm*

SQL Server Sequences and Identity vs. PostgreSQL Sequences and SERIAL/IDENTITY

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Sequences and Identity	Less options with SERIAL Reseeding needs to be rewritten

SQL Server Usage

Automatic enumeration functions and columns are common with relational database management systems and are often used for generating surrogate keys.

SQL Server provides several features that support automatic generation of monotonously increasing value generators.

- IDENTITY property of a table column
- SEQUENCE objects framework
- Numeric functions such as IDENTITY and NEWSEQUENTIALID

Identity

The IDENTITY property is probably the most widely used means of generating surrogate primary keys in SQL Server applications. Each table may have a single numeric column assigned as an IDENTITY, using the CREATE TABLE or ALTER TABLE DDL statements. You can explicitly specify a starting value and increment.

> **Note:** The identity property does not enforce uniqueness of column values, indexing, or any other property. Additional constraints such as Primary or Unique keys, explicit index specifications, or other properties must be specified in addition to the IDENTITY property.

The IDENTITY value is generated as part of the transaction that inserts table rows. Applications can obtain IDENTITY values using the @@IDENTITY, SCOPE_IDENTITY, and IDENT_CURRENT functions.

You can manage IDENTITY columns using the DBCC CHECKIDENT command, which provides functionality for reseeding and altering properties.

Syntax

```
IDENTITY [(<Seed Value>, <Increment Value>)]
```

Examples

Create a table with an IDENTITY column.

```
CREATE TABLE MyTABLE
(
Col1 INT NOT NULL
 PRIMARY KEY NONCLUSTERED IDENTITY(1,1),
Col2 VARCHAR(20) NOT NULL
);
```

Insert a row and retrieve the generated IDENTITY value.

```
DECLARE @LastIdent INT;
INSERT INTO MyTable(Col2)
VALUES('SomeString');
SET @LastIdent = SCOPE_IDENTITY()
```

Create a table with a non-key IDENTITY column and an increment of 10.

```
CREATE TABLE MyTABLE
(
Col1 VARCHAR(20) NOT NULL
 PRIMARY KEY,
Col2 INT NOT NULL
 IDENTITY(1,10),
);
```

Create a table with a compound PK including an IDENTITY column.

```
CREATE TABLE MyTABLE
(
Col1 VARCHAR(20) NOT NULL,
Col2 INT NOT NULL
```

```
 IDENTITY(1,10),
PRIMARY KEY (Col1, Col2)
);
```

SEQUENCE

Sequences are objects that are independent of a particular table or column and are defined using the CREATE SEQUENCE DDL statement. You can manage sequences using the ALTER SEQUENCE statement. Multiple tables and multiple columns from the same table may use the values from one or more SEQUENCE objects.

You can retrieve a value from a SEQUENCE object using the NEXT VALUE FOR function. For example, a SEQUENCE value can be used as a default value for a surrogate key column.

SEQUENCE objects provide several advantages over IDENTITY columns:

- Can be used to obtain a value before the actual INSERT takes place.
- Value series can be shared among columns and tables.
- Easier management, restart, and modification of sequence properties.
- Allows assignment of value ranges using sp_sequence_get_range and not just per-row values.

Syntax

```
CREATE SEQUENCE <Sequence Name> [AS <Integer Data Type> ]
START WITH <Seed Value>
INCREMENT BY <Increment Value>;
```

```
ALTER SEQUENCE <Sequence Name>
RESTART [WITH <Reseed Value>]
INCREMENT BY <New Increment Value>;
```

Examples

Create a sequence and use it for a primary key default.

```
CREATE SEQUENCE MySequence AS INT START WITH 1 INCREMENT BY 1;
CREATE TABLE MyTable
(
Col1 INT NOT NULL
 PRIMARY KEY NONCLUSTERED DEFAULT (NEXT VALUE FOR MySequence),
Col2 VARCHAR(20) NULL
);
```

```
INSERT MyTable (Col1, Col2) VALUES (DEFAULT, 'cde'), (DEFAULT, 'xyz');
```

```
SELECT * FROM MyTable;
```

```
Col1    Col2
----    ----
1       cde
2       xyz
```

Sequential Enumeration Functions

SQL Server provides two sequential generation functions: IDENTITY and NEWSEQUENTIALID.

> **Note:** The IDENTITY function should not be confused with the IDENTITY property of a column.

The IDENTITY function can be used only in a SELECT ... INTO statement to insert IDENTITY column values into a new table.

The NEWSEQUNTIALID function generates a hexadecimal GUID, which is an integer. While the NEWID function generates a random GUID, the NEWSEQUENTIALID function guarantees that every GUID created is greater (in numeric value) than any other GUID previously generated by the same function on the same server since the operating system restart.

> **Note:** NEWSEQUENTIALID can be used only with DEFAULT constraints associated with columns having a UNIQUEIDENTIFIER data type.

Syntax

```
IDENTITY (<Data Type> [, <Seed Value>, <Increment Value>]) [AS <Alias>]
```

```
NEWSEQUENTIALID()
```

Examples

Use the IDENTITY function as surrogate key for a new table based on an existing table.

```
CREATE TABLE MySourceTable
(
Col1 INT NOT NULL PRIMARY KEY,
Col2 VARCHAR(10) NOT NULL,
Col3 VARCHAR(10) NOT NULL
);
```

```
INSERT INTO MySourceTable
VALUES
(12, 'String12', 'String12'),
(25, 'String25', 'String25'),
(95, 'String95', 'String95');
```

```
SELECT  IDENTITY(INT, 100, 1) AS SurrogateKey,
        Col1,
        Col2,
        Col3
INTO MyNewTable
FROM MySourceTable
ORDER BY Col1 DESC;
```

```
SELECT *
FROM MyNewTable;
```

```
SurrogateKey   Col1    Col2       Col3
------------   ----    ----       ----
```

```
100             95      String95    String95
101             25      String25    String25
102             12      String12    String12
```

Use NEWSEQUENTIALID as a surrogate key for a new table.

```
CREATE TABLE MyTable
(
Col1 UNIQUEIDENTIFIER NOT NULL
 PRIMARY KEY NONCLUSTERED DEFAULT NEWSEQUENTIALID()
);
```

```
INSERT INTO MyTable
DEFAULT VALUES;
```

```
SELECT *
FROM MyTable;
```

```
Col1
----
9CC01320-C5AA-E811-8440-305B3A017068
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/relational-databases/sequence-numbers/sequence-numbers?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-table-transact-sql-identity-property?view=sql-server-ver15*

PostgreSQL Usage

The PostgreSQL CREATE SEQUENCE command is mostly compatible with the SQL Server CREATE SEQUENCE command. Sequences in PostgreSQL serve the same purpose as in SQL Server; they generate numeric identifiers automatically. A sequence object is owned by the user that created it.

Sequence Parameters

- **TEMPORARY or TEMP:** PostgreSQL can create a temporary sequence within a session. Once the session ends, the sequence is automatically dropped.
- **IF NOT EXISTS:** Creates a sequence. If a sequence with an identical name already exists, it is replaced.
- **INCREMENT BY:** An optional parameter with a default value of 1. Positive values generate sequence values in ascending order. Negative values generate sequence values in descending sequence.
- **START WITH:** An optional parameter having a default of 1. It uses the MINVALUE for ascending sequences and the MAXVALUE for descending sequences.
- **MAXVALUE | NO MAXVALUE:** Defaults are between 263 for ascending sequences and -1 for descending sequences.
- **MINVALUE | NO MINVALUE:** Defaults are between 1 for ascending sequences and -263 for descending sequences.

- **CYCLE | NO CYCLE:** If the sequence value reaches MAXVALUE or MINVALUE, the CYCLE parameter instructs the sequence to return to the initial value (MINVALUE or MAXVALUE). The default is NO CYCLE.
- **CACHE:** In PostgreSQL, the NOCACHE is not supported. By default, when the CACHE parameter is not specified, no sequence values are pre-cached into memory (equivalent to the SQL Server NOCACHE parameter). The minimum value is 1.
- **OWNED BY | OWNBY NON:** Specifies that the sequence object is to be associated with a specific column in a table. When dropping this type of sequence, an error is returned due to the sequence/table association.
- **AS data_type:** This is a new option, starting at PostgreSQL 10. To easily determine the minimum/maximum values and also improve storage management you can select the data type for the sequence. The available data types are smallint, integer, and bigint (default).

Syntax

```
CREATE [ TEMPORARY | TEMP ] SEQUENCE [ IF NOT EXISTS ] name
[ INCREMENT [ BY ] increment ]
[ MINVALUE minvalue | NO MINVALUE ] [ MAXVALUE maxvalue | NO MAXVALUE ]
[ START [ WITH ] start ] [ CACHE cache ] [ [ NO ] CYCLE ]
[ OWNED BY { table_name.column_name | NONE } ]
```

Most SQL Server CREATE SEQUENCE parameters are compatible with PostgreSQL.

Examples

Create a sequence.

```
CREATE SEQUENCE SEQ_1 START WITH 100
        INCREMENT BY 1 MAXVALUE 99999999999 CACHE 20 NO CYCLE;
```

Drop a sequence.

```
DROP SEQUENCE SEQ_1;
```

View sequences created in the current schema and sequence specifications.

```
SELECT * FROM INFORMATION_SCHEMA.SEQUENCES;
OR
\ds
```

Use a PostgreSQL sequence as part of a CREATE TABLE and an INSERT statement.

```
CREATE TABLE SEQ_TST
          (COL1 NUMERIC DEFAULT NEXTVAL('SEQ_1') PRIMARY KEY, COL2 VARCHAR(30));
INSERT INTO SEQ_TST (COL2) VALUES('A');
SELECT * FROM SEQ_TST;

 col1 | col2
------+------
  100 | A
```

Use the OWNED BY parameter to associate the sequence with a table.

```
CREATE SEQUENCE SEQ_1 START WITH 100 INCREMENT BY 1 OWNED BY SEQ_TST.COL1;
```

Query the current value of a sequence.

```
SELECT CURRVAL('SEQ_1);
```

Manually increment a sequence value according to the INCREMENT BY value.

```
SELECT NEXTVAL('SEQ_1');
OR
SELECT SETVAL('SEQ_1', 200);
```

Alter an existing sequence.

```
ALTER SEQUENCE SEQ_1 MAXVALUE 1000000;
```

IDENTITY Usage

Since PostgreSQL 10, there is a new option called identity columns which is similar to the SERIAL data type but more SQL standard compliant. The identity columns are slightly more compatible compared to SQL Server's Identity columns.

To create a table with Identity columns please use the following:

```
CREATE TABLE emps (
          emp_id     INTEGER GENERATED BY DEFAULT AS IDENTITY PRIMARY KEY,
          emp_name   VARCHAR(35) NOT NULL);

INSERT INTO emps (emp_name) VALUES ('Robert');
INSERT INTO emps (emp_id, emp_name) VALUES (DEFAULT, 'Brian');

SELECT * FROM emps;

col1 | col2
-----+------
1    | Robert
2    | Brian
```

> **Note:** In PostgreSQL (both SERIAL and IDENTITY) you can insert any value, so long as it won't violate the primary key constraint. If the value violates the primary key constraint and you use the identity column sequence value again, the following error might be raised:
> SQL Error [23505]: ERROR: duplicate key value violates unique constraint "emps_iden_pkey"
> Detail: Key (emp_id)=(2) already exists.

SERIAL Usage

PostgreSQL enables you to create a sequence similar to the IDENTITY property supported by identity columns. When creating a new table, the sequence is created through the SERIAL pseudo-type. Other types from the same family are SMALLSERIAL and BIGSERIAL.

By assigning a SERIAL type to a column during table creation, PostgreSQL creates a sequence using the default configuration and adds a NOT NULL constraint to the column. The newly created sequence behaves like a regular sequence (incremented by 1) and no composite SERIAL option.

Use a SERIAL Sequence.

```
CREATE TABLE SERIAL_SEQ_TST(COL1 SERIAL PRIMARY KEY, COL2 VARCHAR(10));

INSERT INTO SERIAL_SEQ_TST(COL2) VALUES('A');
SELECT * FROM SERIAL_SEQ_TST;

col1 | col2
------+------
1 | A

\ds

Schema |          Name           |   Type   | Owner
--------+-------------------------+----------+-------
public | serial_seq_tst_col1_seq | sequence | pg_tst_db
```

Use the PostgreSQL SERIAL pseudo-type (with a Sequence that is created implicitly).

```
CREATE TABLE SERIAL_SEQ_TST(COL1 SERIAL PRIMARY KEY, COL2 VARCHAR(10));

\ds
 Schema |          Name           |   Type   | Owner
--------+-------------------------+----------+-------
 public | serial_seq_tst_col1_seq | sequence | pg_tst_db

ALTER SEQUENCE SERIAL_SEQ_TST_COL1_SEQ RESTART WITH 100 INCREMENT BY 10;
INSERT INTO SERIAL_SEQ_TST(COL2) VALUES('A');
INSERT INTO SERIAL_SEQ_TST(COL1, COL2) VALUES(DEFAULT, 'B');
SELECT * FROM SERIAL_SEQ_TST;

col1 | col2
------+------
100 | A
110 | B
```

Use the ALTER SEQUENCE command to change the default sequence configuration in a SERIAL column.

Create a table with a SERIAL column that uses increments of 10:

```
CREATE TABLE SERIAL_SEQ_TST(COL1 SERIAL PRIMARY KEY, COL2 VARCHAR(10));

ALTER SEQUENCE serial_seq_tst_col1_seq INCREMENT BY 10;
```

> **Note:** The auto generated sequence's name should be created with the following format: *TABLENAME_COLUMNNAME*_seq

Create a table with a compound PK including a SERIAL column:

```
CREATE TABLE SERIAL_SEQ_TST
(COL1 SERIAL, COL2 VARCHAR(10), PRIMARY key (COL1,COL2));
```

Summary

The following table identifies similarities, differences, and key migration considerations.

Feature	SQL Server	Aurora PostgreSQL
Independent SEQUENCE object	CREATE SEQUENCE	CREATE SEQUENCE
Automatic enumerator column property	IDENTITY	SERIAL / IDENTITY
Reseed sequence value	DBCC CHECKIDENT	1. Find sequence name: pg_get_serial_sequence('[table_name]', '[serial_field_name]') 2. SELECT SETVAL((SELECT pg_get_serial_sequence('table_name', 'person_id')), 1, false);
Column restrictions	Numeric	Numeric
Controlling seed and interval values	CREATE/ALTER SEQUENCE	CREATE/ALTER SEQUENCE
Sequence setting initialization	Maintained through service restarts	ALTER SEQUENCE
Explicit values to column	Not allowed by default, SET IDENTITY_INSERT ON required	Allowed

For more information see:

- *https://www.postgresql.org/docs/13/static/sql-createsequence.html*
- *https://www.postgresql.org/docs/13/static/functions-sequence.html*
- *https://www.postgresql.org/docs/13/static/datatype-numeric.html*
- *https://www.postgresql.org/docs/13/sql-createtable.html*

Configuration

SQL Server Upgrades vs. PostgreSQL Upgrades

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
N/A	N/A	N/A	

SQL Server Usage

As a Database Administrator, from time to time a database upgrade is required, it can be either for security fix, bugs fixes, compliance , or new database features.

The database upgrade approach can be planned to minimize the database downtime and risk. You can perform an upgrade in-place or migrate to a new installation

Upgrade in-place

With this approach, we are retaining the current hardware and OS version by adding the new SQL Server binaries on the same server and then upgrade the SQL Server instance.

Before upgrading the Database Engine, review the SQL Server release notes for the intended target release version for any limitations and known issues to help you plan the upgrade.

In general, these will be the steps to perform the upgrade:

Prerequisites steps

- Back up all SQL Server database files, so that it can be restored if required.
- Run the appropriate Database Console Commands (DBCC CHECKDB) on databases to be upgraded to ensure that they are in a consistent state.
- Ensure to allocate enough disk space for SQL Server components, in addition to user databases.

- Disable all startup stored procedures as stored procedures processed at startup time might block the upgrade process.
- Stop all applications, including all services that have SQL Server dependencies

Steps for upgrade

- Install new software
    - Fix issues raised
    - Set if you prefer to have automatic updates or not
    - Select products install to upgrade, this is the new binaries installation
    - Monitor the progress of downloading, extracting, and installing the Setup files.
- Specify the instance of SQL Server to upgrade
    - On the Select Features page, the features to upgrade will be preselected. The prerequisites for the selected features are displayed on the right-hand pane. SQL Server Setup will install the pre-requisite that are not already installed during the installation step described later in this procedure.
- Review upgrade plan before the actual upgrade
- Monitor installation progress

Post upgrade tasks:

- Review summary log file for the installation and other important notes
- Register your servers

Migrate to a new installation

This approach maintains the current environment while building a new SQL Server environment. This is usually done when migrating on a new hardware and with a new version of the operating system. In this approach migrate the system objects so that they are same as as the existing environment, then migrate the user database either using backup and restore.

For additional information, see: https://docs.microsoft.com/en-us/sql/database-engine/install-windows/upgrade-database-engine?view=sql-server-ver15

PostgreSQL Usage

After migrating your databases to RDS running Aurora for PostgreSQL, you will still need to upgrade your database instance from time to time, for the same reasons you have done in the past, new features, bugs and security fixes.

In a managed service like RDS, the upgrade process is much easier and simpler compare to the on-prem Oracle process.

To determine the current Aurora for PostgreSQL version being used, you can use the following aws cli command:

```
aws rds describe-db-engine-versions --engine aurora-postgresql --query '*[].[EngineVer-
sion]' --output text --region your-AWS-Region
```

This can also be queried from the database, using the following queries:

```
SELECT AURORA_VERSION();

aurora_version|
--------------|
4.0.0         |

SHOW SERVER_VERSION;

server_version|
--------------|
12.4          |
```

All Aurora and PostgreSQL versions mapping can be found in here: https://-docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/AuroraPostgreSQL.Updates.20180305.html

AWS doesn't apply major version upgrades on RDS Aurora automatically. Major version upgrades contains new features and functionality which often involves system table and other code changes. These changes may not be backward-compatible with previous versions of the database so application testing are highly recommended.

Applying automatic minor upgrades can be set by configuring the RDS instance to allow it.

You can use the following aws cli command (linux) to determine the current automatic upgrade minor versions.

```
aws rds describe-db-engine-versions --engine aurora-postgresql | grep -A 1 AutoUp-
grade| grep -A 2 true |grep PostgreSQL | sort --unique | sed -e 's/"Description":
"//g'
```

Note: If no results are returned, there is no automatic minor version upgrade available and scheduled.

When enabled, the instance will be automatically upgraded during the scheduled maintenance window.

For major upgrades, this is the recommended process:

- Have a version-compatible parameter group ready.
  If you are using a custom DB instance or DB cluster parameter group, you have two options:
  1. Specify the default DB instance, DB cluster parameter group, or both for the new DB engine version.
  2. Create your own custom parameter group for the new DB engine version.

  Note: If you associate a new DB instance or DB cluster parameter group as a part of the upgrade request, make sure to reboot the database after the upgrade completes to apply the parameters. If a DB instance needs to be rebooted to apply the parameter group changes, the instance's parameter group status shows pending-reboot. You can view an instance's parameter group status in the console or by using a CLI command such as describe-db-instances or describe-db-clusters.
- Check for unsupported usage:
  1. Commit or roll back all open prepared transactions before attempting an upgrade. You can use the following query to verify that there are no open prepared transactions on your instance.

     ```
     SELECT count(*) FROM pg_catalog.pg_prepared_xacts;
     ```

2. Remove all uses of the reg* data types before attempting an upgrade. Except for regtype and regclass, you can't upgrade the reg* data types. The pg_upgrade utility can't persist this data type, which is used by Amazon Aurora to do the upgrade.
   To verify that there are no uses of unsupported reg* data types, use the following query for each database.

```
SELECT count(*) FROM pg_catalog.pg_class c, pg_catalog.pg_namespace n, pg_
catalog.pg_attribute aWHERE c.oid = a.attrelid
AND NOT a.attisdropped
AND a.atttypid IN ('pg_catalog.regproc'::pg_catalog.regtype,
'pg_catalog.regprocedure'::pg_catalog.regtype,
'pg_catalog.regoper'::pg_catalog.regtype,
'pg_catalog.regoperator'::pg_catalog.regtype,
'pg_catalog.regconfig'::pg_catalog.regtype,
'pg_catalog.regdictionary'::pg_catalog.regtype)
AND c.relnamespace = n.oid
AND n.nspname NOT IN ('pg_catalog', 'information_schema');
```

- Perform a backup.

  The upgrade process creates a DB cluster snapshot of your DB cluster during upgrading.

- Upgrade certain extensions to the latest available version before performing the major version upgrade. The extensions to update include the following:

  - pgRouting
  - postGIS

    Run the following command for each extension that you are using.

```
ALTER EXTENSION PostgreSQL-extension UPDATE TO 'new-version'
```

If you are upgrading older versions (older than 12), there are a few more steps, please review here:https://-docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/USER_UpgradeDBInstance.PostgreSQL.html

All mentioned above a prerequsites, the actual upgrade can be done throught the console or aws cli.

Console

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://-console.aws.amazon.com/rds/.
2. In the navigation pane, choose Databases, and then choose the DB cluster that you want to upgrade.
3. Choose Modify. The Modify DB cluster page appears.
4. For DB engine version, choose the new version.
5. Choose Continue and check the summary of modifications.
6. To apply the changes immediately, choose Apply immediately. Choosing this option can cause an outage in some cases. For more information, see Modifying an Amazon Aurora DB cluster.
7. On the confirmation page, review your changes. If they are correct, choose Modify Cluster to save your changes.

   Or choose Back to edit your changes or Cancel to cancel your changes.

AWS CLI

For Linux, macOS, or Unix:

```
aws rds modify-db-cluster \
--db-cluster-identifier mydbcluster \
--engine-version new_version \
--allow-major-version-upgrade \
--no-apply-immediately
```

For Windows:

```
aws rds modify-db-cluster ^
--db-cluster-identifier mydbcluster ^
--engine-version new_version ^
--allow-major-version-upgrade ^
--no-apply-immediately
```

Summary

Phase	SQL Server Step	Aurora for PostgreSQL
Prerequisite	**Performa an instance backup**	Run RDS instance backup
Prerequisite	**DBCC for consistent verification**	N/A
Prerequisite	**Validate disk size and free space**	N/A
Prerequisite	**Disable all startup stored procedures (if applicable)**	N/A
Prerequisite	**Stop application and connection**	N/A
Prerequisite	**Install new software and fix prerequisites errors raised**	1. Remove all uses of the reg* data types 2. Upgrade certain extensions 3. Commit or roll back all open prepared transactions SELECT count(*) FROM pg_catalog.pg_prepared_xacts;
Prerequisite	**Select instances to upgrade**	Select right RDS instance
Prerequisite	**Review pre-upgrade summary**	N/A
Execution	**Monitor upgrade progress**	Can be reviewed from the console
Post-upgrade	**Results**	Can be reviewed from the console
Post-upgrade	**Register server**	N/A

Phase	SQL Server Step	Aurora for PostgreSQL
Post-upgrade	**Test applications again the new upgraded database**	Same
Production deployment	**Re-run all steps in a production enviroment**	Same

https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/USER_UpgradeDBInstance.PostgreSQL.html

SQL Server Session Options vs. PostgreSQL Session Options

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	SET options are significantly different, except for transaction isolation control

SQL Server Usage

Session Options in SQL Server is a collection of run-time settings that control certain aspects of how the server handles data for individual sessions. A session is the period between a login event and a disconnect event (or an exec sp_reset_connection command for connection pooling).

Each session may have multiple execution scopes, which are all the statements before the GO keyword used in SQL Server management Studio scripts, or any set of commands sent as a single execution batch by a client application. Each execution scope may contain additional sub-scopes. For example, scripts calling stored procedures or functions.

You can set the global session options, which all execution scopes use by default, using the SET T-SQL command. Server code modules such as stored procedures and functions may have their own execution context settings, which are saved along with the code to guarantee the validity of results.

Developers can explicitly use SET commands to change the default settings for any session or for an execution scope within the session. Typically, client applications send explicit SET commands upon connection initiation.

You can view the metadata for current sessions using the sp_who_system stored procedure and the sysprocesses system table.

> Note: To change the default setting for SQL Server Management Studio, click **Tools >Options > Query Execution > SQL Server > Advanced**.

Syntax

Syntax for the SET command:

```
SET
Category          Setting
-------------     ----------
Date and time     DATEFIRST | DATEFORMAT
Locking           DEADLOCK_PRIORITY | SET LOCK_TIMEOUT
Miscellaneous     CONCAT_NULL_YIELDS_NULL | CURSOR_CLOSE_ON_COMMIT | FIPS_FLAGGER | SET
```

```
IDENTITY_INSERT
                LANGUAGE | OFFSETS | QUOTED_IDENTIFIER
Query Execution ARITHABORT | ARITHIGNORE | FMTONLY | NOCOUNT | NOEXEC | NUMERIC_
ROUNDABORT | PARSEONLY
                QUERY_GOVERNOR_COST_LIMIT | ROWCOUNT | TEXTSIZE
ANSI            ANSI_DEFAULTS | ANSI_NULL_DFLT_OFF | ANSI_NULL_DFLT_ON | ANSI_NULLS |
ANSI_PADDING
                ANSI_WARNINGS
Execution Stats FORCEPLAN | SHOWPLAN_ALL | SHOWPLAN_TEXT | SHOWPLAN_XML | STATISTICS
IO | STATISTICS XML
                STATISTICS PROFILE | STATISTICS TIME
Transactions    IMPLICIT_TRANSACTIONS | REMOTE_PROC_TRANSACTIONS | TRANSACTION ISOLATION
LEVEL | XACT_ABORT
```

Note: For more details about individual settings, see the link at the end of this section.

SET ROWCOUNT for DML Deprecated Setting

The SET ROWCOUNT for DML statements has been deprecated as of SQL Server 2008 in accordance with https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/ms143729(v=sql.105).

Up to and including SQL Server 2008 R2, you could limit the amount of rows affected by INSERT, UPDATE, and DELETE operations using SET ROWCOUNT. For example, it is a common practice in SQL Server to batch large DELETE or UPDATE operations to avoid transaction logging issues. The following example loops and deletes rows having 'ForDelete' set to 1, but only 5000 rows at a time in separate transactions (assuming the loop is not within an explicit transaction).

```
SET ROWCOUNT 5000;
WHILE @@ROWCOUNT > 0
BEGIN
 DELETE FROM MyTable
 WHERE ForDelete = 1;
END
```

Begining with SQL Server 2012, SET ROWCOUNT is ignored for INSERT, UPDATE and DELETE statements. The same functionality can be achieved by using TOP, which can be converted to the Aurora PostgreSQL LIMIT.

For example, the previous code could be rewritten as:

```
WHILE @@ROWCOUNT > 0
BEGIN
 DELETE TOP (5000)
 FROM MyTable
 WHERE ForDelete = 1;
END
```

The latter syntax can be converted automatically by SCT to Aurora PostgeSQL. See the code example in Aurora PostgreSQL Session Options.

Examples

Use SET within a stored procedure.

```
CREATE PROCEDURE <ProcedureName>
AS
```

```
BEGIN
  <Some non critical transaction code>
  SET TRANSACTION_ISOLATION_LEVEL SERIALIZABLE;
  SET XACT_ABORT ON;
  <Some critical transaction code>
END
```

> **Note:** Explicit SET commands affect their execution scope and sub scopes.
> After the scope terminates and the procedure code exits, the calling scope resumes its original settings used before the calling the stored procedure.

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/set-statements-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL supports hundreds of Server System Variables to control server behavior and the global and session levels.

PostgreSQL provides session-modifiable parameters that are configured using the SET SESSION command. Configuration of parameters using SET SESSION will only be applicable in the current session. To view the list of parameters that can be set with SET SESSION , you can query pg_settings:

```
SELECT * FROM pg_settings where context = 'user';
```

Examples of commonly used session parameters:

- **client_encoding** - configures the connected client character set.
- **force_parallel_mode** - forces use of parallel query for the session.
- **lock_timeout** - sets the maximum allowed duration of time to wait for a database lock to release.
- **search_path** - sets the schema search order for object names that are not schema-qualified.
- **transaction_isolation** - sets the current Transaction Isolation Level for the session.

You can view Aurora PostgreSQL variables using the PostgreSQL command line utility, Aurora database cluster parameters, Aurora database instance parameters, or SQL interface system variables.

Converting from SQL Server 2008 SET ROWCOUNT for DML operations

As mentioned in SQL Server Sessions Options, the use of SET ROWCOUNT for DML operations is deprecated as of SQL Server 2008 R2. Code that uses the SET ROWCOUNT syntax can not be converted automatically. Either rewrite to use TOP before running SCT, or manually change it afterward.

The example used to batch DELETE operations in SQL Server using TOP:

```
WHILE @@ROWCOUNT > 0
BEGIN
 DELETE TOP (5000)
 FROM MyTable
 WHERE ForDelete = 1;
END
```

Can be easily rewritten to use Aurora PostgreSQL LIMIT clause :

```
WHILE row_count() > 0 LOOP
 DELETE FROM num_test
 WHERE ctid IN (
 SELECT ctid
 FROM num_test
 LIMIT 10)
END LOOP;
```

Examples

Change the time zone of the connected session.

```
SET SESSION DateStyle to POSTGRES, DMY;
SET

SELECT NOW();
                  now
-------------------------------------
 Sat 09 Sep 11:03:43.597202 2017 UTC
(1 row)


SET SESSION DateStyle to ISO, MDY;
SET

SELECT NOW();
              now
------------------------------
 2017-09-09 11:04:01.3859+00
(1 row)
```

Summary

The following table summarizes commonly used SQL Server session options and their corresponding Aurora PostgreSQL system variables.

Category	SQL Server	Aurora PostgreSQL
Date and time	DATEFIRST	Use DOW in queries
	DATEFORMAT	DateStyle
Locking	LOCK_TIMEOUT	lock_timeout
Transactions	IMPLICIT_TRANSACTIONS	SET TRANSACTION
	TRANSACTION ISOLATION LEVEL	BEGIN TRANSACTION ISOLATION LEVEL
Query execution	IDENTITY_INSERT	See Identity and sequences
	LANGUAGE	lc_monetary / lc_numeric / lc_time
	QUOTED_IDENTIFIER	N/A
	NOCOUNT	N/A and not needed
Execution stats	SHOWPLAN_ALL, TEXT, and XML	See Execution Plans

Category	SQL Server	Aurora PostgreSQL
	STATISTICS IO, XML, PROFILE, and TIME	
Miscellaneous	CONCAT_NULL_YIELDS_NULL ROWCOUNT	N/A Use LIMIT within SELECT

For more information, see: For more details, see https://www.postgresql.org/docs/13/static/sql-set.html

SQL Server Database Options vs. PostgreSQL Database Options

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Use Cluster and Database/Cluster Parameter

SQL Server Usage

SQL Server provides database level options that can be set using the ALTER DATABASE ... SET command. These settings enable you to:

- Set default session options. For more information, see Session Options.
- Enable or disable database features such as SNAPSHOT_ISOLATION, CHANGE_TRANCKING, and ENABLE_BROKER.
- Configure High availability and disaster recovery options such as always on availability groups.
- Configure security access control such as restricting access to a single user, setting the database offline, or setting the database to read-only.

Syntax

Syntax for setting database options:

```
ALTER DATABASE { <database name> } SET { <option> [ ,...n ] };
```

Examples

Set a database to read-only and use ARITHABORT by default.

```
ALTER DATABASE Demo SET READ_ONLY, ARITHABORT ON;
```

Set a database to use automatic statistic creation.

```
ALTER DATABASE Demo SET AUTO_CREATE_STATISTICS ON;
```

Set a database offline immediately.

```
ALTER DATABASE DEMO SET OFFLINE WITH ROLLBACK IMMEDIATE;
```

For more information, see https://docs.microsoft.com/en-us/sql/t-sql/statements/alter-database-transact-sql-set-options?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL supports both the CREATE SCHEMA and CREATE DATABASE statements.

As with SQL Server, Aurora PostgreSQL does have the concept of an instance hosting multiple databases, which in turn contain multiple schemas. Objects in Aurora PostgreSQL are referenced as a three part name: <database>.<schema>.<object>.

Database options are related to the cluster level parameters which are managed by the AWS Cluster Parameter Groups but some MSSQL equivalent parameters can be found at the instance level in the AWS Database Parameter Group.

Datable Options are being compared to "AWS Database Parameter Group" and Server Options are being compared to "AWS Cluster Parameter Group", for more information, see Server Options.

SQL Server Server Options vs. PostgreSQL Aurora Parameter Groups

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Use Cluster and Database/Cluster Parameter

SQL Server Usage

SQL Server provides server-level settings that affect all databases and all sessions. You can modify these settings using the sp_configure system stored procedure.

You can use Server Options to perform the following configuration tasks:

- Define hardware utilization such as memory management, affinity mask, priority boost, network packet size, and soft Non-Uniform Memory Access (NUMA) .
- Alter run time global values such as recovery interval, remote login timeout, optimization for ad-hoc workloads, and cost threshold for parallelism.
- Enable and disable global features such as C2 Audit, OLE, procedures, CLR procedures, and allow trigger recursion.
- Configure global security settings such as server authentication mode, remote access, shell access with xp_cmdshell, CLR access level, and database chaining.
- Set default values for sessions such as user options, default language, backup compression, and fill factor.

Some settings require an explicit RECONFIGURE command to apply the changes to the server. High risk settings require RECONFIGURE WITH OVERRIDE for the changes to be applied. Some advanced options are hidden by default. To view and modify these settings, set *show advanced options* to *1* and re-execute sp_configure.

Note: Server audits are managed with the T-SQL commands CREATE and ALTER SERVER AUDIT.

Syntax

```
EXECUTE sp_configure <option>, <value>;
```

Examples

Limit server memory usage to 4GB.

```
EXECUTE sp_configure 'show advanced options', 1;
```

```
RECONFIGURE;
```

```
sp_configure 'max server memory', 4096;
```

```
RECONFIGURE;
```

Allow command shell access from T-SQL.

```
EXEC sp_configure 'show advanced options', 1;
```

```
RECONFIGURE;
```

```
EXEC sp_configure 'xp_cmdshell', 1;
```

```
RECONFIGURE;
```

Viewing current values.

```
EXECUTE sp_configure
```

For more information, see
https://docs.microsoft.com/en-us/sql/database-engine/configure-windows/server-configuration-options-sql-server-?view=sql-server-ver15

PostgreSQL Usage

When running PostgreSQL databases as Amazon Aurora Clusters, Parameter Groups are used to change to cluster-level and database-level parameters.

Most of the PostgreSQL parameters are configurable in an Amazon Aurora PostgreSQL cluster, but some are disabled and cannot be modified. Since Amazon Aurora clusters restrict access to the underlying operating system, modification to PostgreSQL parameters must be made using Parameter Groups.

Amazon Aurora is a cluster of database instances and, as a direct result, some of the PostgreSQL parameters apply to the entire cluster while other parameters apply only to a particular database instance.

Aurora PostgreSQL Parameter Class	Controlled Via
Cluster-level parameters Single cluster parameter group per Amazon Aur-	Managed via cluster parameter groups For example:

Aurora PostgreSQL Parameter Class	Controlled Via
ora Cluster	• The PostgreSQL wal_buffers parameter is controlled via a cluster parameter group. • The PostgreSQL autovacuum parameter is controlled via a cluster parameter group. • The client_encoding parameter is controlled via a cluster parameter group.
Database Instance-Level parameters Every instance in an Amazon Aurora cluster can be associated with a unique database parameter group	Managed via database parameter groups For example: • The PostgreSQL shared_buffers memory cache configuration parameter is controlled via a database parameter group with an AWS-optimized default value based on the configured database class: {DBInstanceClassMemory/10922}. • The PostgreSQL max_connections parameter, which controls maximum number of client connections allowed to the PostgreSQL instance, is controlled via a database parameter group. Default value is optimized by AWS based on the configured database class: LEAST({DBInstanceClassMemory/9531392},5000). • The authentication_timeout parameter, which controls the maximum time to complete client authentication (in seconds), is controlled via a database parameter group. • The superuser_reserved_connections parameter, which determines the number of reserved connection "slots" for PostgreSQL superusers, is configured via a database parameter group. • The PostgreSQL effective_cache_size, which informs the query optimizer how much cache is present in the kernel and helps control how expensive large index scans will be, is controlled via a database level parameter group. The default value is optimized by AWS based on database class (RAM): {DBInstanceClassMemory/10922}.

New parameters in PostgreSQL 10:

1. enable_gathermerge - enable execution plan Gather Merge
2. max_parallel_workers - maximum number of parallel workers process
3. max_sync_workers_per_subscription - maximum number of synchronous workers for subscription
4. wal_consistency_checking - check consistency of WAL on the standby instance (can't be set in Aurora PostgreSQL)
5. max_logical_replication_workers - maximum number of logical replication worker process
6. max_pred_locks_per_relation - Maximum number of records that can be predicate-lock before locking the entire relation (sighup)
7. max_pred_locks_per_page - Maximum number of records that can be predicate-lock before locking the entire page
8. min_parallel_table_scan_size - minimum table size to consider parallel table scan
9. min_parallel_index_scan_size - minimum table size to consider parallel index scan

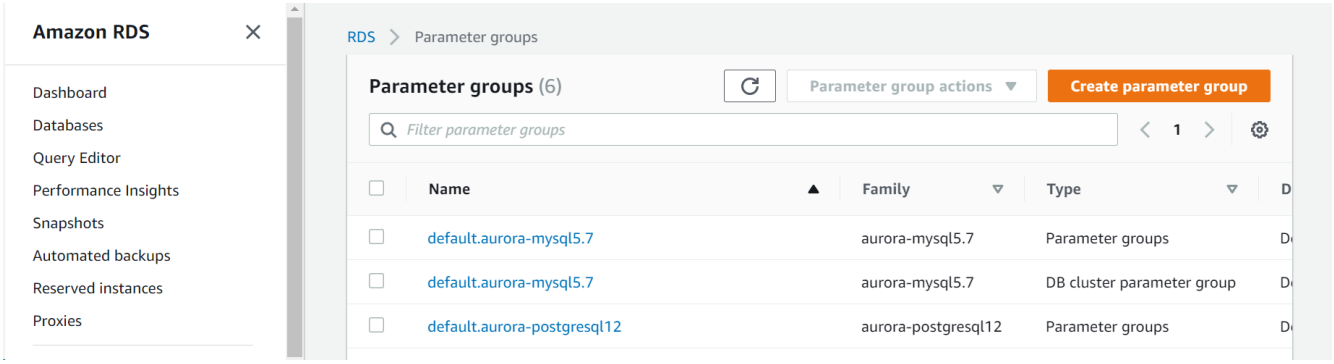
Examples

Create and Configure a New Parameter Group

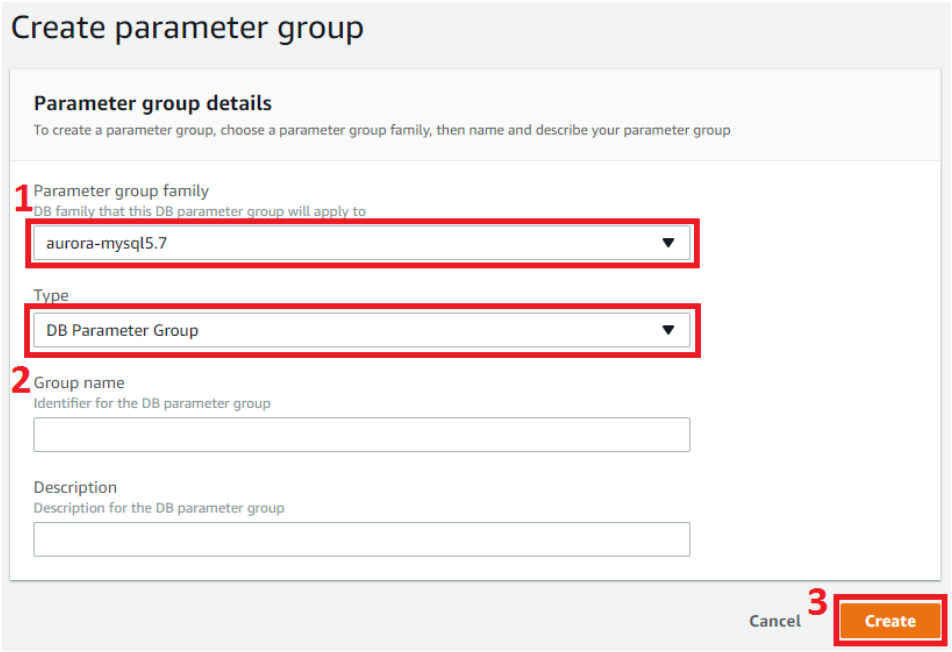
Follow the steps below to create and configure Amazon Aurora database and cluster parameter groups:

1. Navigate to the "Parameter group" section in the RDS Service of the AWS Console.
2. Click **Create Parameter Group**.

   Note: You cannot edit the default parameter group. You must create a custom parameter group to apply changes to your Amazon Aurora cluster and its database instances.



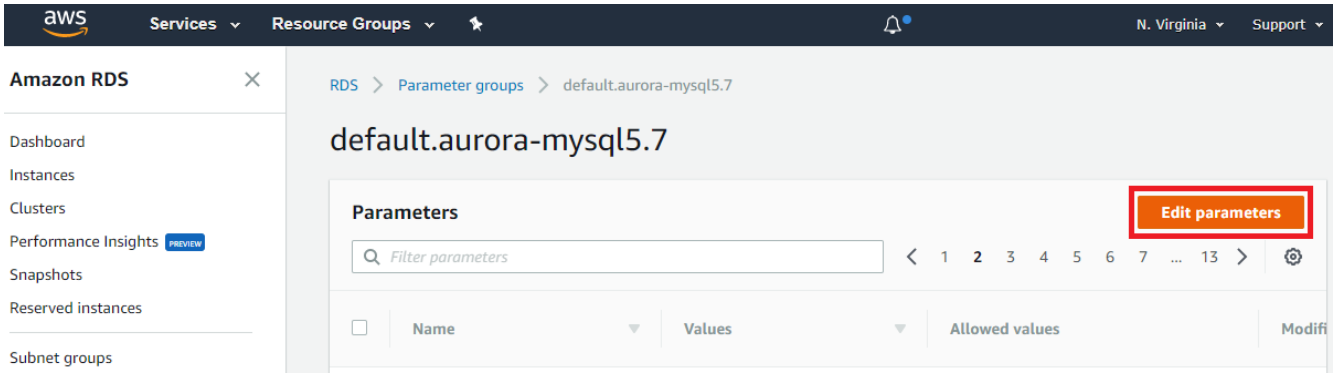
3. Select the DB family from the **Parameter group family** drop-down list. Select **DB Parameter Group** from the **Type** drop-down list (another option is to select **Cluster Parameter Group** for modifying cluster parameters). Click **Create**.



Modify an Existing Parameter Group

1. Navigate to the "Parameter group" section in the RDS Service of the AWS Console.
2. Click the name of the parameter to edit.

3. Click the **Edit parameters** button.



4. Change parameter values and click **Save changes**

For more information, see:

- *https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_WorkingWithParamGroups.html*

High Availability and Disaster Recovery (HADR)

SQL Server Backup and Restore vs. PostgreSQL Backup and Restore

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	SCT Action Codes - Backup	Storage level backup managed by Amazon RDS

SQL Server Usage

The term *Backup* refers to both the process of copying data and to the resulting set of data created by the processes that copy data for safekeeping and disaster recovery. Backup processes copy SQL Server data and transaction logs to media such as tapes, network shares, cloud storage, or local files. These "backups" can then be copied back to the database using a *restore* process.

SQL Server uses files, or filegroups, to create backups for an individual database or subset of a database. Table backups are not supported.

When a database uses the FULL recovery model, transaction logs also need to be backed up. Transaction logs allow backing up only database changes since the last full backup and provide a mechanism for point-in-time restore operations.

Recovery Model is a database-level setting that controls transaction log management. The three available recovery models are SIMPLE, FULL, and BULK LOGGED. For more information, see https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/recovery-models-sql-server?view=sql-server-ver15.

The SQL Server RESTORE process copies data and log pages from a previously created backup back to the database. It then triggers a recovery process that rolls forward all committed transactions not yet flushed to the data pages when the backup took place. It also rolls back all uncommitted transactions written to the data files.

SQL Server supports the following types of backups:

- **Copy-Only Backups** are independent of the standard chain of SQL Server backups. They are typically used as "one-off" backups for special use cases and do not interrupt normal backup operations.

- **Data Backups** copy data files and the transaction log section of the activity during the backup. A Data Backup may contain the whole database (Database Backup) or part of the database. The parts can be a Partial Backup or a file/filegroup.
- A **Database Backup** is a Data Backup representing the entire database at the point in time when the backup process finished.
- A **Differential Backup** is a data backup containing only the data structures (extents) modified since the last full backup. A differential backup is dependent on the previous full backup and can not be used alone.
- A **Full Backup** is a data backup containing a Database Backup and the transaction log records of the activity during the backup process.
- **Transaction Log Backups** do not contain data pages. They contain the log pages for all transaction activity since the last Full Backup or the previous Transaction Log Backup.
- **File Backups** consist of one or more files or filegroups.

SQL Server also supports Media Families and Media Sets that can be used to mirror and stripe backup devices. For more information, see https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/media-sets-media-families-and-backup-sets-sql-server?view=sql-server-ver15

SQL Server 2008 Enterprise edition and later versions, support Backup Compression. Backup Compression provides the benefit of a smaller backup file footprint, less I/O consumption, and less network traffic at the expense of increased CPU utilization for executing the compression algorithm. For more information, see https://-docs.microsoft.com/en-us/sql/relational-databases/backup-restore/backup-compression-sql-server?view=sql-server-ver15

A database backed up in the SIMPLE recovery mode can only be restored from a full or differential backup. For FULL and BULK LOGGED recovery models, transaction log backups can be restored also to minimize potential data loss.

Restoring a database involves maintaining a correct sequence of individual backup restores. For example, a typical restore operation may include the following steps:

1. Restore the most recent Full Backup.
2. Restore the most recent Differential Backup.
3. Restore a set of uninterrupted Transaction Log Backups, in order.
4. Recover the database.

For large databases, a full restore, or a complete database restore, from a full database backup is not always a practical solution. SQL Server supports Data File Restore that restores and recovers a set of files and a single Data Page Restore, except for databases using the SIMPLE recovery model.

Syntax

Backup syntax:

```
Backing Up a Whole Database
BACKUP DATABASE <Database Name> [ <Files / Filegroups> ] [ READ_WRITE_FILEGROUPS ]
  TO <Backup Devices>
  [ <MIRROR TO Clause> ]
  [ WITH [DIFFERENTIAL ]
  [ <Option List> ][;]
```

```
BACKUP LOG <Database Name>
  TO <Backup Devices>
  [ <MIRROR TO clause> ]
  [ WITH <Option List> ][;]
```

```
<Option List> =
COPY_ONLY | {COMPRESSION | NO_COMPRESSION } | DESCRIPTION = <Description>
| NAME = <Backup Set Name> | CREDENTIAL | ENCRYPTION | FILE_SNAPSHOT | { EXPIREDATE =
<Expiration Date> | RETAINDAYS = <Retention> }
{ NOINIT | INIT } | { NOSKIP | SKIP } | { NOFORMAT | FORMAT } |
{ NO_CHECKSUM | CHECKSUM } | { STOP_ON_ERROR | CONTINUE_AFTER_ERROR }
{ NORECOVERY | STANDBY = <Undo File for Log Shipping> } | NO_TRUNCATE
ENCRYPTION ( ALGORITHM = <Algorithm> | SERVER CERTIFICATE = <Certificate> | SERVER
ASYMMETRIC KEY = <Key> );
```

Restore Syntax:

```
RESTORE DATABASE <Database Name>  [ <Files / Filegroups> ] | PAGE = <Page ID>
FROM <Backup Devices>
[ WITH   [ RECOVERY | NORECOVERY | STANDBY = <Undo File for Log Shipping> } ]
[, <Option List>]
[;]
```

```
RESTORE LOG <Database Name>  [ <Files / Filegroups> ] | PAGE = <Page ID>
[ FROM <Backup Devices>
[ WITH   [ RECOVERY | NORECOVERY | STANDBY = <Undo File for Log Shipping> } ]
[, <Option List>]
[;]
```

```
<Option List> =
MOVE <File to Location>
| REPLACE | RESTART | RESTRICTED_USER | CREDENTIAL
| FILE = <File Number> | PASSWORD = <Passord>
| { CHECKSUM | NO_CHECKSUM } | { STOP_ON_ERROR | CONTINUE_AFTER_ERROR }
| KEEP_REPLICATION | KEEP_CDC
| { STOPAT = <Stop Time>
| STOPATMARK = <Log Sequence Number>
| STOPBEFOREMARK = <Log Sequence Number>
```

Examples

Perform a full compressed database backup.

```
BACKUP DATABASE MyDatabase TO DISK='C:\Backups\MyDatabase\FullBackup.bak'
WITH COMPRESSION;
```

Perform a log backup.

```
BACKUP DATABASE MyDatabase TO DISK='C:\Backups\MyDatabase\LogBackup.bak'
WITH COMPRESSION;
```

Perform a partial differential backup.

```
BACKUP DATABASE MyDatabase
   FILEGROUP = 'FileGroup1',
   FILEGROUP = 'FileGroup2'
   TO DISK='C:\Backups\MyDatabase\DB1.bak'
   WITH DIFFERENTIAL;
```

Restore a database to a point in time.

```
RESTORE DATABASE MyDatabase
   FROM DISK='C:\Backups\MyDatabase\FullBackup.bak'
   WITH NORECOVERY;

RESTORE LOG AdventureWorks2012
   FROM DISK='C:\Backups\MyDatabase\LogBackup.bak'
   WITH NORECOVERY, STOPAT = '20180401 10:35:00';

RESTORE DATABASE AdventureWorks2012 WITH RECOVERY;
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/backup-overview-sql-server?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/restore-and-recovery-overview-sql-server-?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL continuously backs up all cluster volumes and retains restore data for the duration of the backup retention period. The backups are incremental and can be used to restore the cluster to any point in time within the backup retention period. You can specify a backup retention period from one to 35 days when creating or modifying a database cluster. Backups incur no performance impact and do not cause service interruptions.

Additionally, you can manually trigger data snapshots in a cluster volume that can be saved beyond the retention period. You can use Snapshots to create new database clusters.

> **Note:** Manual snapshots incur storage charges for Amazon RDS.

Restoring Data

You can recover databases from Aurora's automatically retained data or from a manually saved snapshot. Using the automatically retained data significantly reduces the need to take frequent snapshots and maintain Recovery Point Objective (RPO) policies.

The RDS console displays the available time frame for restoring database instances in the Latest Restorable Time and Earliest Restorable Time fields. The Latest Restorable Time is typically within the last five minutes. The Earliest Restorable Time is the end of the backup retention period.

> **Note:** The Latest Restorable Time and Earliest Restorable Time fields display when a database cluster restore has been completed. Both display NULL until the restore process completes.

Database Cloning

Database cloning is a fast and cost-effective way to create copies of a database. You can create multiple clones from a single DB cluster and additional clones can be created from existing clones. When first created, a cloned database requires only minimal additional storage space.

Database cloning uses a copy-on-write protocol. Data is copied only when it changes either on the source or cloned database.

Data cloning is useful for avoiding impacts on production databases. For example:

- Testing schema or parameter group modifications.
- Isolating intensive workloads. For example, exporting large amounts of data and running high resource-consuming queries.
- Development and Testing with a copy of a production database.

Copying and sharing snapshots

Database snapshots can be copied and shared within the same AWS Region, across AWS Regions, and across AWS accounts. Snapshot sharing allows an authorized AWS account to access and copy snapshots. Authorized users can restore a snapshot from its current location without first copying it.

Copying an automated snapshot to another AWS account requires two steps:

- Create a manual snapshot from the automated snapshot.
- Copy the manual snapshot to another account.

Backup Storage

In all RDS regions, Backup Storage is the collection of both automated and manual snapshots for all database instances and clusters. The size of this storage is the sum of all individual instance snapshots.

When an Aurora PostgreSQL database instance is deleted, all automated backups of that database instance are also deleted. However, Amazon RDS provides the option to create a final snapshot before deleting a database instance. This final snapshot is retained as a manual snapshot. Manual snapshots are not automatically deleted.

The Backup Retention Period

Retention periods for Aurora PostgreSQL DB cluster backups are configured when creating a cluster. If not explicitly set, the default retention is one day when using the Amazon RDS API or the AWS CLI. The retention period is seven days if using the AWS Console. You can modify the backup retention period at any time with values of one to 35 days.

Disabling automated backups

You cannot disable automated backups on Aurora PostgreSQL. The backup retention period for Aurora PostgreSQL is managed by the database cluster.

Migration Considerations

Migrating from a self managed backup policy to a Platform as a Service (PaaS) environment such as Aurora PostgreSQL is a complete paradigm shift. You no longer need to worry about transaction logs, file groups, disks running out of space, and purging old backups.

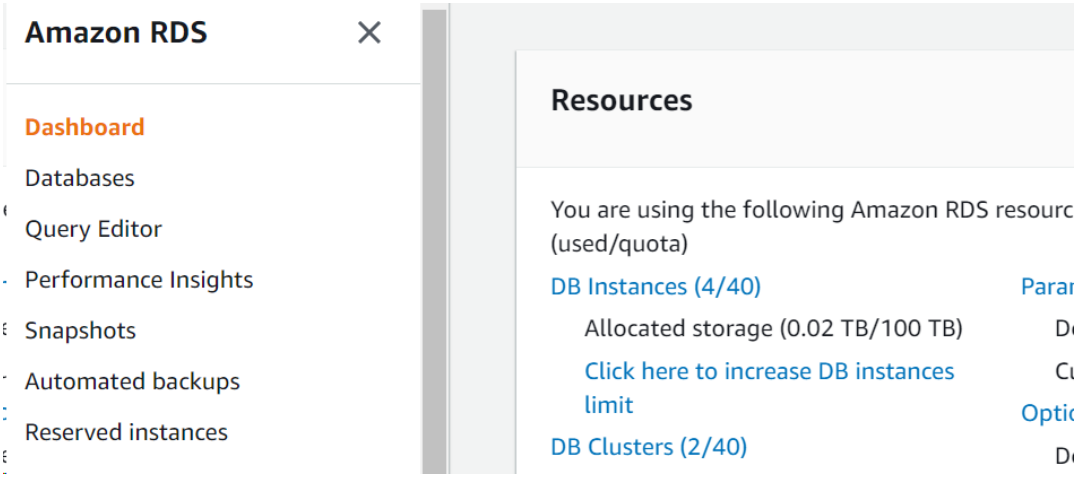
Amazon RDS provides guaranteed continuous backup with point-in-time restore up to 35 days.

Managing a SQL Server backup policy with similar RTO and RPO is a challenging task. With Aurora PostgreSQL, all you need to set is the retention period and take some manual snapshots for special use cases.

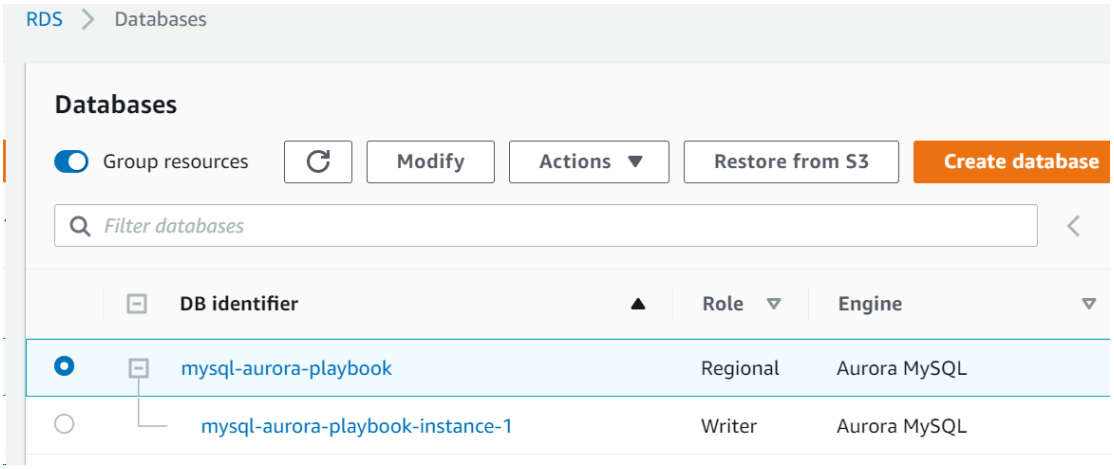
Examples

The following walk-through describes how to change Aurora PostgreSQL DB cluster retention settings from one day to seven days using the RDS console.

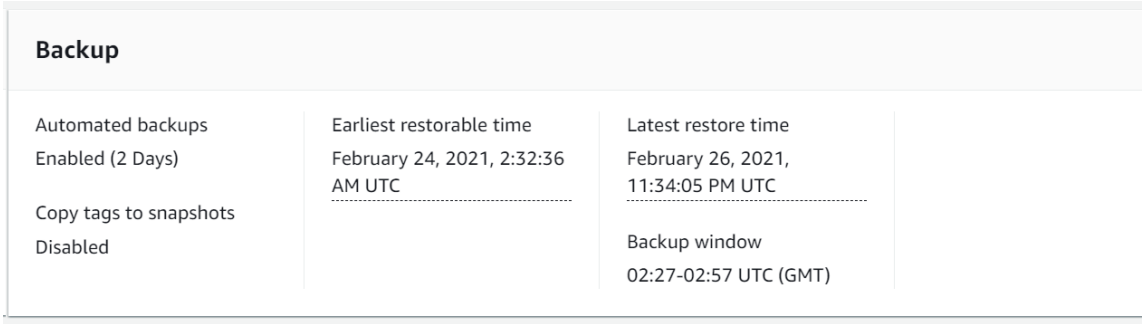
Login to the RDS Console and on dashboard click **Databases**.



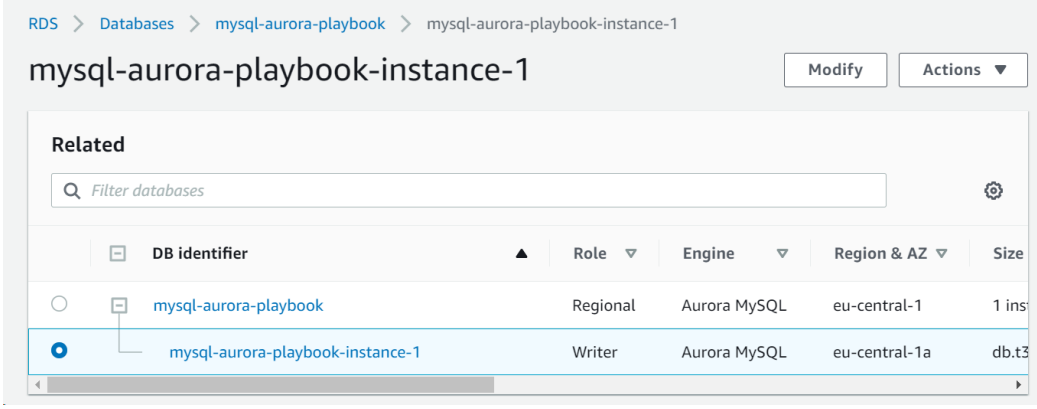
Click on relevant **DB identifier**.



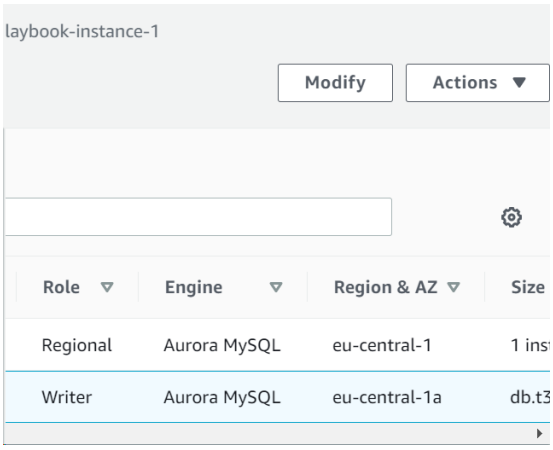
Verify the current automatic backup settings.



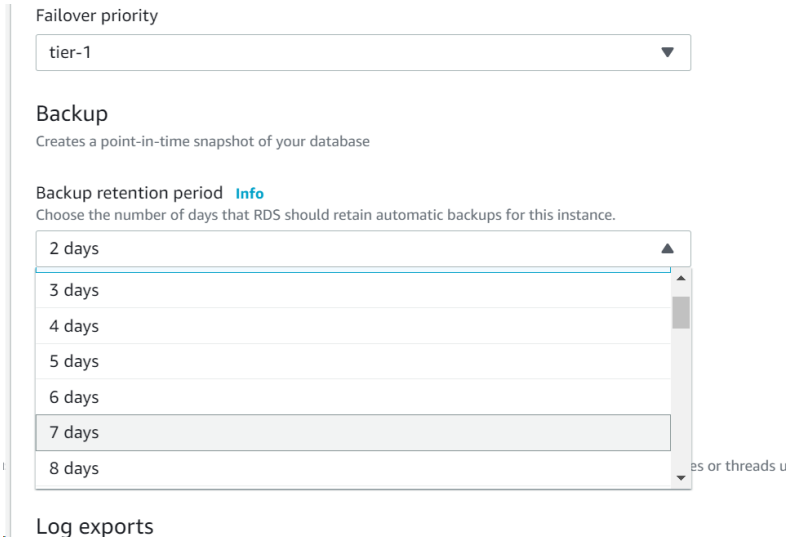
In this cluster select database instance with the **writer** role.



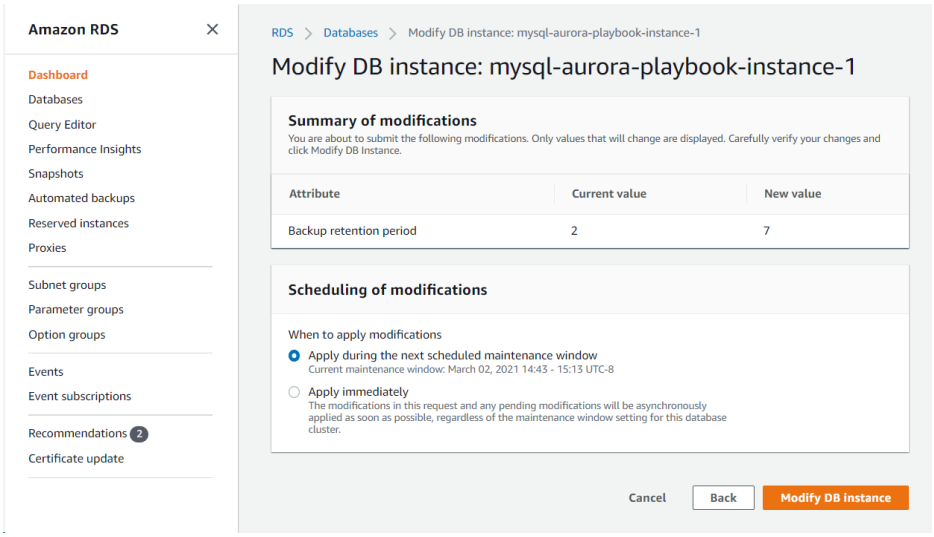
On the top right, click **Modify**



Scroll down to the **Backup** section. Select **7 Days** from the drop-down list.



Click **Continue**, review the summary, select if to use scheduled maintenance window or to apply immediate and click **Modify DB Instance**.



For more information and an example of creating a manual snapshot, see Maintenance Plans.

Summary

Feature	SQL Server	Aurora PostgreSQL	Comments
Recovery Model	SIMPLE, BULK LOGGED, FULL	N/A	The functionality of Aurora PostgreSQL backups is equivalent to the FULL recovery model.
Backup Database	BACKUP DATABASE	aws rds create-db-cluster-snapshot --db-cluster-snapshot-identifier Snapshot_name --db-cluster-identifier Cluster_Name	
Partial Backup	BACKUP DATABASE ... FILE= ... | FILEGROUP = ...	N/A	Can use export utils
Log Backup	BACKUP LOG	N/A	Backup is at the storage level.
Differential Backups	BACKUP DATABASE ... WITH DIFFERENTIAL	N/A	Can be done manually using export tools.
Database Snapshots	BACKUP DATABASE ... WITH COPY_ONLY	RDS console or API	The terminology is inconsistent between SQL Server and Aurora PostgreSQL. A database snapshot in SQL Server is similar to database cloning in Aurora PostgreSQL. Aurora PostgreSQL database snapshots are similar to a COPY_ONLY backup in SQL Server.
Database Clones	CREATE DATABASE... AS SNAPSHOT OF...	Create new cluster from a cluster snapshot: aws rds restore-db-cluster-	The terminology is inconsistent between SQL Server and Aurora PostgreSQL. A database snapshot in SQL Server is similar to database cloning in Aur-

Feature	SQL Server	Aurora PostgreSQL	Comments
		from-snapshot --db-cluster-identifier NewCluster --snapshot-identifier SnapshotToRestore --engine aurora-postgresql Add a new instance to the new/restored cluster: aws rds create-db-instance --region us-east-1 --db-subnet-group default --engine aurora-postgresql --db-cluster-identifier cluster-name-restore --db-instance-identifier newinstance-nodeA --db-instance-class db.r4.large	ora PostgreSQL. Aurora PostgreSQL database snapshots are similar to a COPY_ONLY backup in SQL Server.
Point in time restore	RESTORE DATABASE | LOG ... WITH STOPAT...	Create new cluster from a cluster snapshot by given custom time to restore: aws rds restore-db-cluster-to-point-in-time --db-cluster-identifier clustername-restore --source-db-cluster-identifier clustername --restore-to-time 2017-09-19T23:45:00.000Z Add a new instance to the new/restored cluster: aws rds create-db-instance --region us-east-1 --db-subnet-group default --engine aurora-postgresql --db-cluster-identifier cluster-name-restore --db-instance-identifier newinstance-nodeA --db-instance-class db.r4.large	
Partial Restore	RESTORE DATABASE... FILE= ... | FILEGROUP = ...	N/A	The cluster can be restored to a new cluster and the needed data can be copied to the primary cluster.

For more information, see https://-docs.aws.amazon.com/AmazonRDS/latest/UserGuide/Aurora.Managing.html#Aurora.Managing.Backups

SQL Server High Availability Essentials vs. PostgreSQL High Availability Essentials

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Multi replica, scale out solution using Amazon Aurora clusters and Availability Zones

SQL Server Usage

SQL Server provides several solutions to support high availability and disaster recovery requirements including Always On Failover Cluster Instances (FCI), Always On Availability Groups, Database Mirroring, and Log Shipping. The following sections describe each solution.

SQL Server 2017 also adds new Availability Groups functionality which includes read-scale support without a cluster, Minimum Replica Commit Availability Groups setting, and Windows-Linux cross-OS migrations and testing.

SQL Server 2019 introduces support for creating Database Snapshots of databases that include memory-optimized filegroups. A database snapshot is a read-only, static view of a SQL Server database. The database snapshot is transactional consistent with the source database as of the moment of the snapshot's creation. Among other things, some benefits of the database snapshots with regard to high availability are:

- Snapshots can be used for reporting purposes.
- Maintaining historical data for report generation.
- Using a mirror database that you are maintaining for availability purposes to offload reporting.

For more information about snapshots, see Database Snapshots

SQL Server 2019 introduces secondary to primary connection redirection for Always On Availability Groups. It allows client application connections to be directed to the primary replica regardless of the target server specified in the connections string. The connection string can target a secondary replica. Using the right configuration of the availability group replica and the settings in the connection string, the connection can be automatically redirected to the primary replica.

For more information about snapshots, see Secondary to primary replica read/write connection redirection

Always On Failover Cluster Instances (FCI)

Always On Failover Cluster Instances use the Windows Server Failover Clustering (WSFC) operating system framework to deliver redundancy at the server instance level.

An FCI is an instance of SQL Server installed across two or more WSFC nodes. For client applications, the FCI is transparent and appears to be a normal instance of SQL Server running on a single server. The FCI provides fail-

over protection by moving the services from one WSFC node Windows server to another WSFC node windows server in the event the current "active" node becomes unavailable or degraded.

FCIs target scenarios where a server fails due to a hardware malfunction or a software hangup. Without FCI, a significant hardware or software failure would render the service unavailable until the malfunction is corrected. With FCI, another server can be configured as a "stand by" to replace the original serverif it stops servicing requests.

For each service or cluster resource, there is only one node that actively services client requests (known as "owning a resource group"). A monitoring agent constantly monitors the resource owners and can transfer ownership to another node in the event of a failure or planned maintenance such as installing service packs or security patches. This process is completely transparent to the client application, which may continue to submit requests as normal when the failover or ownership transfer process completes.

FCI can significantly minimize downtime due to hardware or software general failures. The main benefits of FCI are:

- Full instance level protection.
- Automatic failover of resources from one node to another.
- Supports a wide range of storage solutions. WSFC cluster disks can be iSCSI, Fiber Channel, SMB file shares, and others.
- Supports multi-subnet.
- No need client application configuration after a failover.
- Configurable failover policies.
- Automatic health detection and monitoring.

For more information, see https://docs.microsoft.com/en-us/sql/sql-server/failover-clusters/windows/always-on-failover-cluster-instances-sql-server?view=sql-server-ver15

Always On Availability Groups

Always On Availability Groups is the most recent high availability and disaster recovery solution for SQL Server. It was introduced in SQL Server 2012 and supports high availability for one or more user databases. Because it can be configured and managed at the database level rather than the entire server, it provides much more control and functionality. As with FCI, Always On Availability Groups relies on the framework services of Windows Server Failover Cluster (WSFC) nodes.

Always On Availability Groups utilize real-time log record delivery and apply mechanism to maintain near real-time, readable copies of one or more databases.
These copies can also be used as redundant copies for resource usage distribution between servers (a scale-out read solution).

The main characteristics of Always On Availability Groups are:

- Supports up to nine availability replicas: One primary replica and up to eight secondary readable replicas.
- Supports both asynchronous-commit and synchronous-commit availability modes.
- Supports automatic failover, manual failover, and a forced failover. Only the latter can result in data loss.
- Secondary replicas allow both read-only access and offloading of backups.
- Availability Group Listener may be configured for each availability group. It acts as a virtual server address where applications can submit queries. The listener may route requests to a read-only replica or to the primary replica for read-write operations. This configuration also facilitates fast failover as client applications do not need to be reconfigured post failover.
- Flexible failover policies.
- The automatic page repair feature protects against page corruption.

- Log transport framework uses encrypted and compressed channels.
- Rich tooling and APIs including Transact-SQL DDL statements, management studio wizards, Always On Dashboard Monitor, and Powershell scripting.

For more information, see https://docs.microsoft.com/en-us/sql/database-engine/availability-groups/windows/always-on-availability-groups-sql-server?view=sql-server-ver15

Database Mirroring.

> **Note:** Microsoft recommends avoiding Database Mirroring for new development. This feature is deprecated and will be removed in a future release. It is recommended to use Always On Availability Groups instead.

Database mirroring is a legacy solution to increase database availability by supporting near instantaneous failover. It is similar in concept to Always On Availability Groups, but can only be configured for one database at a time and with only one "standby" replica.

For more information, see https://docs.microsoft.com/en-us/sql/database-engine/database-mirroring/database-mirroring-sql-server?view=sql-server-ver15

Log Shipping

Log shipping is one of the oldest and well tested high availability solutions. It is configured at the database level similar to Always On Availability Groups and Database Mirroring. Log shipping can be used to maintain one or more standby (secondary) databases for a single master (primary) database.

The Log shipping process involves three steps:

1. Backing up the transaction log of the primary database instance.
2. Copying the transaction log backup file to a secondary server.
3. Restoring the transaction log backup to apply changes to the secondary database.

Log shipping can be configured to create multiple secondary database replicas by repeating steps 2 and 3 above for each secondary server. Unlike FCI and Always On Availability Groups, log shipping solutions do not provide automatic failover.

In the event the primary database becomes unavailable or unusable for any reason, an administrator must configure the secondary database to serve as the primary and potentially reconfigure all client applications to connect to the new database.

> **Note:** Secondary databases can be used for read-only access, but require special handling. For more information, see https://docs.microsoft.com/en-us/sql/database-engine/log-shipping/configure-log-shipping-sql-server?view=sql-server-ver15

The main characteristics of Log Shipping solutions are:

- Provides redundancy for a single primary database and one or more secondary databases. Log Shipping is considered less of a high availability solution due to the lack of automatic failover.
- Supports limited read-only access to secondary databases.
- Administrators have control over the timing and delays of the primary server log backup and secondary

server restoration.
- Longer delays can be useful if data is accidentally modified or deleted in the primary database.

For more information about log shipping, see https://docs.microsoft.com/en-us/sql/database-engine/log-shipping/about-log-shipping-sql-server?view=sql-server-ver15

Examples

Configure an Always On Availability Group.

```
CREATE DATABASE DB1;

ALTER DATABASE DB1 SET RECOVERY FULL;

BACKUP DATABASE DB1 TO DISK = N'\\MyBackupShare\DB1\DB1.bak' WITH FORMAT;

CREATE ENDPOINT DBHA STATE=STARTED
AS TCP (LISTENER_PORT=7022) FOR DATABASE_MIRRORING (ROLE=ALL);

CREATE AVAILABILITY GROUP AG_DB1
   FOR
      DATABASE DB1
   REPLICA ON
      'SecondarySQL' WITH
         (
         ENDPOINT_URL = 'TCP://SecondarySQL.MyDomain.com:7022',
         AVAILABILITY_MODE = ASYNCHRONOUS_COMMIT,
         FAILOVER_MODE = MANUAL
         );

-- On SecondarySQL
ALTER AVAILABILITY GROUP AG_DB1 JOIN;

RESTORE DATABASE DB1 FROM DISK = N'\\MyBackupShare\DB1\DB1.bak'
WITH NORECOVERY;

-- On Primary
BACKUP LOG DB1
TO DISK = N'\\MyBackupShare\DB1\DB1_Tran.bak'
    WITH NOFORMAT

-- On SecondarySQL
RESTORE LOG DB1
    FROM DISK = N'\\MyBackupShare\DB1\DB1_Tran.bak'
    WITH NORECOVERY

ALTER DATABASE MyDb1 SET HADR AVAILABILITY GROUP = MyAG;
```

For more information, see https://docs.microsoft.com/en-us/sql/sql-server/failover-clusters/high-availability-solutions-sql-server?view=sql-server-ver15

PostgreSQL Usage

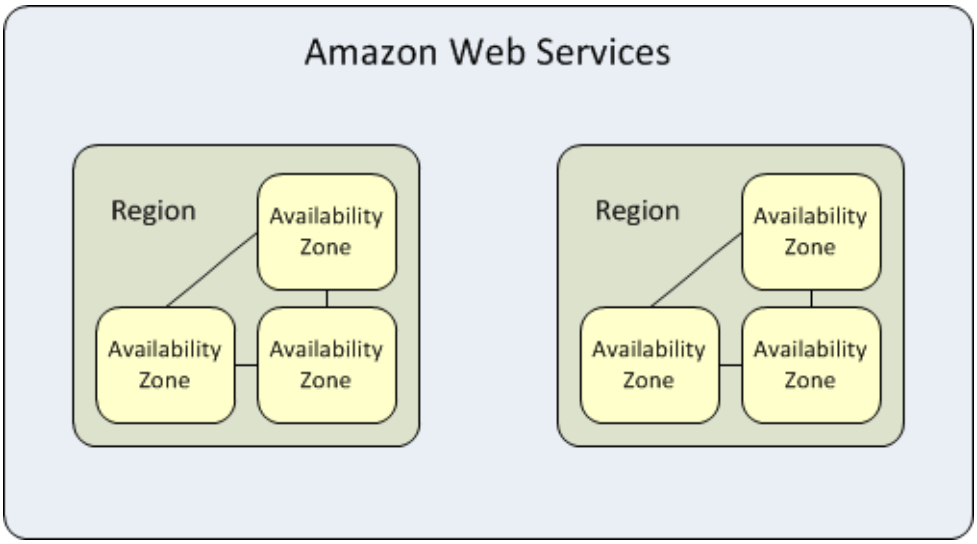
Aurora PostgreSQL is a fully managed Platform as a Service (PaaS) providing high availability capabilities. Amazon RDS provides database and instance administration functionality for provisioning, patching, backup, recovery, failure detection, and repair.

New Aurora PostgreSQL database instances are always created as part of a cluster. If you don't specify replicas at creation time, a single-node cluster is created. You can add database instances to clusters later.

Regions and Availability Zones

Amazon RDS is hosted in multiple global locations. Each location is composed of Regions and Availability Zones. Each Region is a separate geographic area having multiple, isolated Availability Zones. Amazon RDS supports placement of resources such as database instances and data storage in multiple locations. By default, resources are not replicated across regions.

Each Region is completely independent and each Availability Zone is isolated from all others. However, the main benefit of Availability Zones within a Region is that they are connected through low-latency, high bandwidth local network links.



Resources may have different scopes. A resource may be global, associated with a specific region (region level) , or associated with a specific Availability Zone within a region. For more information, see https://-docs.aws.amazon.com/AWSEC2/latest/UserGuide/resources.html

When creating a database instance, you can specify an availability zone or use the default "No Preference", in which case Amazon chooses the availability zone for you.

Aurora PostgreSQL instances can be distributed across multiple availability zones. Applications can be designed to take advantage of failover such that in the event of an instance in one availability zone failing, another instance in different availability zone will take over and handle requests.

Elastic IP addresses can be used to abstract the failure of an instance by remapping the virtual IP address to one of the available database instances in another Availability Zone. For more information, see https://-docs.aws.amazon.com/AWSEC2/latest/UserGuide/elastic-ip-addresses-eip.html

An Availability Zone is represented by a region code followed by a letter identifier. For example, us-east-1a.

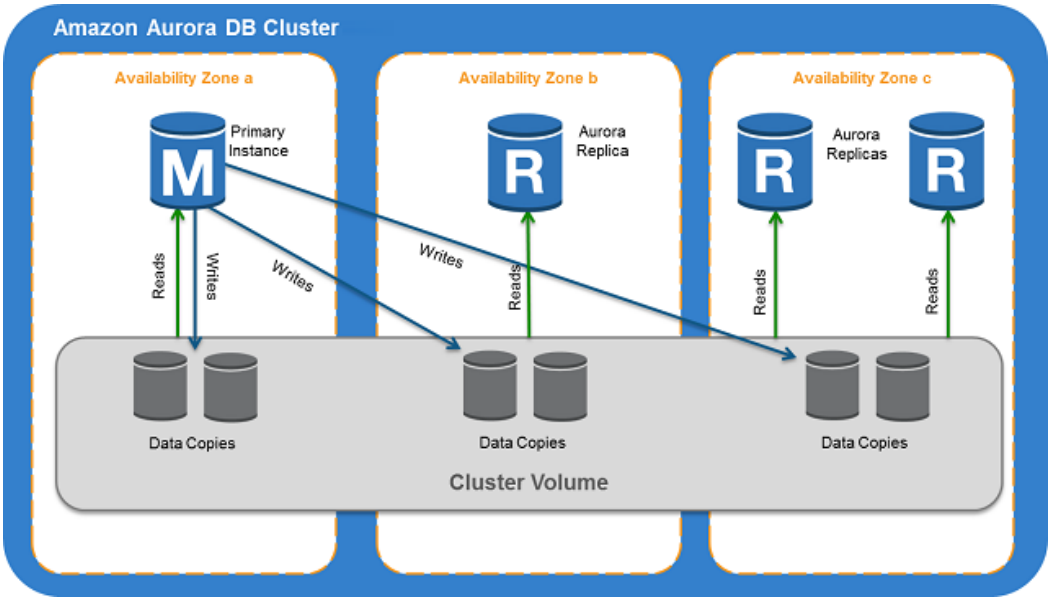
Note: To guarantee even resource distribution across Availability Zones for a region, Amazon RDS independently maps Availability Zones to identifiers for each account. For example, the Availability Zone us-east-1a for one account might not be in the same location as us-east-1a for another account. Users cannot coordinate Availability Zones between accounts.

Aurora PostgreSQL DB Cluster

A DB cluster consists of one or more DB instances and a cluster volume that manages the data for those instances. A cluster volume is a virtual database storage volume that may span multiple Availability Zones with each holding a copy of the database cluster data.

An Aurora database cluster is made up of one of more of the following types of instances:

- A **Primary instance** that supports both read and write workloads. This instance is used for all DML transactions. Every Aurora DB cluster has one, and only, one primary instance.
- An **Aurora Replica** that supports read-only workloads. Every Aurora PostgreSQL database cluster may contain from zero to 15 Aurora Replicas in addition to the primary instance for a total maximum of 16 instances. Aurora Replicas enable scale-out of read operations by offloading reporting or other read-only processes to multiple replicas. Place aurora replicas in multiple availability Zones to increase availability of the databases.



Endpoints

Endpoints are used to connect to Aurora PostgreSQL databases. An endpoint is a Universal Resource Locator (URL) comprised of a host address and port number.

- A **Cluster Endpoint** is an endpoint for an Aurora database cluster that connects to the current primary instance for that database cluster regardless of the availability zone in which the primary resides. Every Aurora PostgreSQL DB cluster has one cluster endpoint and one primary instance. The cluster endpoint should be used for transparent failover for either read or write workloads.

  Note: Use the cluster endpoint for all write operations including all DML and DDL statements.

  If the primary instance of a DB cluster fails for any reason, Aurora automatically fails over server requests to a new primary instance. An example of a typical Aurora PostgreSQL DB Cluster endpoint is: `mydb-cluster.cluster-123456789012.us-east-1.rds.amazonaws.com:3306`

- A **Reader Endpoint** is an endpoint that is used to connect to one of the Aurora read-only replicas in the database cluster. Each Aurora PostgreSQL database cluster has one reader endpoint. If there are more than one Aurora Replicas in the cluster, the reader endpoint redirects the connection to one of the available replicas. Use the Reader Endpoint to support load balancing for read-only connections. If the DB cluster contains no replicas, the reader endpoint redirects the connection to the primary instance. If an Aurora Replica is created later, the Reader Endpoint starts directing connections to the new Aurora Replica with minimal interruption in service. An example of a typical Aurora PostgreSQL DB Reader Endpoint is: `mydbcluster.cluster-ro-123456789012.us-east-1.rds.amazonaws.com:3306`
- An **Instance Endpoint** is a specific endpoint for every database instance in an Aurora DB cluster. Every Aurora PostgreSQL DB instance regardless of its role has its own unique instance endpoint. Use the Instance Endpoints only when the application handles failover and read workload scale-out on its own. For example, you can have certain clients connect to one replica and others to another. An example of a typical Aurora PostgreSQL DB Reader Endpoint is: `pgsdbinstance.123456789012.us-east-1.rds.amazonaws.com:3306`

Some general considerations for using endpoints:

- Consider using the cluster endpoint instead of individual instance endpoints because it supports high-availability scenarios. In the event that the primary instance fails, Aurora PostgreSQL automatically fails over to a new primary instance. This configuration can be accomplished by either promoting an existing Aurora Replica to be the new primary or by creating a new primary instance.
- If you use the cluster endpoint instead of the instance endpoint, the connection is automatically redirected to the new primary.
- If you choose to use the instance endpoint, you must use the RDS cosole or the API to discover which database instances in the database cluster are available and their current roles. Then, connect using that instance endpoint.
- Be aware that the reader endpoint load balances connections to Aurora Replicas in an Aurora database cluster, but it does not load balance specific queries or workloads. If your application requires custom rules for distributing read workloads, use instance endpoints.
- The reader endpoint may redirect connection to a primary instance during the promotion of an Aurora Replica to a new primary instance.

Amazon Aurora Storage

Aurora PostgreSQL data is stored in a cluster volume. The Cluster volume is a single, virtual volume that uses fast solid state disk (SSD) drives.The cluster volume is comprised of multiple copies of the data distributed between availability zones in a region. This configuration minimizes the chances of data loss and allows for the failover scenarios mentioned above.

Aurora cluster volumes automatically grow to accommodate the growth in size of your databases. An Aurora cluster volume has a maximum size of 64 terabytes (TiB). Since table size is theoretically limited to the size of the cluster volume, the maximum table size in an Aurora DB cluster is 64 TiB.

Storage Auto-Repair

The chance of data loss due to disk failure is greatly minimize due to the fact that Aurora PostgreSQL maintains multiple copies of the data in three Availability Zones. Aurora PostgreSQL detects failures in the disks that make up the cluster volume. If a disk segment fails, Aurora repairs the segment automatically. Repairs to the disk segments are made using data from the other cluster volumes to ensure correctness. This process allows Aurora to significantly minimize the potential for data loss and the subsequent need to restore a database.

Survivable Cache Warming

When a database instance starts, Aurora PostgreSQL performs a "warming" process for the buffer pool. Aurora PostgreSQL pre-loads the buffer pool with pages that have been frequently used in the past. This approach improves performance and shortens the natural cache filling process for the initial period when the database instance starts servicing requests. Aurora PostgreSQL maintains a separate process to manage the cache, which can stay alive even when the database process restarts. The buffer pool entries remain in memory regardless of the database restart providing the database instance with a fully "warm" buffer pool.

Crash Recovery

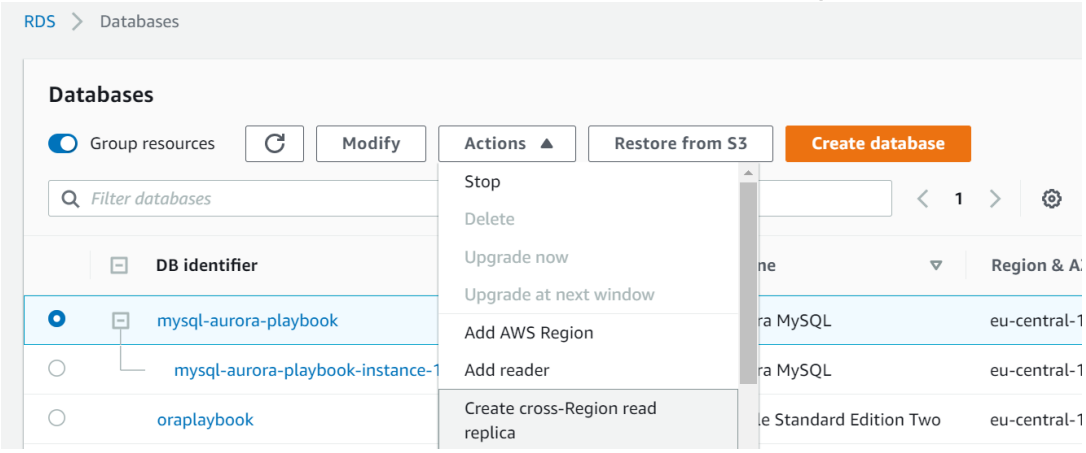
Aurora PostgreSQL can instantaneously recover from a crash and continue to serve requests. Crash recovery is performed asynchronously using parallel threads enabling the database to remain open and available immediately after a crash.

For more information about crash recovery, see https://-docs.aws.amazon.com/AmazonRDS/latest/UserGuide/Aurora.Managing.html#Aurora.Managing.FaultTolerance.

Examples

The following walk-through demonstrates how to create a read-replica:

1. Navigate to the RDS databases page.
2. Select the instance and click **Instance actions > Create cross region read replica**.



3. On the next page, enter all required details and click **Create**.

After the replica is created, you can execute read and write operations on the primary instance and read-only operations on the replica.

Summary

Feature	SQL Server	Aurora PostgreSQL	Comments
Server level failure protection	Failover Cluster Instances	N/A	Not applicable. Clustering is handled by Aurora PostgreSQL.
Database level fail-	Always On Avail-	Aurora Replicas	

Feature	SQL Server	Aurora PostgreSQL	Comments
ure protection	ability Groups		
Log replication	Log Shipping	N/A	Not applicable. Aurora PostgreSQL handles data replication at the storage level.
Disk error protection	RESTORE... PAGE=	Automatically	
Maximum Read Only replicas	8 + Primary	15 + Primary	
Failover address	Availability Group Listener	Cluster Endpoint	
Read Only workloads	READ INTENT connection	Read Endpoint	

For more information, see:

- *https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/Aurora.Overview.html*
- *https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-regions-availability-zones.html*

Indexes

SQL Server Clustered and Non Clustered Indexes vs. PostgreSQL Clustered and Non Clustered Indexes

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Indexes	CLUSTERED INDEX is not supported Few missing options

SQL Server Usage

Indexes are physical disk structures used to optimize data access. They are associated with tables or materialized views and allow the query optimizer to access rows and individual column values without scanning an entire table.

An index consists of index keys, which are columns from a table or view. They are sorted in ascending or descending order providing quick access to individual values for queries that use equality or range predicates. Database indexes are similar to book indexes that list page numbers for common terms. Indexes created on multiple columns are called Composite Indexes.

SQL Server implements indexes using the Balanced Tree algorithm (B-tree).

> Note: SQL Server supports additional index types such as hash indexes (for memory-optimized tables), spatial indexes, full text indexes, and XML indexes.

Indexes are created automatically to support table primary keys and unique constraints. They are required to efficiently enforce uniqueness. Up to 250 indexes can be created on a table to support common queries.

SQL Server provides two types of B-Tree indexes: Clustered Indexes and Non-Clustered Indexes.

Clustered Indexes

Clustered indexes include all the table's column data in their leaf level. The entire table data is sorted and logically stored in order on disk. A Clustered Index is similar to a phone directory index where the entire data is contained for every index entry. Clustered indexes are created by default for Primary Key constraints. However, a primary key doesn't necessarily need to use a clustered index if it is explicitly specified as non-clustered.

Clustered indexes are created using the CREATE CLUSTERED INDEX statement. Only one clustered index can be created for each table because the index itself is the table's data. A table having a clustered index is called a "clustered table" (also known as an "index organized table" in other relational database management systems). A table with no clustered index is called a "heap".

Examples

Create a Clustered Index as part of table definition.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL
 PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
);
```

Create an explicit clustered index using CREATE INDEX.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL
 PRIMARY KEY NONCLUSTERED,
Col2 VARCHAR(20) NOT NULL
);
```

```
CREATE CLUSTERED INDEX IDX1
ON MyTable(Col2);
```

Non-Clustered Indexes

Non clustered indexes also use the B-Tree algorithm but consist of a data structure separate from the table itself. They are also sorted by the index keys, but the leaf level of a non-clustered index contains pointers to the table rows; not the entire row as with a clustered index.

Up to 999 non-clustered indexes can be created on a SQL Server table. The type of pointer used at the lead level of a non-clustered index (also known as a row locator) depends on whether the table has a clustered index (clustered table) or not (heap). For heaps, the row locators use a physical pointer (RID). For clustered tables, row locators use the clustering key plus a potential uniquifier. This approach minimizes non-clustered index updates when rows move around, or the clustered index key value changes.

Both clustered and non clustered indexes may be defined as UNIQUE using the CREATE UNIQUE INDEX statement. SQL Server maintains indexes automatically for a table or view and updates the relevant keys when table data is modified.

Examples

Create a unique non-clustered index as part of table definition.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL
 PRIMARY KEY,
Col2 VARCHAR(20) NOT NULL
 UNIQUE
);
```

Create a unique non-clustered index using CREATE INDEX.

```
CREATE TABLE MyTable
(
Col1 INT NOT NULL
 PRIMARY KEY CLUSTERED,
Col2 VARCHAR(20) NOT NULL
);
```

```
CREATE UNIQUE NONCLUSTERED INDEX IDX1 ON MyTable(Col2);
```

Filtered Indexes and Covering Indexes

SQL Server also supports two special options for non clustered indexes. Filtered indexes can be created to index only a subset of a table's data. They are useful when it is known that the application will not need to search for specific values such as NULLs.

For queries that typically require searching on particular columns but also need additional column data from the table, non-clustered indexes can be configured to include additional column data in the index leaf level in addition to the row locator. This may prevent expensive lookup operations, which follow the pointers to either the physical row location (in a heap) or traverse the clustered index key in order to fetch the rest of the data not part of the index. If a query can get all the data it needs from the non-clustered index leaf level, that index is considered a "covering" index.

Examples

Create a filtered index to exclude NULL values.

```
CREATE NONCLUSTERED INDEX IDX1
ON MyTable(Col2)
WHERE Col2 IS NOT NULL;
```

Create a covering index for queries that search on col2 but also need data from col3.

```
CREATE NONCLUSTERED INDEX IDX1
ON MyTable (Col2)
INCLUDE (Col3);
```

Indexes On Computed Columns

SQL Server allows creating indexes on persisted computed columns. Computed columns are table or view columns that derive their value from an expression based on other columns in the table. They are not explicitly specified when data is inserted or updated. This feature is useful when a query's filter predicates are not based on the column table data as-is, but on a function or expression.

Examples

For example, consider the following table that stores phone numbers for customers, but the format is not consistent for all rows; some include country code and some do not:

```
CREATE TABLE PhoneNumbers
(
PhoneNumber VARCHAR(15) NOT NULL
 PRIMARY KEY,
Customer VARCHAR(20) NOT NULL
);
```

```
INSERT INTO PhoneNumbers
VALUES
('+1-510-444-3422','Dan'),
('644-2442-3119','John'),
('1-402-343-1991','Jane');
```

The following query to look up the owner of a specific phone number must scan the entire table because the index cannot be used due to the preceding % wild card.

```
SELECT Customer
FROM PhoneNumbers
WHERE PhoneNumber LIKE '%510-444-3422';
```

A potential solution would be to add a computed column that holds the phone number in reverse order.

```
ALTER TABLE PhoneNumbers
ADD ReversePhone AS REVERSE(PhoneNumber)
PERSISTED;
```

```
CREATE NONCLUSTERED INDEX IDX1
ON PhoneNumbers (ReversePhone)
INCLUDE (Customer);
```

Now, the following query can be used to search for the customer based on the reverse string, which places the wild card at the end of the LIKE predicate. This approach provides an efficient index seek to retrieve the customer based on the phone number value.

```
DECLARE @ReversePhone VARCHAR(15) = REVERSE('510-444-3422');
SELECT Customer
FROM PhoneNumbers
WHERE ReversePhone LIKE @ReversePhone + '%';
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/indexes/clustered-and-nonclustered-indexes-described?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-index-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL supports Balanced Tree (b-tree) indexes similar to SQL Server. However, the terminology, use, and options for these indexes are different.

Aurora PostgreSQL is missing the CLUSTERED INDEX feature but has other options which SQL Server doesn't have, Index Prefix and Blob indexing.

Since PostgreSQL 10, there are many improvements in performance, related to joins and parallel scans of the indexes.

Starting with PostgreSQL 12 it is now possible to monitor progress of CREATE INDEX and REINDEX operartions by querying system view pg_stat_progress_create_index

Cluster Table

PostgreSQL does not support cluster tables directly, but provides similar functionality using the CLUSTER feature. The PostgreSQL CLUSTER statement specifies table sorting based on an index already associated with the table. When using the PostgreSQL CLUSTER command, the data in the table is physically sorted based on the index, possibly using a primary key column.

The CLUSTER statement can be used as needed to re-cluster the table.

Example

```
CREATE TABLE SYSTEM_EVENTS (
        EVENT_ID NUMERIC,
        EVENT_CODE VARCHAR(10) NOT NULL,
        EVENT_DESCIPTION VARCHAR(200),
        EVENT_TIME DATE NOT NULL,
        CONSTRAINT PK_EVENT_ID PRIMARY KEY(EVENT_ID));

INSERT INTO SYSTEM_EVENTS VALUES(9, 'EV-A1-10', 'Critical', '01-JAN-2017');
INSERT INTO SYSTEM_EVENTS VALUES(1, 'EV-C1-09', 'Warning', '01-JAN-2017');
INSERT INTO SYSTEM_EVENTS VALUES(7, 'EV-E1-14', 'Critical', '01-JAN-2017');

CLUSTER SYSTEM_EVENTS USING PK_EVENT_ID;
SELECT * FROM SYSTEM_EVENTS;

 event_id | event_code | event_desciption | event_time
----------+------------+------------------+------------
        1 | EVNT-C1-09 | Warning          | 2017-01-01
        7 | EVNT-E1-14 | Critical         | 2017-01-01
        9 | EVNT-A1-10 | Critical         | 2017-01-01
```

```
INSERT INTO SYSTEM_EVENTS VALUES(2, 'EV-E2-02', 'Warning', '01-JAN-2017');
SELECT * FROM SYSTEM_EVENTS;

 event_id | event_code | event_desciption | event_time
----------+------------+------------------+------------
        1 | EVNT-C1-09 | Warning          | 2017-01-01
        7 | EVNT-E1-14 | Critical         | 2017-01-01
        9 | EVNT-A1-10 | Critical         | 2017-01-01
        2 | EVNT-E2-02 | Warning          | 2017-01-01

CLUSTER SYSTEM_EVENTS USING PK_EVENT_ID; -- Run CLUSTER again to re-cluster
SELECT * FROM SYSTEM_EVENTS;

 event_id | event_code | event_desciption | event_time
----------+------------+------------------+------------
        1 | EVNT-C1-09 | Warning          | 2017-01-01
        2 | EVNT-E2-02 | Warning          | 2017-01-01
        7 | EVNT-E1-14 | Critical         | 2017-01-01
        9 | EVNT-A1-10 | Critical         | 2017-01-01
```

Btree Indexes

When creating an Index in PostgreSQL, a B-Tree Index is created by default, similar to the behavior in SQL Server. PostgreSQL B-Tree indexes have the same characteristics as SQL Server and can handle equality and range queries on data. The PostgreSQL optimizer considers using B-Tree indexes especially for one or more of the following operators in queries: >, >=, <, <=, =

In addition, performance improvements can be achieved when using IN, BETWEEN, IS NULL, or IS NOT NULL.

Since PostgreSQL 10, there is a support of parallel B-tree index scans - this change allows this index type pages to be searched by separate parallel workers

Example

Create a PostgreSQL B-Tree Index.

```
CREATE INDEX IDX_EVENT_ID ON SYSTEM_LOG(EVENT_ID);
OR
CREATE INDEX IDX_EVENT_ID1 ON SYSTEM_LOG USING BTREE (EVENT_ID);
```

For more details, seehttps://www.postgresql.org/docs/13/static/sql-createindex.html

Column and Multiple Column Secondary Indexes

Currently, only B-tree, GiST, GIN, and BRIN support Multi-Column Indexes. 32 columns can be specified when creating a Multi-Column Index.

PostgreSQL uses the exact same syntax as SQL Server to create Multi-Column Indexes.

Example

Create a multi-column index on the EMPLOYEES table.

```
CREATE INDEX IDX_EMP_COMPI
  ON EMPLOYEES (FIRST_NAME, EMAIL, PHONE_NUMBER);
```

Drop a multiple-column Index.

```
DROP INDEX IDX_EMP_COMPI;
```

For additional details: https://www.postgresql.org/docs/13/static/indexes-multicolumn.html

Expression Indexes and Partial Indexes

Example

Create an Expression Index in PostgreSQL.

```
CREATE TABLE SYSTEM_EVENTS(
         EVENT_ID NUMERIC PRIMARY KEY,
         EVENT_CODE VARCHAR(10) NOT NULL,
         EVENT_DESCIPTION VARCHAR(200),
         EVENT_TIME TIMESTAMP NOT NULL);

CREATE INDEX EVNT_BY_DAY ON SYSTEM_EVENTS(EXTRACT(DAY FROM EVENT_TIME));
```

Insert records into the SYSTEM_EVENTS table, gathering table statistics using the ANALYZE statement and verifying that the Expression Index ("EVNT_BY_DAY") is being used for data access.

```
INSERT INTO SYSTEM_EVENTS
  SELECT ID AS event_id,
        'EVNT-A'||ID+9||'-'||ID AS event_code,
        CASE WHEN mod(ID,2) = 0 THEN 'Warning' ELSE 'Critical' END AS event_desc,
        now() + INTERVAL '1 minute' * ID AS event_time
       FROM
       (SELECT generate_series(1,1000000) AS ID) A;
INSERT 0 1000000

ANALYZE SYSTEM_EVENTS;
ANALYZE

EXPLAIN
       SELECT * FROM SYSTEM_EVENTS
       WHERE EXTRACT(DAY FROM EVENT_TIME) = '22';

                                    QUERY PLAN
-------------------------------------------------------------------------------
 Bitmap Heap Scan on system_events  (cost=729.08..10569.58 rows=33633 width=41)
   Recheck Cond: (date_part('day'::text, event_time) = '22'::double precision)
   ->  Bitmap Index Scan on evnt_by_day  (cost=0.00..720.67 rows=33633 width=0)
         Index Cond: (date_part('day'::text, event_time) = '22'::double precision)
```

Partial Indexes

PostgreSQL also provides Partial Indexes, which are indexes that use a WHERE clause when created. The most significant benefit of using partial indexes is a reduction of the overall subset of indexed data, allowing users to index relevant table data only. Partial indexes can be used to increase efficiency and reduce the size of the index.

Example

Create a PostgreSQL partial Index.

```
CREATE TABLE SYSTEM_EVENTS(
         EVENT_ID NUMERIC PRIMARY KEY,
```

```
          EVENT_CODE VARCHAR(10) NOT NULL,
          EVENT_DESCIPTION VARCHAR(200),
          EVENT_TIME DATE NOT NULL);

CREATE INDEX IDX_TIME_CODE ON SYSTEM_EVENTS(EVENT_TIME)
          WHERE EVENT_CODE like '01-A%';
```

For additional details, see
https://www.postgresql.org/docs/13/static/sql-createindex.html#SQL-CREATEINDEX-CONCURRENTLY

BRIN Indexes

PostgreSQL does not provide native support for BITMAP indexes. However, a BRIN index, which splits table records into block ranges with MIN/MAX summaries, can be used as a partial alternative for certain analytic workloads. For example, BRIN indexes are suited for queries that rely heavily on aggregations to analyze large numbers of records.

Example

Create a PostgreSQL BRIN Index.

```
CREATE INDEX IDX_BRIN_EMP ON EMPLOYEES USING BRIN(salary);
```

Summary

The following table summarizes the key differences to consider when migrating b-tree indexes from SQL Server to Aurora PostgreSQL

Index Feature	SQL Server	Aurora PostgreSQL
Clustered indexes supported for	Table keys, composite or single column, unique and non-unique, null or not null	On indexes
Non clustered index supported for	Table keys, composite or single column, unique and non unique, null or not null	Table keys, composite or single column, unique and non unique, null or not null
Max number of non clustered indexes	999	N/A
Max total index key size	900 bytes	N/A
Max columns per index	32	32
Index Prefix	N/A	Supported
Filtered Indexes	Supported	Supported (Partial Indexes)
Indexes on BLOBS	N/A	Supported

For additional details, see:

- *https://www.postgresql.org/docs/13/static/indexes-types.html*
- *https://www.postgresql.org/docs/13/static/sql-createindex.html*
- *https://www.postgresql.org/docs/13/static/sql-cluster.html*
- *https://www.postgresql.org/docs/13/static/sql-createindex.html#SQL-CREATEINDEX-CONCURRENTLY*

Management

SQL Server Agent vs. PostgreSQL Scheduled Lambda

SQL Server Usage

SQL Server Agent provides two main functions: Scheduling automated maintenance jobs, and alerting.

> **Note:** Other SQL built-in frameworks such as replication, also use SQL Agent jobs.

See Maintenance Plans and Alerting.

For more information about SQL Server Agent, see https://docs.microsoft.com/en-us/sql/ssms/agent/sql-server-agent?view=sql-server-ver15

PostgreSQL Usage

SQL Server Agent provides two main functions: Scheduling automated maintenance jobs and alerting.

> **Note:** Other SQL built-in frameworks such as replication also use SQL Agent jobs.

Maintenance Plans and Alerting are covered in separate sections:

- Maintenance Plans
- Alerting

Currently, there is no equivalent in Aurora PostgreSQL for scheduling tasks but you can create scheduled AWS Lambda that will execute a stored procedure, find an example in DB Mail.

SQL Server Alerting vs. PostgreSQL Alerting

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Use Event Notifications Subscription with Amazon Simple Notification Service (SNS)

SQL Server Usage

SQL Server provides *SQL Server Agent* to generate alerts. When running, SQL Server Agent constantly monitors SQL Server windows application log messages, performance counters, and Windows Management Instrumentation (WMI) objects. When a new error event is detected, the agent checks the MSDB database for configured alerts and executes the specified action.

You can define SQL Server Agent alerts for the following categories:

- SQL Server events
- SQL Server performance conditions
- WMI events

For SQL Server events, the alert options include the following settings:

- **Error Number:** Alert when a specific error is logged.
- **Severity Level:** Alert when any error in the specified severity level is logged.
- **Database:** Filter the database list for which the event will generate an alert.
- **Event Text:** Filter specific text in the event message.

Note: SQL Server agent is pre-configured with several high severity alerts. It is highly recommended to enable these alerts.

To generate an alert in response to a specific performance condition, specify the performance counter to be monitored, the threshold values for the alert, and the predicate for the alert to occur. The following list identifies the performance alert settings:

- **Object:** The Performance counter *category* or the monitoring area of performance.
- **Counter:** A counter is a specific attribute value of the object.
- **Instance:** Filter by SQL Server instance (multiple instances can share logs).
- **Alert if counter and Value:** The threshold for the alert and the predicate. The threshold is a number. Predicates are *Falls below*, *becomes equal* to, or *rises above* the threshold.

WMI events require the WMI namespace and the WMI Query Language (WQL) query for specific events.

Alerts can be assigned to specific operators with schedule limitations and multiple response types including:

- Execute an SQL Server Agent Job.
- Send Email, Net Send command, or a pager notification.

You can configure Alerts and responses with SQL Server Management Studio or system stored procedures.

Examples

Configure an alert for all errors with severity 20.

```
EXEC msdb.dbo.sp_add_alert
 @name = N'Severity 20 Error Alert',
 @severity = 20,
 @notification_message = N'A severity 20 Error has occurred. Initiating emergency pro-
cedure',
 @job_name = N'Error 20 emergency response';
```

For more information, see https://docs.microsoft.com/en-us/sql/ssms/agent/alerts?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL does not support direct configuration of engine alerts. Use the Event Notifications Infrastructure to collect history logs or receive event notifications in near real-time.

Amazon Relational Database Service (RDS) uses Amazon Simple Notification Service (SNS) to provide notifications for events. SNS can send notifications in any form supported by the region including email, text messages, or calls to HTTP endpoints for response automation.

Events are grouped into categories. You can only subscribe to event categories, not individual events. SNS sends notifications when any event in a category occurs.

You can subscribe to alerts for database instances, database clusters, database snapshots, database cluster snapshots, database security groups, and database parameter groups. For example, a subscription to the *Backup* category for a specific database instance sends notifications when backup related events occur on that instance. A subscription to a *Configuration Change* category for a database security group sends notifications when the security group changes.

> **Note:** For Amazon Aurora, some events occur at the cluster rather than instance level. You will not receive those events if you subscribe to an Aurora DB instance.

SNS sends event notifications to the address specified when the subscription was created. Typically, administrators create several subscriptions. For example, one subscription to receive logging events and another to receive only critical events for a production environment requiring immediate responses.

You can disable notifications without deleting a subscription by setting the *Enabled* radio button to *No* in the Amazon RDS console. Alternatively, use the Command Line Interface (CLI) or RDS API to change the *Enabled* setting.

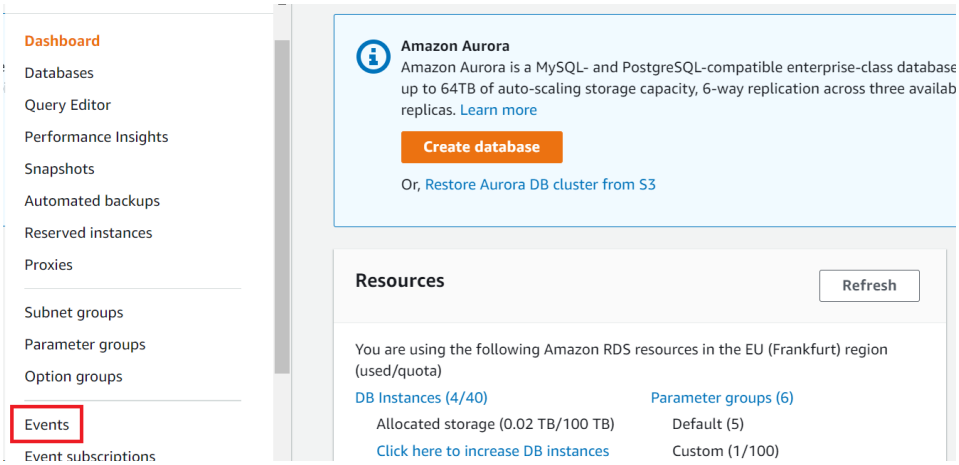
Subscriptions are identified by the Amazon Resource Name (ARN) of an Amazon SNS topic. The Amazon RDS console creates ARNs when subscriptions are created. When using the CLI or API, you must create the ARN using the Amazon SNS console or the Amazon SNS API.

Examples

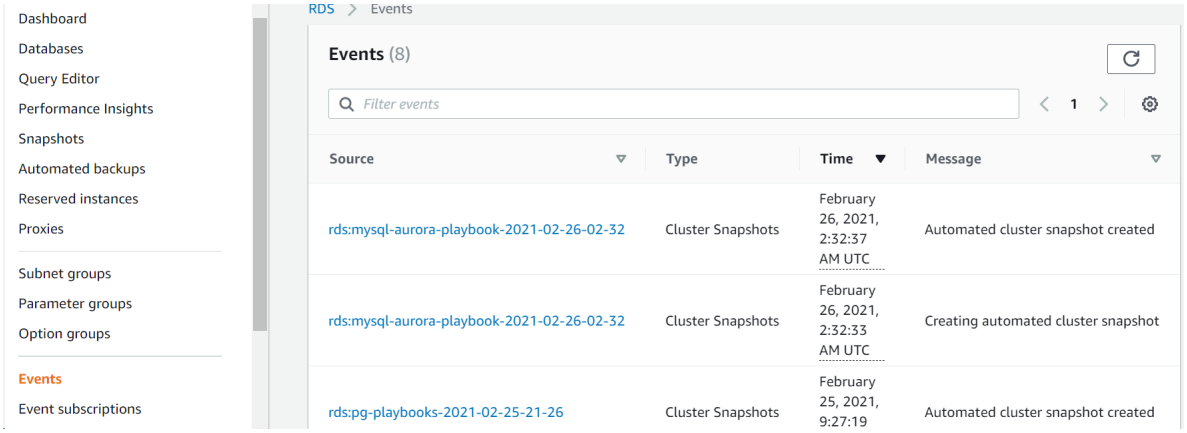
The following walk-through demonstrates how to create an Event Notification Subscription:

Sign into an AWS account, open the AWS Console, and navigate to the Amazon RDS page.

Click **Events** on the left navigation pane.

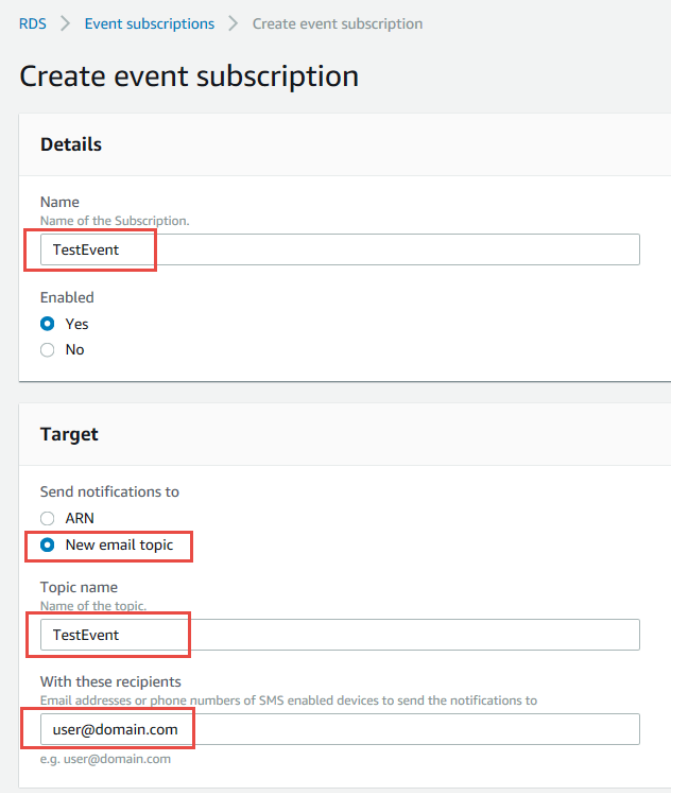


This screen will present relevant RDS events occured

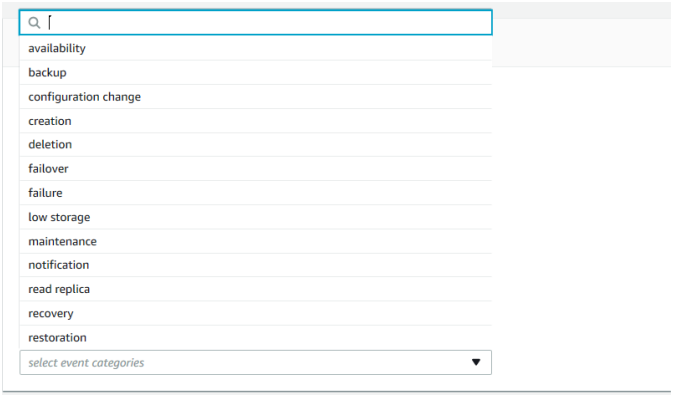


Click **Event Subscriptions** and then click **CREATE EVENT SUBSCRIPTION** on the top right side.

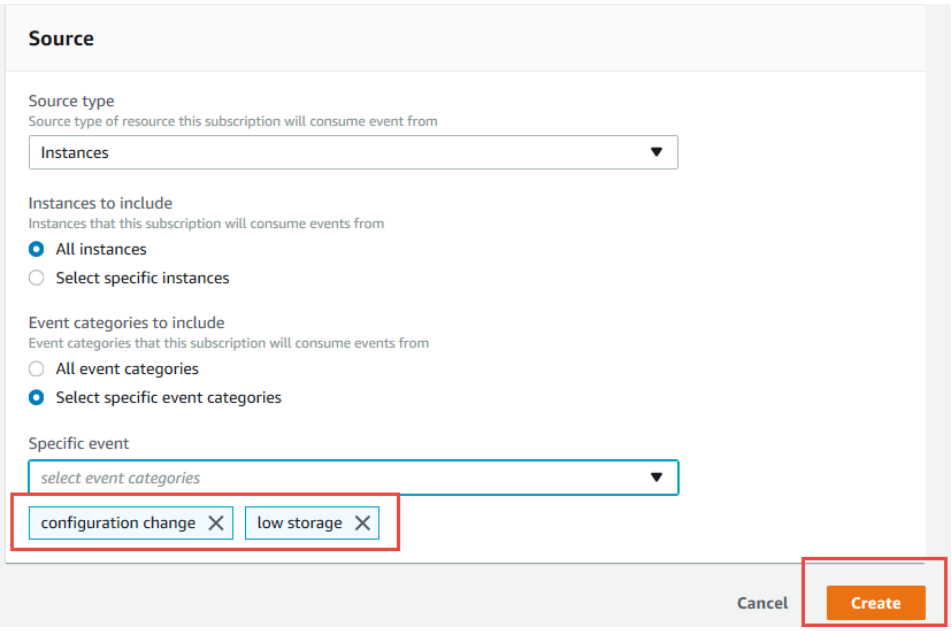
Enter the **Name of the subscription** and select a **Target** of ARN or Email. For email subscriptions, enter values for **Topic name** and **With these recipients**.



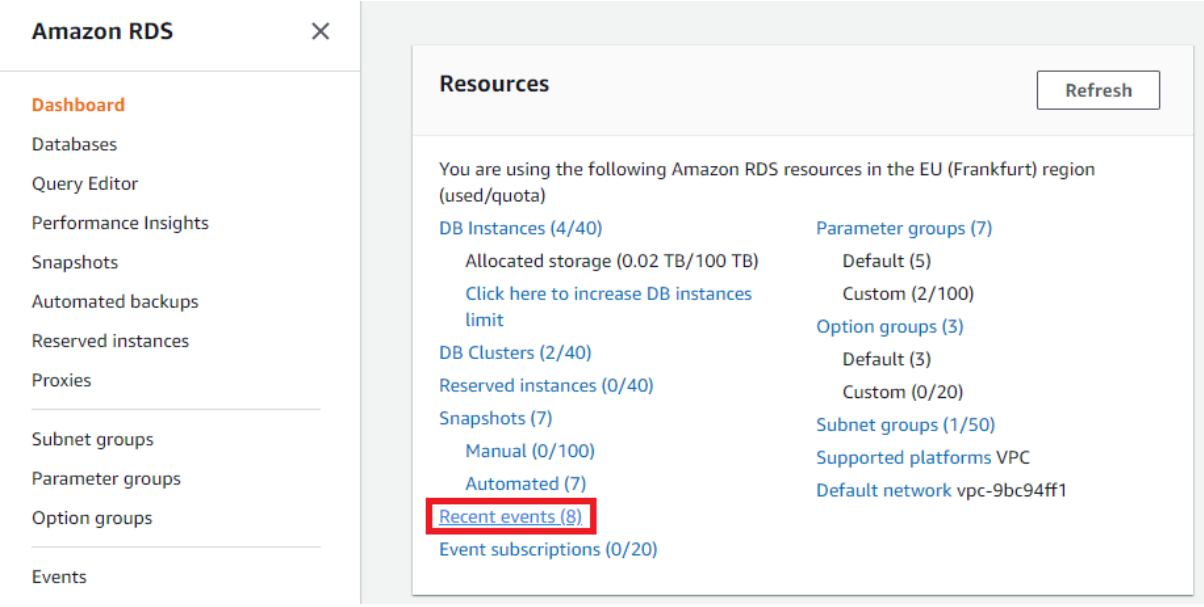
Select the event source and choose specific event categories. Click the drop-down menu to view the list of available categories.



Choose the event categories to be monitored and click **Create**.



From the AWS RDS Dashboard, click the **View Recent Events** button.



For more information, see https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_Events.html

Raising Errors from Within the Database

Error Log Types

PostgreSQL supports the following log severity levels:

Log Type	Information Written to Log
DEBUG1...DEBUG5	Provides successively-more-detailed information for use by developers.
INFO	Provides information implicitly requested by the user.
NOTICE	Provides information that might be helpful to users.
WARNING	Provides warnings of likely problems.
ERROR	Reports the error that caused the current command to abort.
LOG	Reports information of interest to administrators.
FATAL	Reports the error that caused the current session to abort.
PANIC	Reports the error that caused all database sessions to abort.

Several parameters control how and where PostgreSQL log and errors files are placed:

Parameter	Description
log_filename	Sets the file name pattern for log files. Modifiable via an Aurora Database Parameter Group.
log_rotation_age	(min) Automatic log file rotation will occur after N minutes. Modifiable via an Aurora Database Parameter Group.
log_rotation_size	(kB) Automatic log file rotation will occur after N kilobytes. Modifiable via an Aurora Database Parameter Group.
log_min_messages	Sets the message levels that are logged (DEBUG, ERROR, INFO, etc....). Modifiable via an Aurora Database Parameter Group.
log_min_error_state-ment	Causes all statements generating errors at or above this level to be logged (DEBUG, ERROR, INFO, etc....). Modifiable via an Aurora Database Parameter Group.
log_min_duration_ statement	Sets the minimum execution time above which statements will be logged (ms). Modifiable via an Aurora Database Parameter Group.

Note: Modifications to certain parameters such as log_directory (which sets the destination directory for log files) or logging_collector (which starts a subprocess to capture stderr output and/or csvlogs into log files) are disabled for an Aurora PostgreSQL instance.

For more information, see https://www.postgresql.org/docs/13/static/runtime-config-logging.html

SQL Server Database Mail vs. PostgreSQL Database Mail

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	SCT Action Codes - Mail	Use Lambda Integration

SQL Server Usage

The Database Mail framework is an email client solution for sending messages directly from SQL Server. Email capabilities and APIs within the database server provide easy management of the following messages:

- Server administration messages such as alerts, logs, status reports, and process confirmations.
- Application messages such as user registration confirmation and action verifications.

Note: Database Mail is turned off by default.

The main features of the Database Mail framework are:

- Database Mail sends messages using the standard and secure Simple Mail Transfer Protocol (SMTP) .
- The email client engine runs asynchronously and sends messages in a separate process to minimize dependencies.
- Database Mail supports multiple SMTP Servers for redundancy.
- Full support and awareness of Windows Server Failover Cluster for high availability environments.
- Multi-profile support with multiple failover accounts in each profile.
- Enhanced security management with separate roles in MSDB.
- Security is enforced for mail profiles.
- Attachment sizes are monitored and can be capped by the administrator.
- Attachment file types can be blacklisted.
- Email activity can be logged to SQL Server, the Windows application event log, and a set of system tables in MSDB.
- Supports full auditing capabilities with configurable retention policies.
- Supports both plain text and HTML messages.

Architecture

Database Mail is built on top of the Microsoft SQL Server Service Broker queue management framework.

The system stored procedure sp_send_dbmail sends email messages. When this stored procedure is executed, it inserts an row to the mail queue and records the Email message.

The queue insert operation triggers execution of the Database Mail process (DatabaseMail.exe). The Database Mail process then reads the Email information and sends the message to the SMTP servers.

When the SMTP servers acknowledge or reject the message, the Database Mail process inserts a status row into the status queue, including the result of the send attempt. This insert operation triggers the execution of a system stored procedure that updates the status of the Email message send attempt.

Database Mail records all Email attachments in the system tables. SQL Server provides a set of system views and stored procedures for troubleshooting and administration of the Database Mail queue.

Deprecated SQL Mail framework

The previous SQL Mail framework using xp_sendmail has been deprecated as of SQL Server 2008R2 in accordance with https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/ms143729(v=sql.105).

The legacy mail system has been completely replaced by the greatly enhanced DB mail framework described here. The previous system has been out of use for many years because it was prone to synchronous execution issues and windows mail profile quirks.

Syntax

```
EXECUTE sp_send_dbmail
    [[,@profile_name =] '<Profile Name>']
    [,[,@recipients =] '<Recipients>']
    [,[,@copy_recipients =] '<CC Recipients>']
    [,[,@blind_copy_recipients =] '<BCC Recipients>']
    [,[,@from_address =] '<From Address>']
    [,[,@reply_to =] '<Reply-to Address>']
    [,[,@subject =] '<Subject>']
    [,[,@body =] '<Message Body>']
    [,[,@body_format =] '<Message Body Format>']
    [,[,@importance =] '<Importance>']
    [,[,@sensitivity =] '<Sensitivity>']
    [,[,@file_attachments =] '<Attachments>']
    [,[,@query =] '<SQL Query>']
    [,[,@execute_query_database =] '<Execute Query Database>']
    [,[,@attach_query_result_as_file =] <Attach Query Result as File>]
    [,[,@query_attachment_filename =] <Query Attachment Filename>]
    [,[,@query_result_header =] <Query Result Header>]
    [,[,@query_result_width =] <Query Result Width>]
    [,[,@query_result_separator =] '<Query Result Separator>']
    [,[,@exclude_query_output =] <Exclude Query Output>]
    [,[,@append_query_error =] <Append Query Error>]
    [,[,@query_no_truncate =] <Query No Truncate>]
    [,[,@query_result_no_padding =] @<Parameter for Query Result No Padding>]
    [,[,@mailitem_id =] <Mail item id>] [,OUTPUT]
```

Examples

Create a Database Mail account.

```
EXECUTE msdb.dbo.sysmail_add_account_sp
    @account_name = 'MailAccount1',
    @description = 'Mail account for testing DB Mail',
    @email_address = 'Address@MyDomain.com',
```

```
    @replyto_address = 'ReplyAddress@MyDomain.com',
    @display_name = 'Mailer for registration messages',
    @mailserver_name = 'smtp.MyDomain.com' ;
```

Create a Database Mail profile.

```
EXECUTE msdb.dbo.sysmail_add_profile_sp
    @profile_name = 'MailAccount1 Profile',
    @description = 'Mail Profile for testing DB Mail' ;
```

Associate the account with the profile.

```
EXECUTE msdb.dbo.sysmail_add_profileaccount_sp
    @profile_name = 'MailAccount1 Profile',
    @account_name = 'MailAccount1',
    @sequence_number =1 ;
```

Grant the profile access to DBMailUsers role.

```
 EXECUTE msdb.dbo.sysmail_add_principalprofile_sp
    @profile_name = 'MailAccount1 Profile',
    @principal_name = 'ApplicationUser',
    @is_default = 1 ;
```

Send a message with sp_db_sendmail.

```
EXEC msdb.dbo.sp_send_dbmail
    @profile_name = 'MailAccount1 Profile',
    @recipients = 'Recipient@Mydomain.com',
    @query = 'SELECT * FROM fn_WeeklySalesReport(GETDATE())',
    @subject = 'Weekly Sales Report',
    @attach_query_result_as_file = 1 ;
```

For more information, see https://docs.microsoft.com/en-us/sql/relational-databases/database-mail/database-mail?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL does not provide native support for sending email message from the database. For alerting purposes, use the Event Notification Subscription feature to send email notifications to operators. For more information, see Alerting.

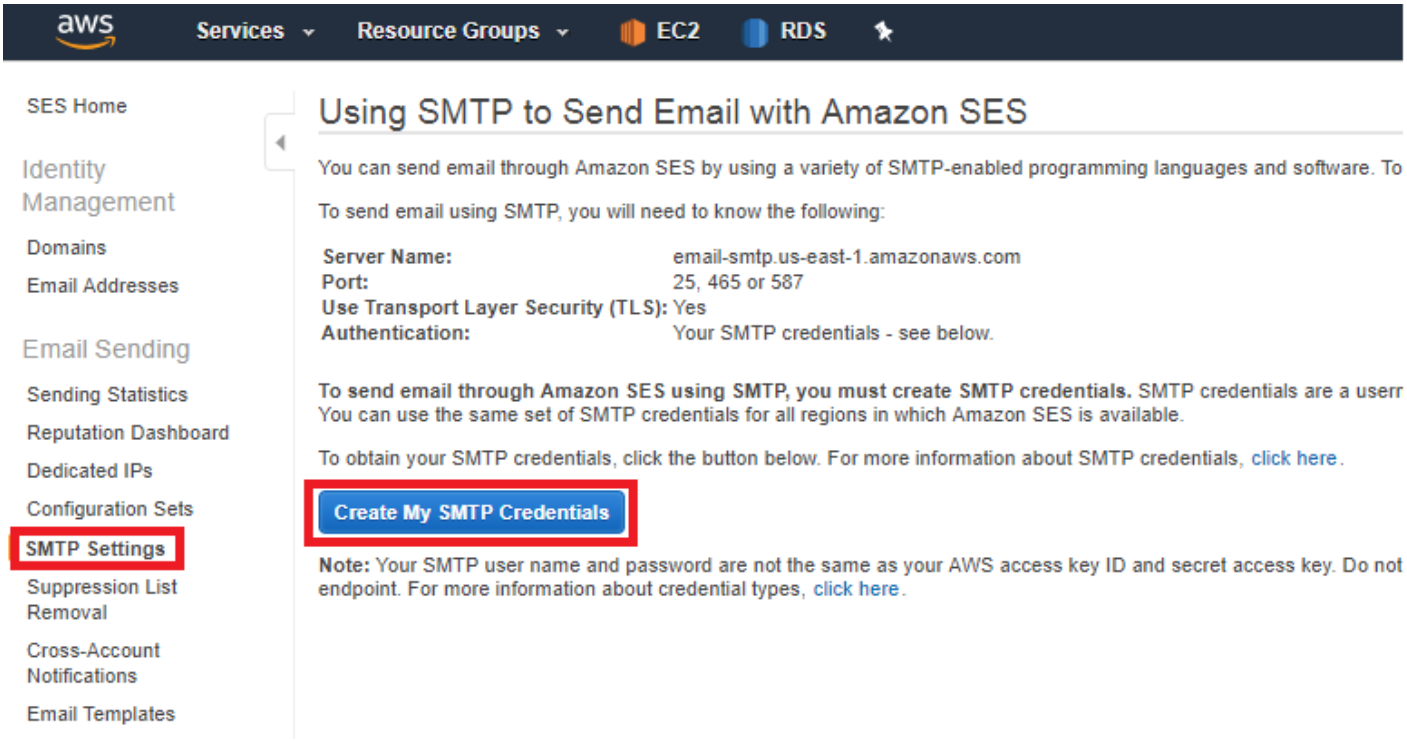
The only way to sent Email from the database is to use the LAMBDA integration. For more information about Lambda, see https://aws.amazon.com/lambda.

Examples

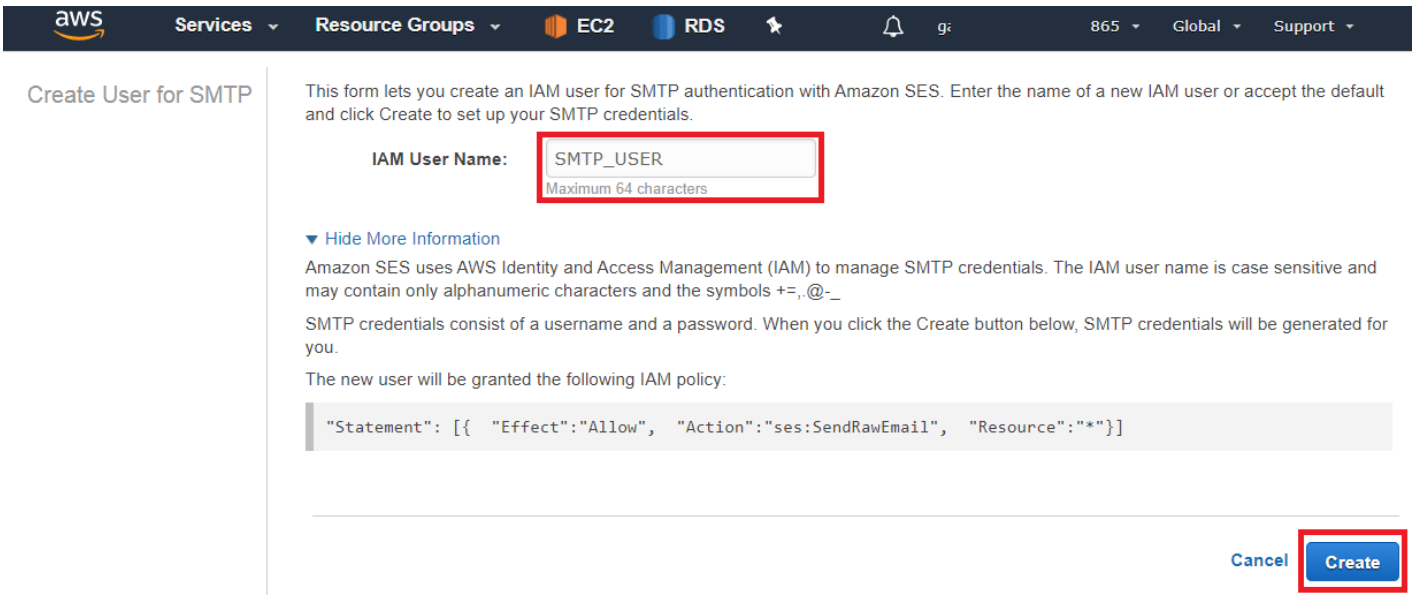
Sending an Email from Aurora PostgreSQL via Lambda Integration

First, configure AWS SES.

In the AWS console, navigate to **SES > SMTP Settings** and click **Create My SMTP Credentials**. Note the SMTP server name; you will use it in the Lambda function.

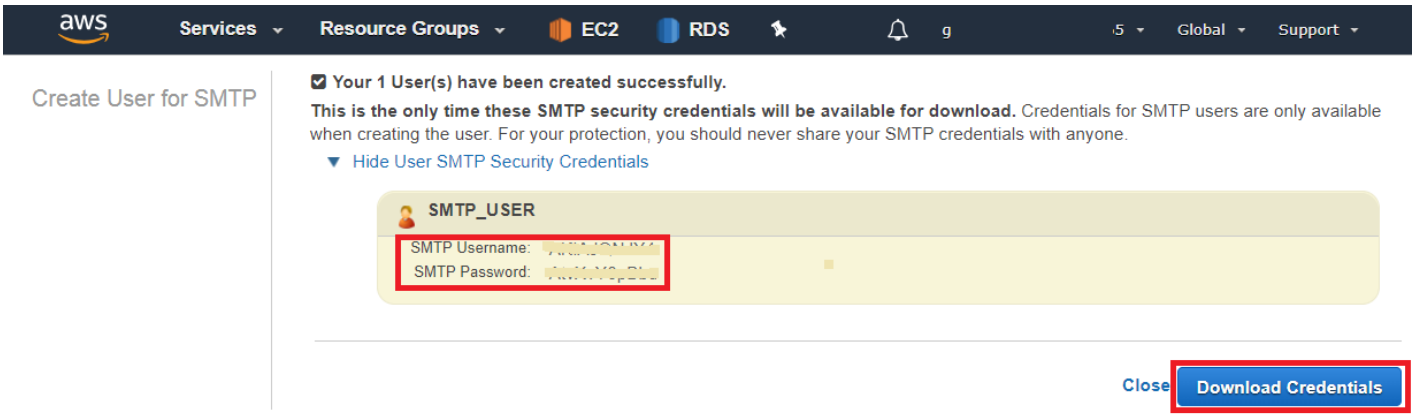


Enter a name for **IAM User Name** (SMTP user) and click **Create**.

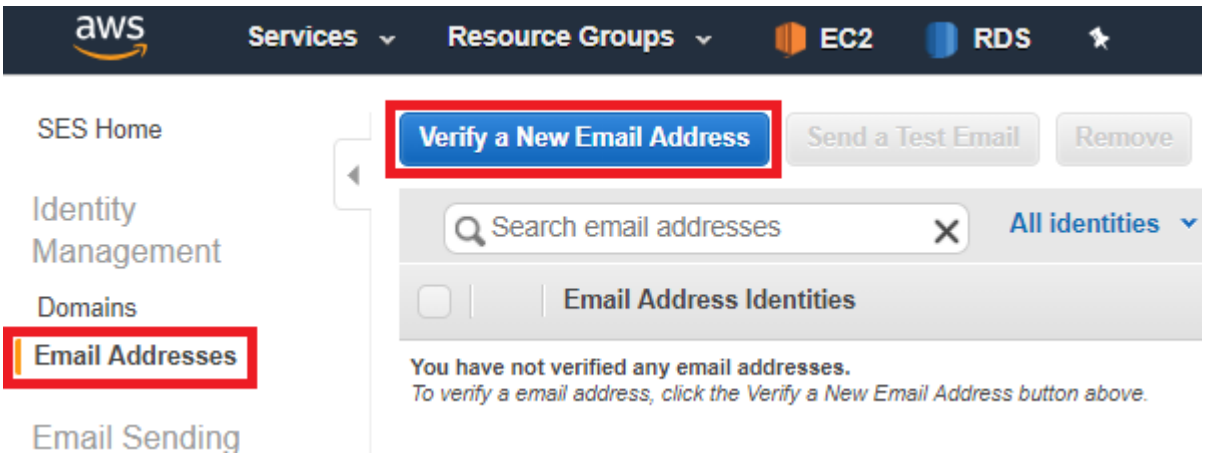


Note the credentials; you will use them to authenticate with the SMTP server.

> **Note:** After leaving this page, the credentials cannot be retrieved.



Navigate back to the SES page, click **Email Addresses** on the left, and click **Verify a New Email Address**. Before sending email, they must be verified.

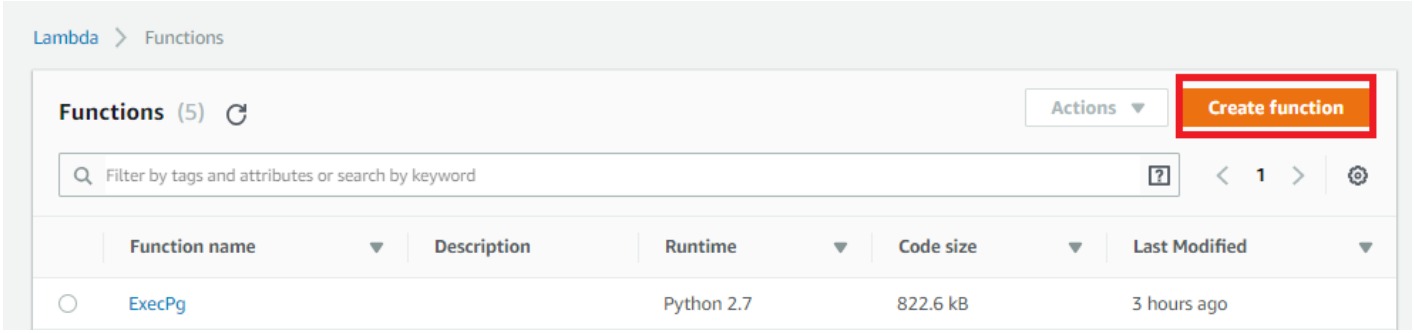


The next page indicates that the email is pending verification.

After the email is verified, create a table to store messages to be sent by the Lambda fuction.

```
CREATE TABLE emails (title varchar(600), body varchar(600), recipients varchar(600));
```

To create the Lambda function, navigate to the Lambda page and click **Create function**.



Select **Author from Scratch**, enter a name for your project, and select **Python 2.7** as the runtime. Be sure to use a role with the correct permissions. Click **Create function**.

Download this Github project.

In your local environment, create two files: main.py and db_util.py. Cut and paste the content below into main.py and db_util.py respectively. Be sure to replace the code highlighted in red with values for your environment.

main.py:

```
#!/usr/bin/python
import sys
import logging
import psycopg2

from db_util import make_conn, fetch_data
def lambda_handler(event, context):
    query_cmd = "select * from mails"
    print query_cmd

    # get a connection, if a connect cannot be made an exception will be raised here
    conn = make_conn()

    result = fetch_data(conn, query_cmd)
    conn.close()

    return result
```

db_util.py:

```
#!/usr/bin/python
import psycopg2
import smtplib
import email.utils
from email.mime.multipart import MIMEMultipart
from email.mime.text import MIMEText

db_host = 'YOUR_RDS_HOST'
db_port = 'YOUR_RDS_PORT'
db_name = 'YOUR_RDS_DBNAME'
db_user = 'YOUR_RDS_USER'
db_pass = 'YOUR_RDS_PASSWORD'

def sendEmail(recp, sub, message):
    # Replace sender@example.com with your "From" address.
    # This address must be verified.
    SENDER = 'PUT HERE THE VERIFIED EMAIL'
    SENDERNAME = 'AWS Lambda'

    # Replace recipient@example.com with a "To" address. If your account
    # is still in the sandbox, this address must be verified.
    RECIPIENT  = recp

    # Replace smtp_username with your Amazon SES SMTP user name.
    USERNAME_SMTP = "YOUR_SMTP_USERNAME"
```

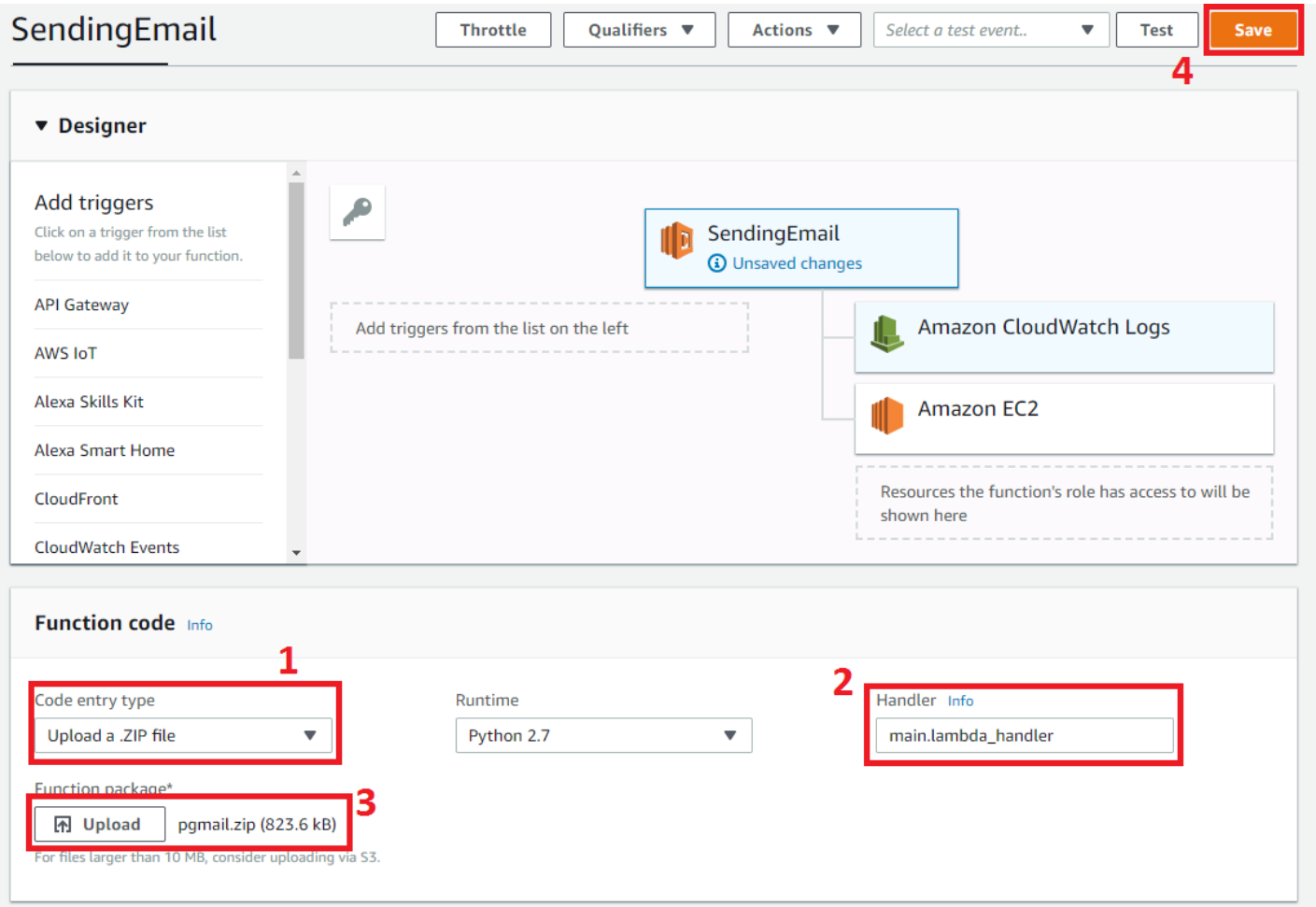
```
# Replace smtp_password with your Amazon SES SMTP password.
PASSWORD_SMTP = "YOUR_SMTP PASSWORD"

# (Optional) the name of a configuration set to use for this message.
# If you comment out this line, you also need to remove or comment out
# the "X-SES-CONFIGURATION-SET:" header below.
CONFIGURATION_SET = "ConfigSet"

# If you're using Amazon SES in an AWS Region other than US West (Oregon),
# replace email-smtp.us-west-2.amazonaws.com with the Amazon SES SMTP
# endpoint in the appropriate region.
HOST = "YOUR_SMTP_SERVERNAME"
PORT = 587

# The subject line of the email.
SUBJECT = sub

# The email body for recipients with non-HTML email clients.
BODY_TEXT = ("Amazon SES Test\r\n"
         "This email was sent through the Amazon SES SMTP "
         "Interface using the Python smtplib package."
        )

# The HTML body of the email.
BODY_HTML = """<html>
<head></head>
<body>
<h1>Amazon SES SMTP Email Test</h1>""" + message + """</body>
</html>
        """

# Create message container - the correct MIME type is multipart/alternative.
msg = MIMEMultipart('alternative')
msg['Subject'] = SUBJECT
msg['From'] = email.utils.formataddr((SENDERNAME, SENDER))
msg['To'] = RECIPIENT
# Comment or delete the next line if you are not using a configuration set
#msg.add_header('X-SES-CONFIGURATION-SET',CONFIGURATION_SET)

# Record the MIME types of both parts - text/plain and text/html.
part1 = MIMEText(BODY_TEXT, 'plain')
part2 = MIMEText(BODY_HTML, 'html')

# Attach parts into message container.
# According to RFC 2046, the last part of a multipart message, in this case
# the HTML message, is best and preferred.
msg.attach(part1)
msg.attach(part2)

# Try to send the message.
try:
    server = smtplib.SMTP(HOST, PORT)
    server.ehlo()
    server.starttls()
    #stmplib docs recommend calling ehlo() before & after starttls()
```

```
        server.ehlo()
        server.login(USERNAME_SMTP, PASSWORD_SMTP)
        server.sendmail(SENDER, RECIPIENT, msg.as_string())
        server.close()
    # Display an error message if something goes wrong.
    except Exception as e:
        print ("Error: ", e)
    else:
        print ("Email sent!")

def make_conn():
    conn = None
    try:
        conn = psycopg2.connect("dbname='%s' user='%s' host='%s' password='%s'" % (db_
name, db_user, db_host, db_pass))
    except:
        print "I am unable to connect to the database"
    return conn


def fetch_data(conn, query):
    result = []
    print "Now executing: %s" % (query)
    cursor = conn.cursor()
    cursor.execute(query)

    print("Number of new mails to be sent: ", cursor.rowcount)

    raw = cursor.fetchall()

    for line in raw:
        print(line[0])
        sendEmail(line[2],line[0],line[1])
        result.append(line)

    cursor.execute('delete from mails')
    cursor.execute('commit')

    return result
```

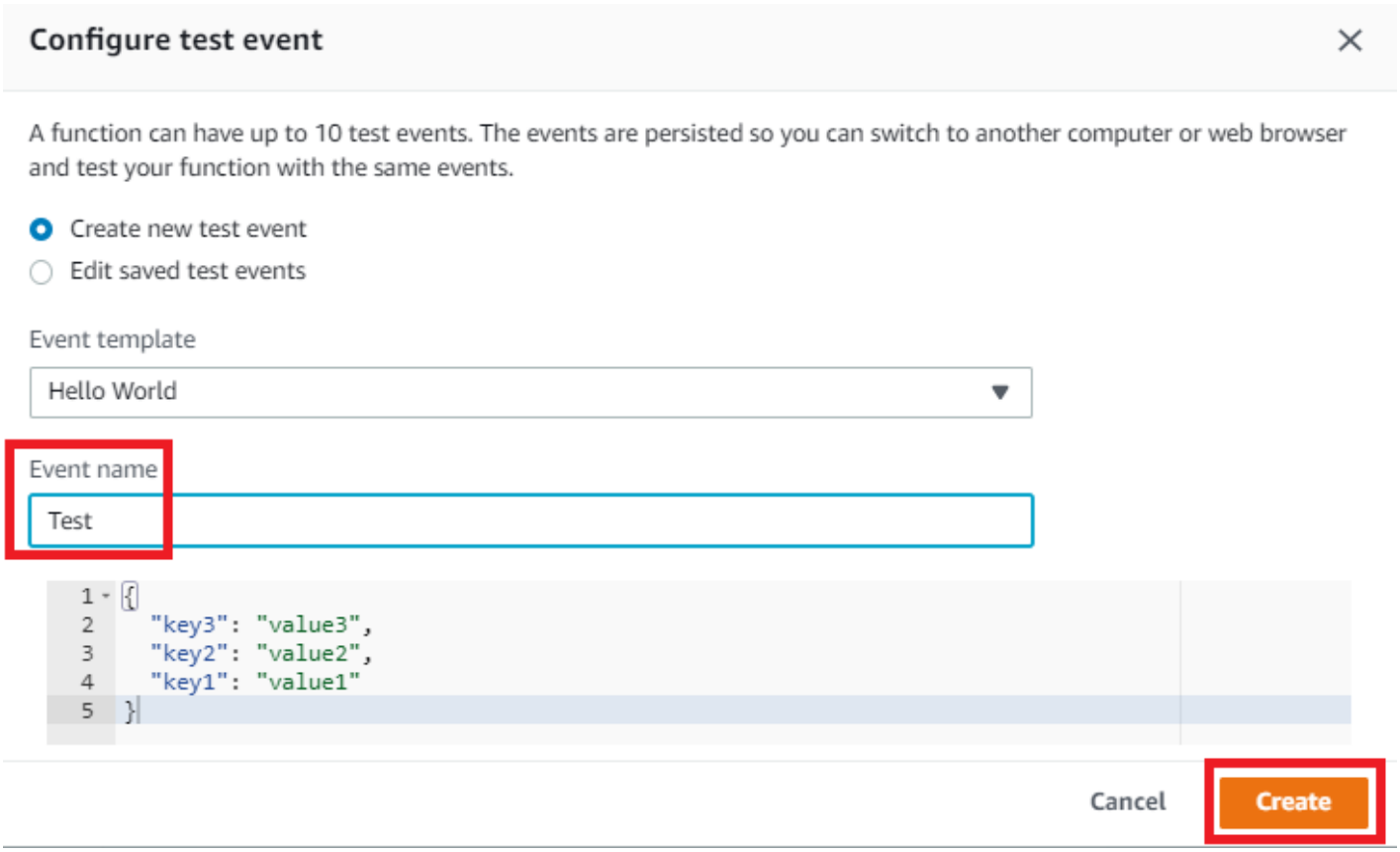
Note: In the body of db_util.py, Lambda deletes the content of the mails table.

Place the main.py and db_util.py files inside the Github extracted folder and create a new zipfile that includes your two new files.

Return to your Lambda project and change the **Code entry type** to **Upload a .ZIP file**, change the Handler to **mail.lambda_handler**, and upload the file. Click **Save**.

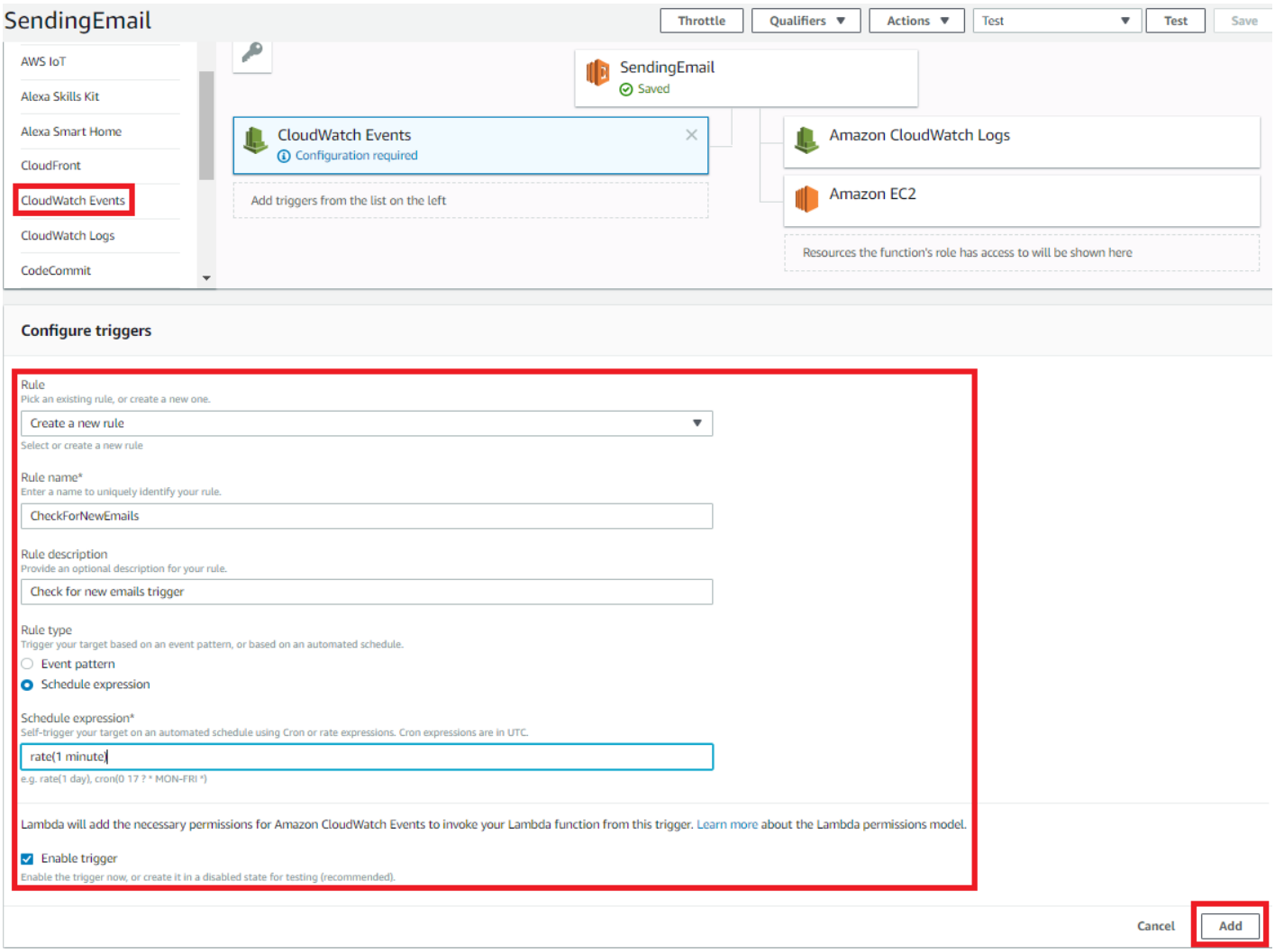


To test the lambda function, click **Test** and enter the **Event name**.



Note: The Lambda function can be triggered by multiple options. This walkthrough demonstrates how to schedule it to run every minute. Remember, you are paying for each Lambda execution.

To create a scheduled trigger, use CloudWatch, enter all details, and click **Add**.



Note: This example runs every minute, but you can use a different interval. For more information, see https://docs.aws.amazon.com/lambda/latest/dg/tutorial-scheduled-events-schedule-expressions.html

Cick **Save**.

SQL Server ETL vs. PostgreSQL ETL

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Use Amazon Glue for ETL

SQL Server Usage

SQL Server offers a native Extract, Transform, and Load (ETL) framework of tools and services to support enterprise ETL requirements. The legacy Data Transformation Services (DTS) has been deprecated as of SQL Server 2008 (see https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/cc707786(v=sql.105)) and replaced with SQL Server Integration Services (SSIS), which was introduced with SQL Server 2005.

DTS

DTS was introduced in SQL Server version 7 in 1998. It was significantly expanded in SQL Server 2000 with features such as FTP, database level operations, and Microsoft Message Queuing (MSMQ) integration. It included a set of objects, utilities, and services that enabled easy, visual construction of complex ETL operations across heterogeneous data sources and targets.

DTS supported OLE DB, ODBC, and text file drivers. It allowed transformations to be scheduled using SQL Server Agent. DTS also provided version control and backup capabilities with version control systems such as Microsoft Visual SourceSafe.

The fundamental entity in DTS was the DTS Package. Packages were the logical containers for DTS objects such as connections, data transfers, transformations, and notifications. The DTS framework also included the following tools:

- DTS Wizards
- DTS Package Designers
- DTS Query Designer
- DTS Run Utility

SSIS

The SSIS framework was introduced in SQL Server 2005, but was limited to the top-tier editions only, unlike DTS which was available with all editions.

SSIS has evolved over DTS to offer a true modern, enterprise class, heterogeneous platform for a broad range of data migration and processing tasks. It provides a rich workflow oriented design with features for all types of enterprise data warehousing. It also supports scheduling capabilities for multi-dimensional cubes management.

SSIS Provides the following tools:

- **SSIS Import/Export Wizard** is an SQL Server Management Studio extension that enables quick creation of packages for moving data between a wide array of sources and destinations. However, it has limited transformation capabilities.
- **SQL Server Business Intelligence Development Studio (BIDS)** is a developer tool for creating complex packages and transformations. It provides the ability to integrate procedural code into package transformations and provides a scripting environment. Recently, BIDS has been replaced by **SQL Server Data Tools - Business intelligence (SSDT-BI)**.

SSIS objects include:

- Connections
- Event handlers
- Workflows
- Error handlers
- Parameters (Beginning with SQL Server 2012)
- Precedence constraints
- Tasks
- Variables

SSIS packages are constructed as XML documents and can be saved to the file system or stored within a SQL Server instance using a hierarchical name space.

For more information, see

- https://docs.microsoft.com/en-us/sql/integration-services/sql-server-integration-services?view=sql-server-ver15
- https://en.wikipedia.org/wiki/Data_Transformation_Services

PostgreSQL Usage

Aurora PostgreSQL provides Amazon Glue for enterprise class Extract, Transform, and Load (ETL). It is a fully managed service that performs data cataloging, cleansing, enriching, and movement between heterogeneous data sources and destinations. Being a fully managed service, the user does not need to be concerned with infrastructure management.

Amazon Glue Key Features

Integrated Data Catalog

The Amazon Glue Data Catalog is a persistent metadata store, that can be used to store all data assets, whether in the cloud or on-premises. It stores table schemas, job steps, and additional meta data information for managing these processes. Amazon Glue can automatically calculate statistics and register partitions in order to make queries more efficient. It maintains a comprehensive schema version history for tracking changes over time.

Automatic Schema Discovery

Amazon Glue provides automatic crawlers that can connect to source or target data providers. The crawler uses a prioritized list of classifiers to determine the schema for your data and then generates and stores the metadata in the Amazon Glue Data Catalog. Crawlers can be scheduled or executed on-demand. You can also trigger a crawler when an event occurs to keep metadata current.

Code Generation

Amazon Glue automatically generates the code to extract, transform, and load data. All you need to do is point Glue to your data source and target. The ETL scripts to transform, flatten, and enrich data are created automatically. Amazon Glue scripts can be generated in Scala or Python and are written for Apache Spark.

Developer Endpoints

When interactively developing Glue ETL code, Amazon Glue provides development endpoints for editing, debugging, and testing. You can use any IDE or text editor for ETL development. Custom readers, writers, and transformations can be imported into Glue ETL jobs as libraries. You can also use and share code with other developers in the Amazon Glue GitHub repository (see https://github.com/awslabs/aws-glue-libs).

Flexible Job Scheduler

Amazon Glue jobs can be triggered for execution either on a pre-defined schedule, on-demand, or as a response to an event.

Multiple jobs can be started in parallel and dependencies can be explicitly defined across jobs to build complex ETL pipelines. Glue handles all inter-job dependencies, filters bad data, and retries failed jobs. All logs and notifications are pushed to Amazon CloudWatch; you can monitor and get alerts from a central service.

Migration Considerations

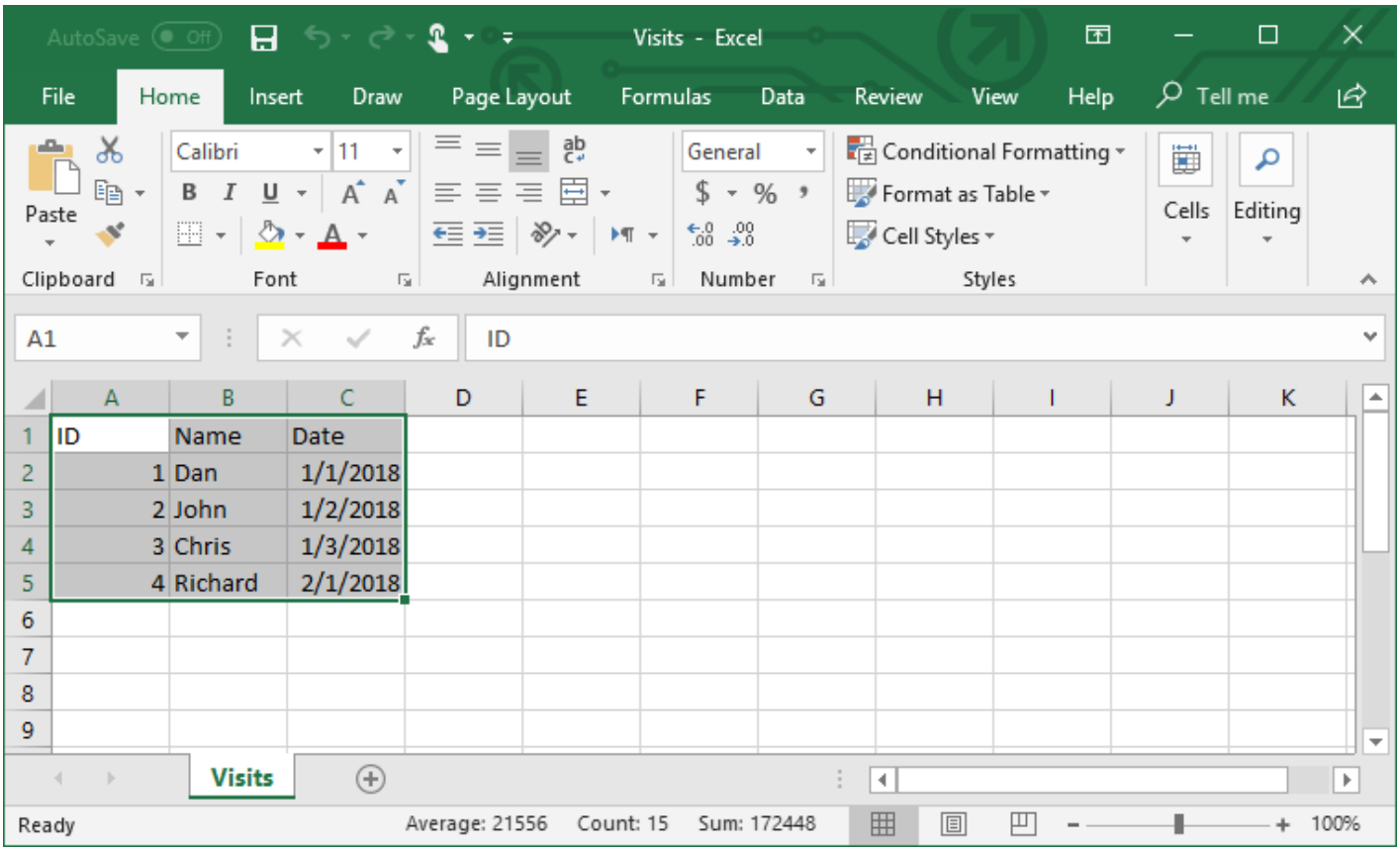
Currently, there are no automatic tools for migrating ETL packages from DTS or SSIS into Amazon Glue. Migration from SQL Server to Aurora PostgreSQL requires rewriting ETL processes to use Amazon Glue.

Alternatively, consider using an EC2 SQL Server instance to run the SSIS service as an interim solution. The connectors and tasks must be revised to support Aurora PostgreSQL instead of SQL Server, but this approach allows gradual migration to Amazon Glue.

Examples

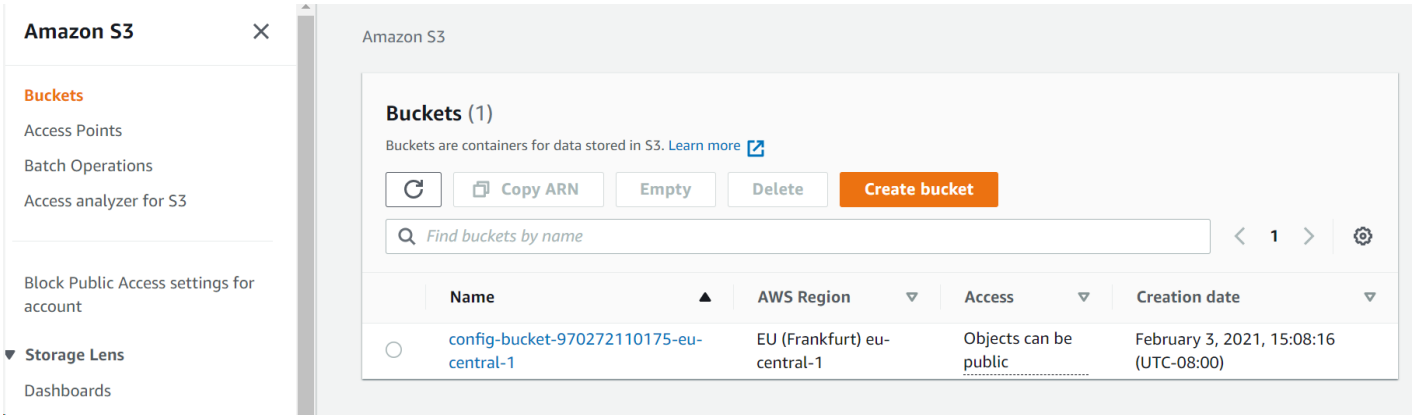
The following walk-through describes how to create an Amazon Glue job to upload a CSV file from S3 to Aurora PostgreSQL.

The source file for this walk-through is a simple Visits table in CSV format. The objective is to upload this file to an S3 bucket and create a Glue job to discover and copy it into an Aurora PostgreSQL database.



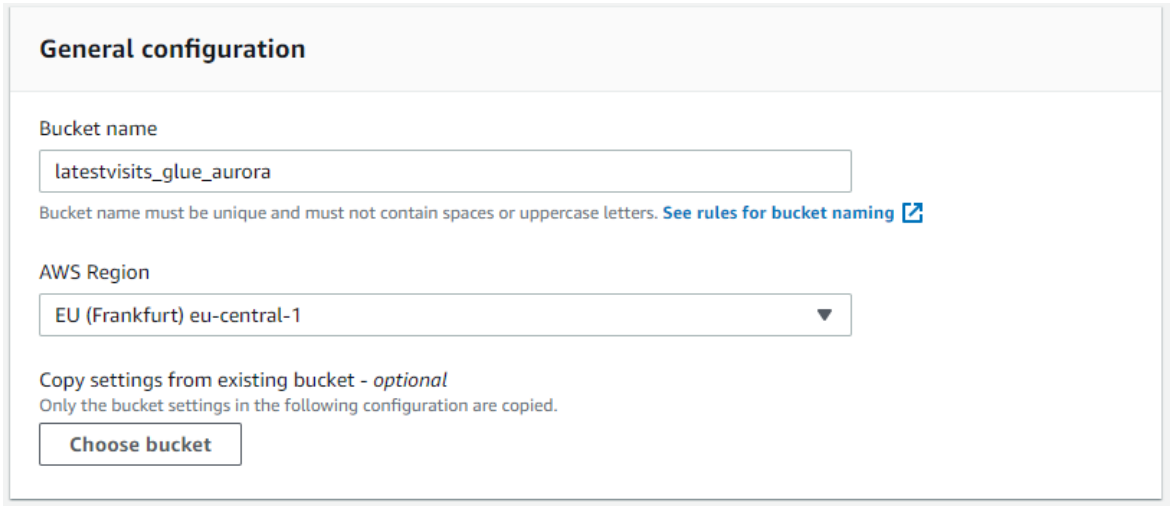
Step 1 - Create a Bucket in Amazon S3 and Upload the CSV File

Navigate to the S3 management console page https://s3.console.aws.amazon.com/s3/home and click **Create Bucket**.



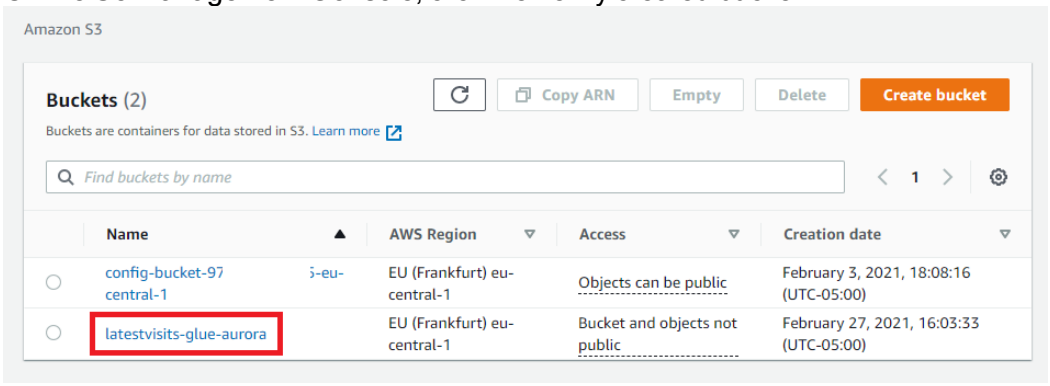
Note: This walk-through demonstrates how to create the buckets and upload the files manually, which is automated using the S3 API for production ETLs. Using the console to manually execute all the settings will help you get familiar with the terminology, concepts, and work flow.

In the create bucket wizard, enter a unique name for the bucket, select a region and click **Next**.

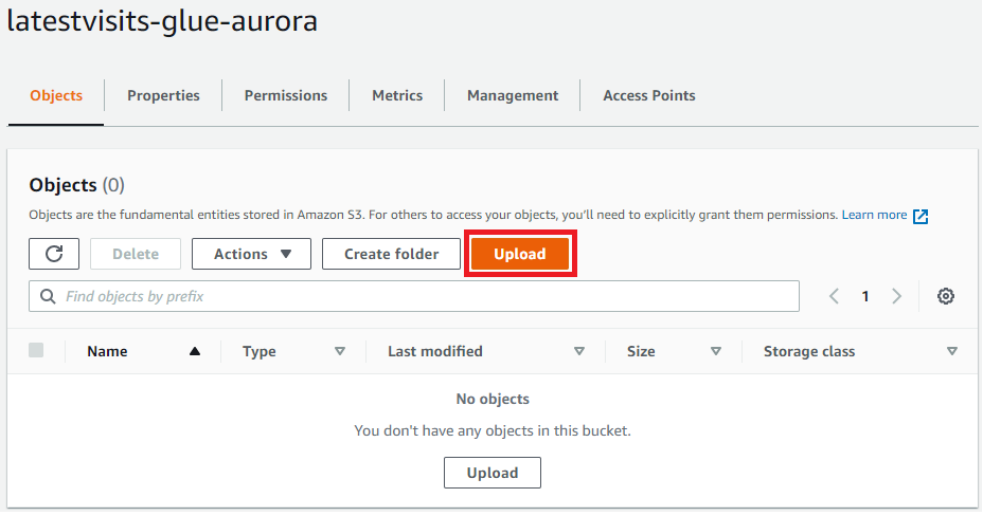


Scroll down to define the level of access, enable versioning, add tags, and enable encryption.

On the S3 Management Console, click the newly created bucket.

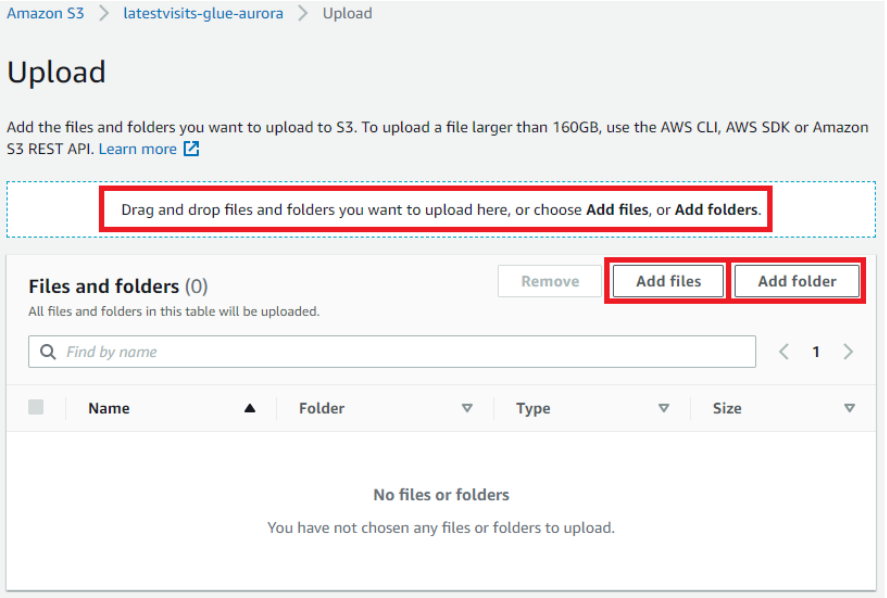


On the bucket page, click **Upload**.



On the upload page, either "drag and drop", use the **Add Files**, or the **Add folder** button to upload.

And upload the visits.xlsx file you have created based on example image above.

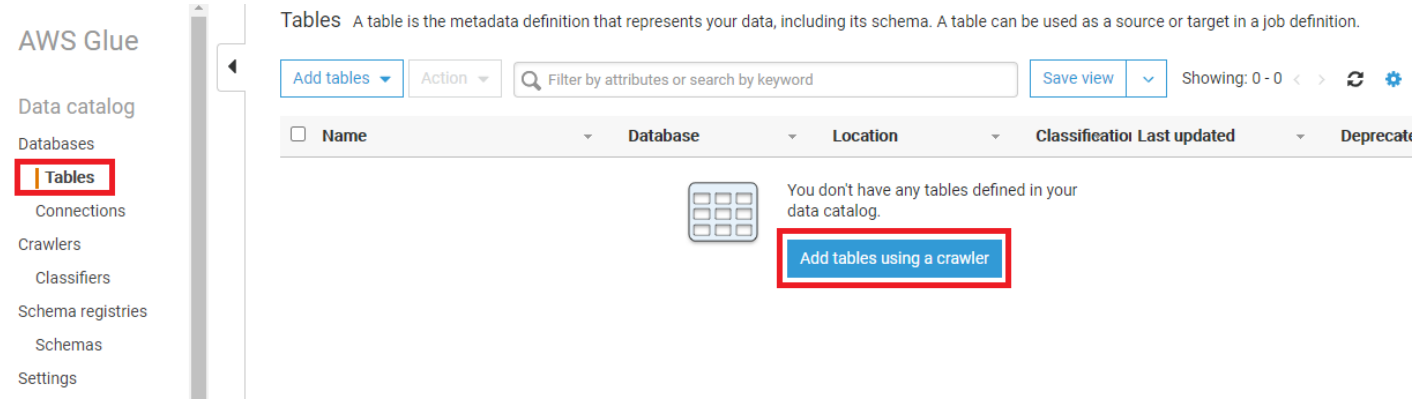


Scroll down to set storage class, server-side encryption, ACL and click **Upload**

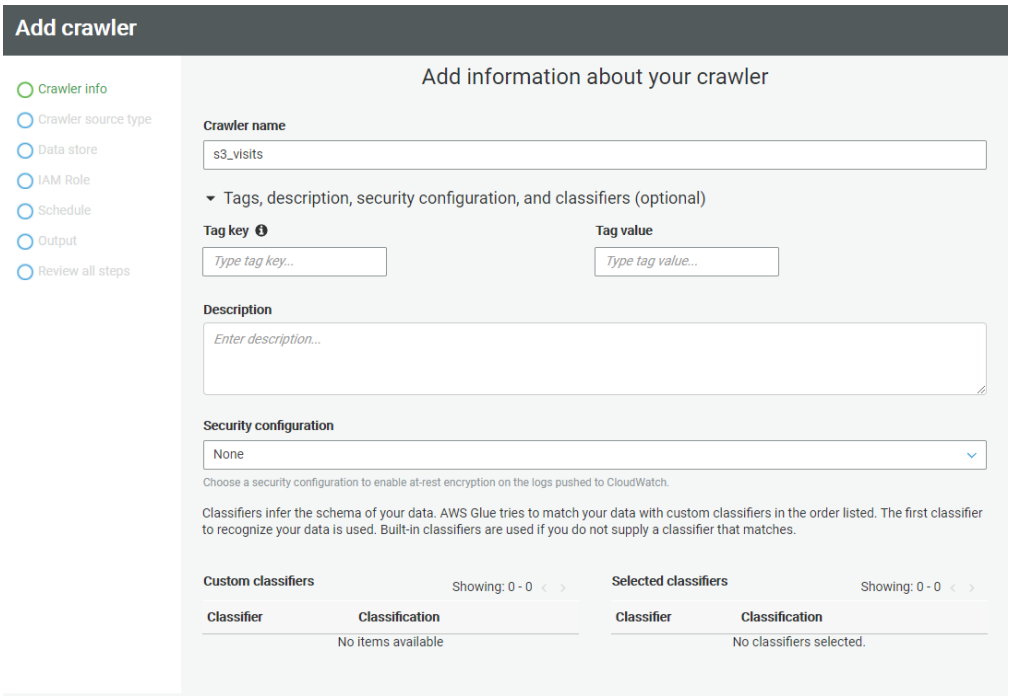
Step 2 - Add an Amazon Glue Crawler to Discover and Catalog the Visits File

Navigate to the Amazon Glue management console page at https://console.aws.amazon.com/glue/home.

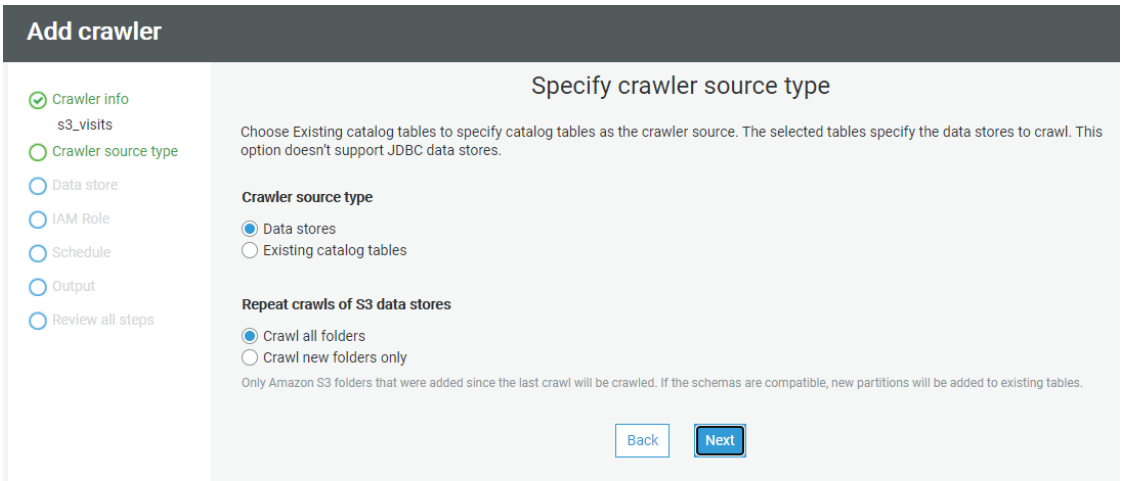
Use the **Tables** link in the navigation panel and click on **Add tables using a crawler**. Alternatively, click the **Crawlers** navigation link on the left and then click **Add Crawler**.



Provide a descriptive name for the crawler and click **Next**.

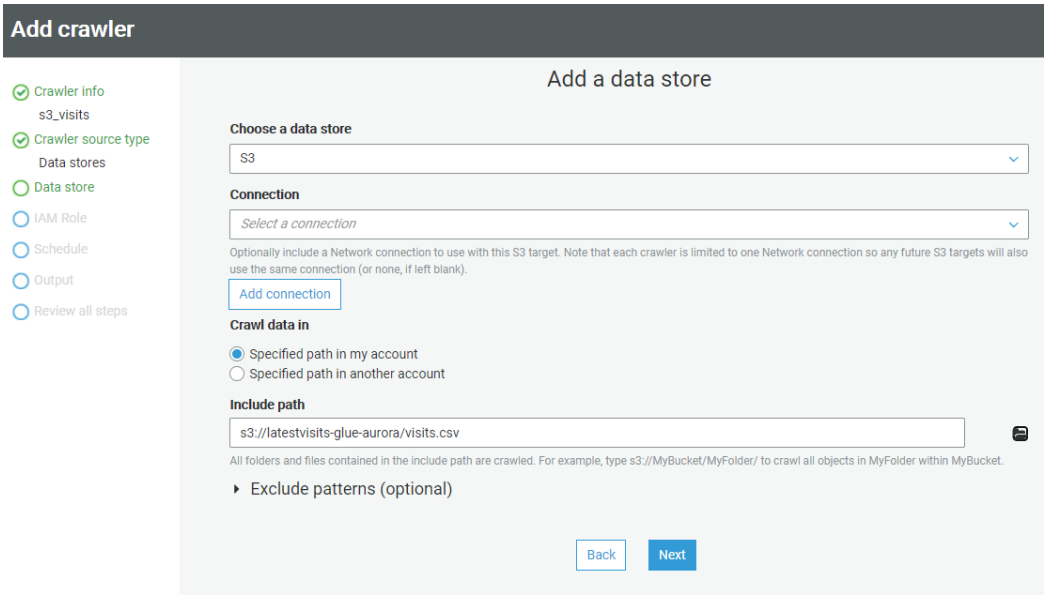


Pick the crawler behavior.

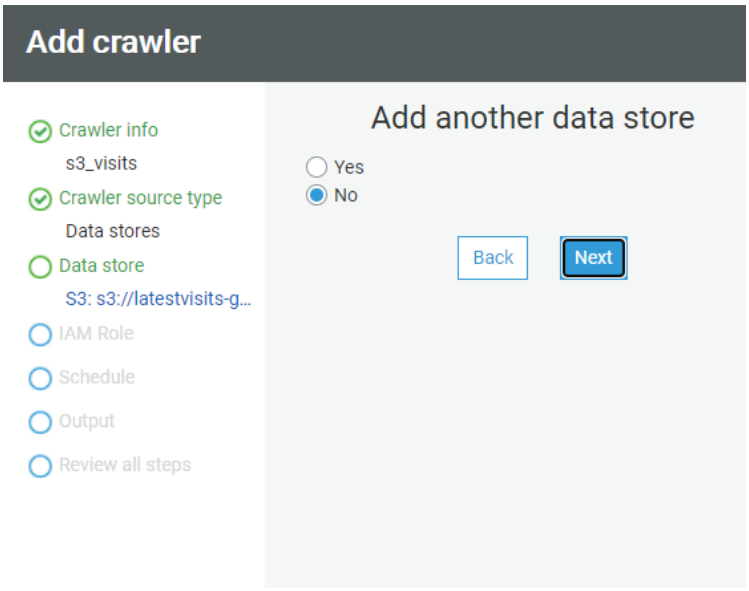


Leave the default S3 data store and choose whether the file is in a path in your account or another account. For this example, the path is in my account and specified in the **Include path** text box. Click **Next**.

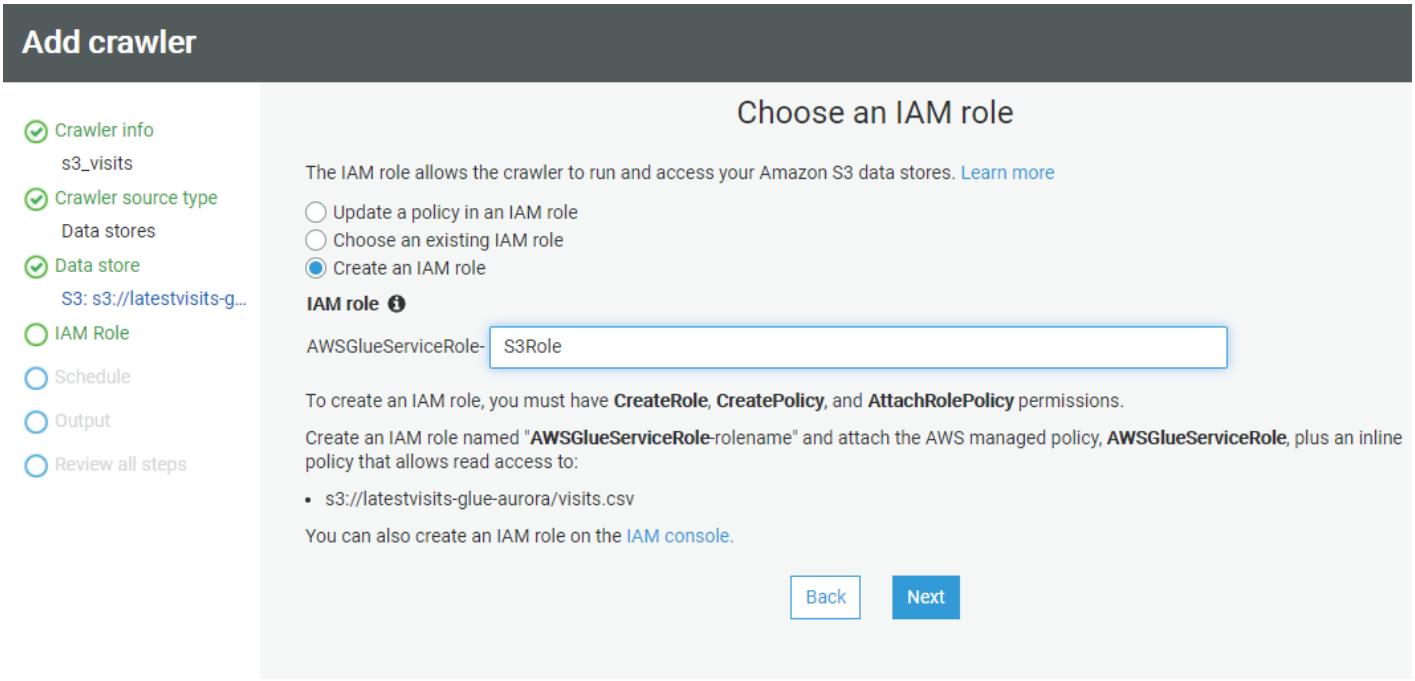
Note: Click the small folder icon to the right of the **Include path** text box to open a visual folder hierarchy navigation window.



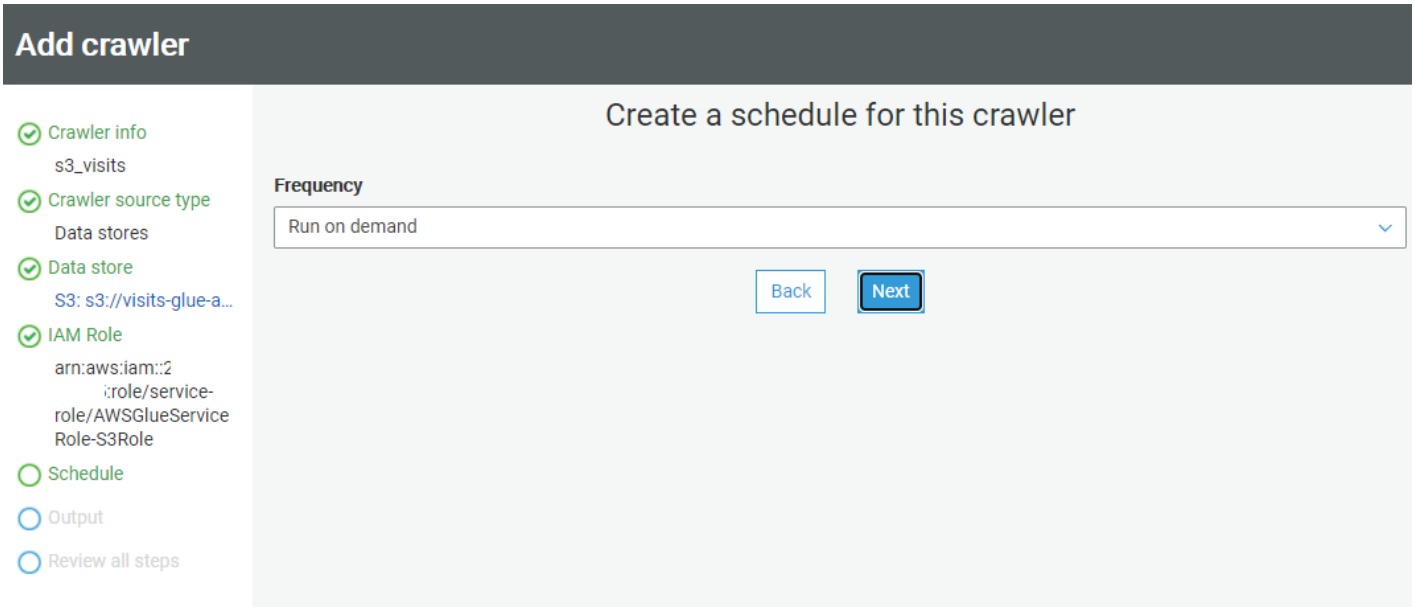
Select whether the crawler accesses another data store or not. For this example, only uses the visits file. Click **Next**.



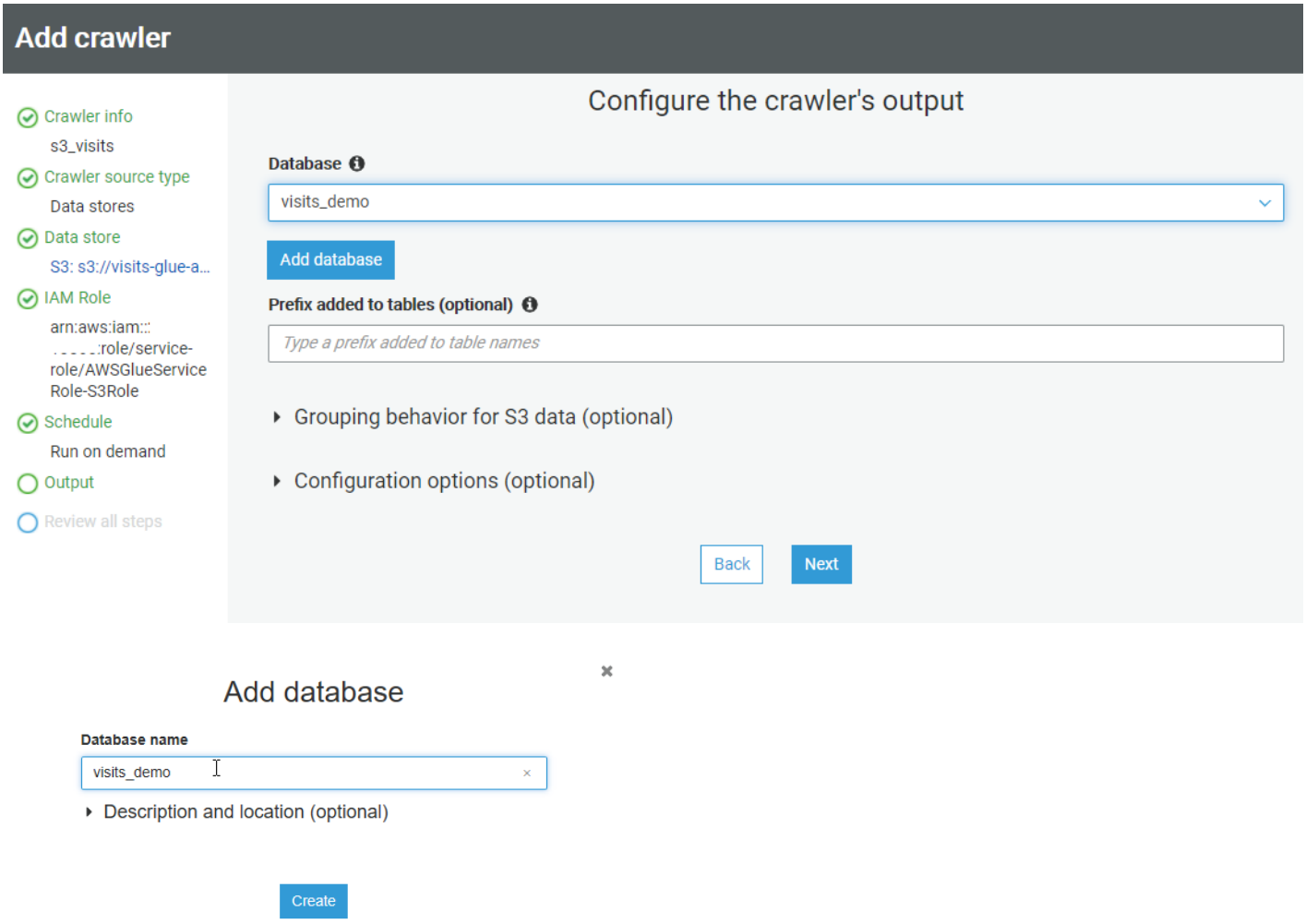
The IAM role window allows selection of the security context the crawler uses to execute. You can choose an existing role, update an existing policy, or create a new role. For this example, create a new role. Click **Next**.



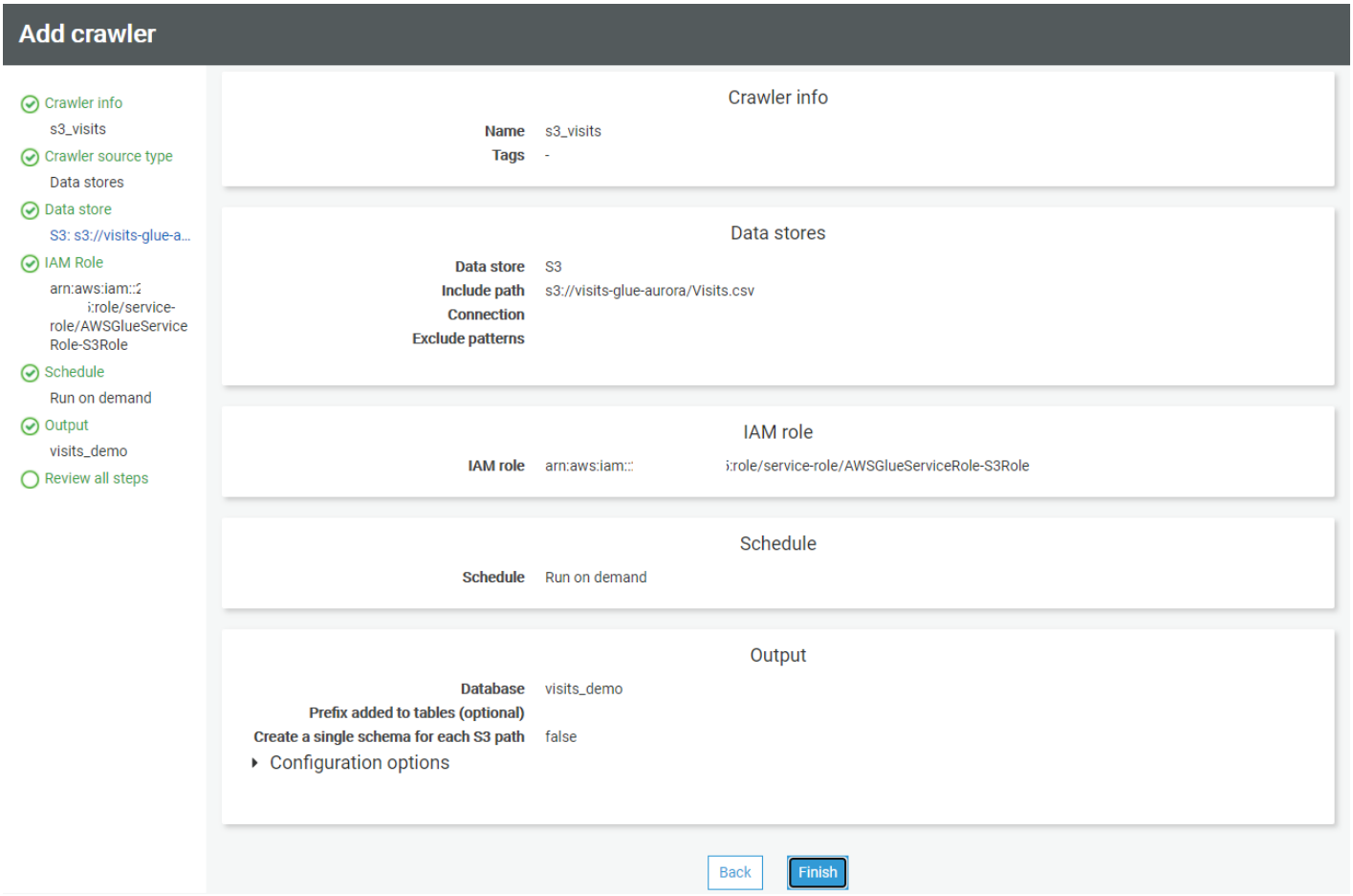
Choose the crawler schedule and frequency. For this example, use **Run on demand**. Click **Next**.



Click **Add database** and provide a name for the new catalog database. Enter an optional table prefix for easy reference. Click **Next**.



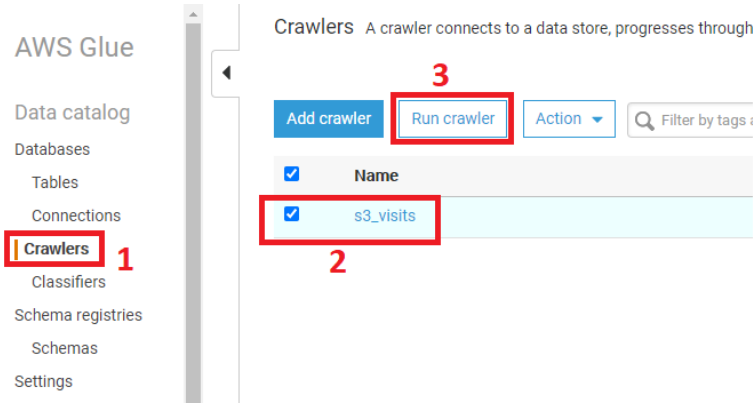
Review your entries and click **Finish** to create the crawler.


Add crawler
Crawler info
s3_visits
Crawler source type
Data stores
Data store
S3: s3://visits-glue-a...
IAM Role
arn:aws:iam::2 i:role/service-role/AWSGlueServiceRole-S3Role
Schedule
Run on demand
Output
visits_demo
Review all steps
Crawler info
Name s3_visits
Tags -
Data stores
Data store S3
Include path s3://visits-glue-aurora/Visits.csv
Connection
Exclude patterns
IAM role
IAM role arn:aws:iam::: :role/service-role/AWSGlueServiceRole-S3Role
Schedule
Schedule Run on demand
Output
Database visits_demo
Prefix added to tables (optional)
Create a single schema for each S3 path false
Configuration options
Back
Finish

Step 3 - Run the Crawler

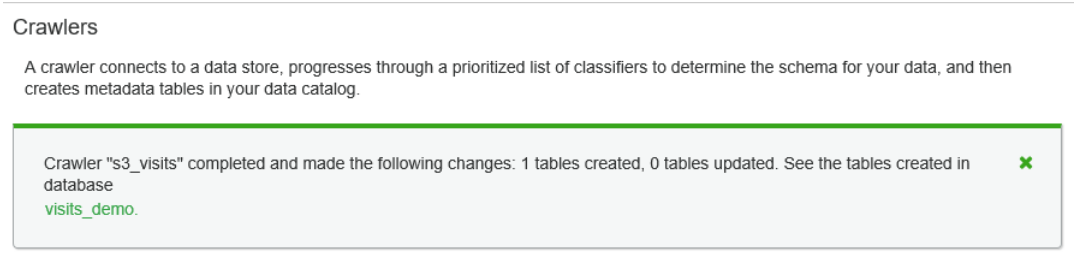
Navigate to the **Crawlers** page on the glue management console https://console.aws.amazon.com/glue/home?catalog:tab=crawlers.

Since you just created a new crawler, a message box asks if you want to run it now. You can click the link or check the check-box near the crawler's name and click the **Run crawler** button.

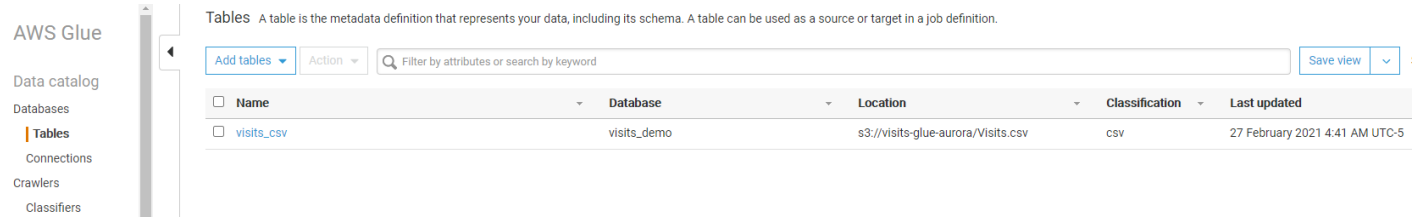


After the crawler completes, the Visits table should be discovered and recorded in the catalog in the table specified.

The following message box appears on the page:

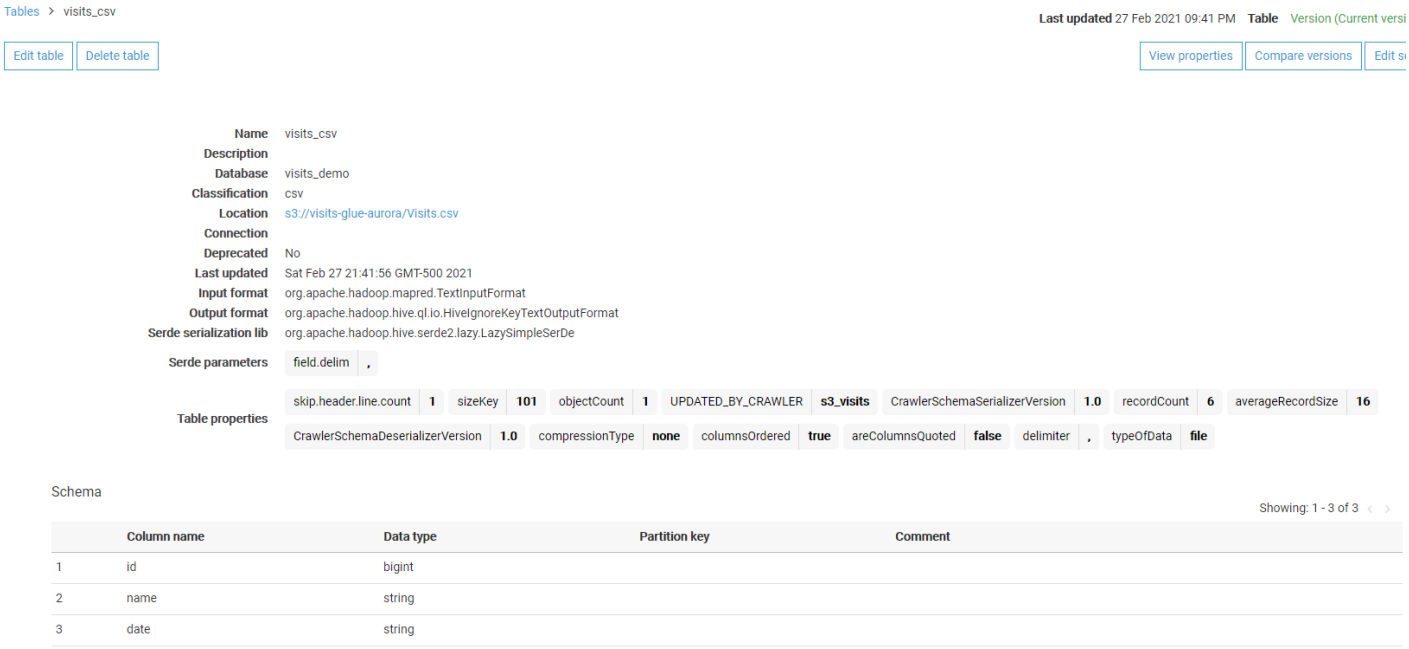


Click the link to get to the table that was just discovered and then click the table name.



Verify the crawler identified the table's properties and schema correctly.

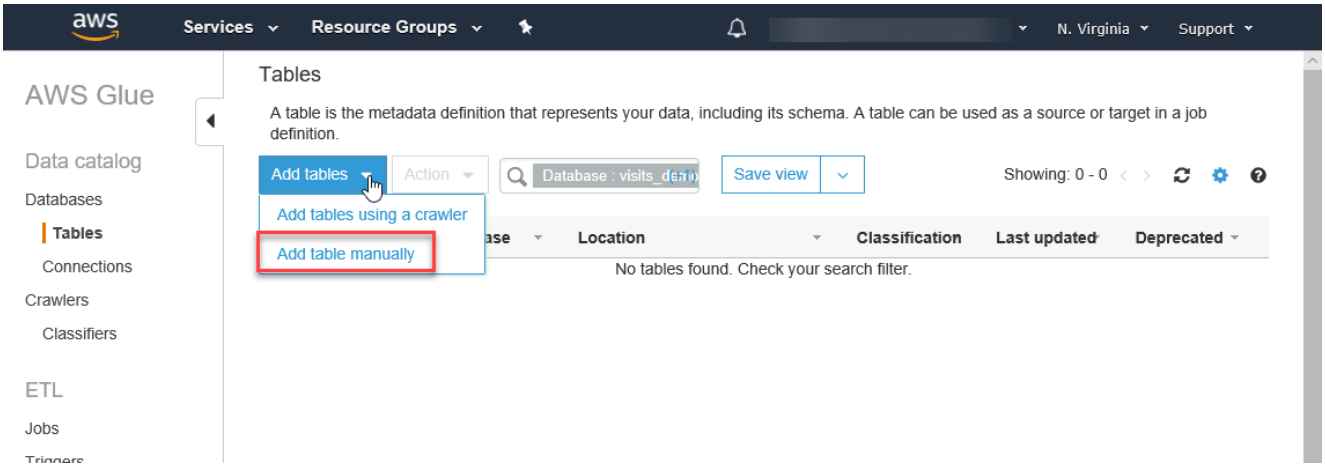
> **Note:** You can manually adjust the properties and schema JSON files using the buttons on the top right.



Optional - Add Tables Manually

If you don't want to add a crawler, you can add tables manually.

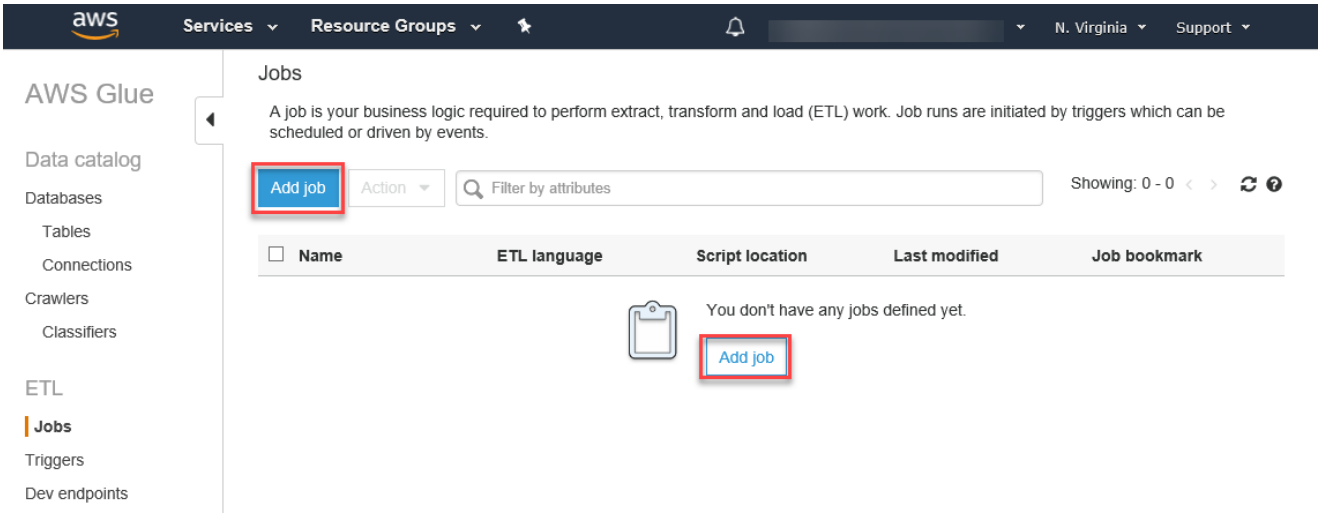
Navigate to https://console.aws.amazon.com/glue/home, the default page is the Tables page. Click **Add tables** and select **Add table manually**.



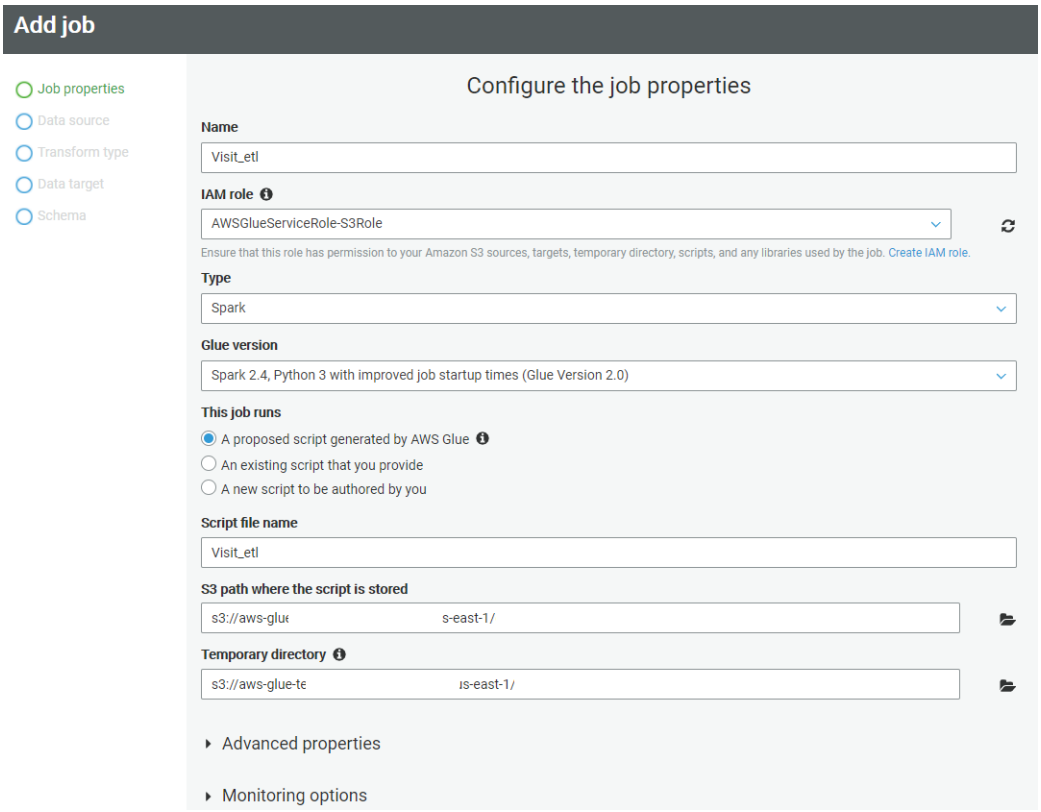
The process is similar the one used for the crawler.

Step 4 - Create an ETL Job to Copy the Visits Table to an Aurora PostgreSQL Database.

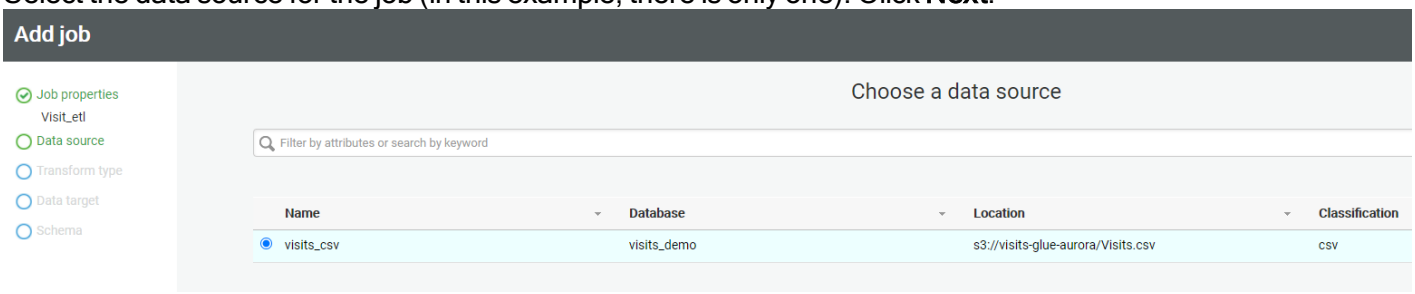
Navigate to the Amazon Glue ETL Jobs page at https://console.aws.amazon.com/glue/home?etl:tab=jobs. Since this is the first job, the list is empty. Click Add Job.



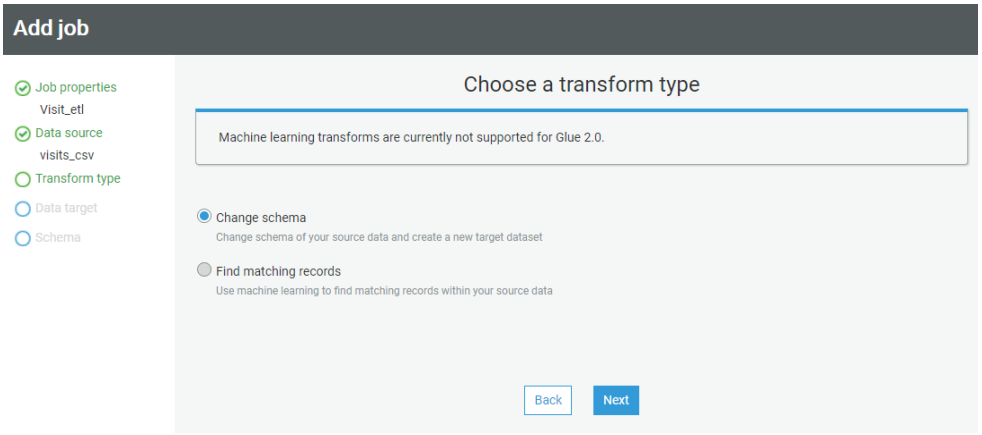
Enter a name for the ETL job and pick a role for the security context. For this example, use the same role created for the crawler. The job may consist of a pre-existing ETL script, a manually-authored script, or an automatic script generated by Amazon Glue. For this example, use Amazon Glue. Enter a name for the script file or accept the default, which is also the job's name. Configure advanced properties and parameters if needed and click **Next**.



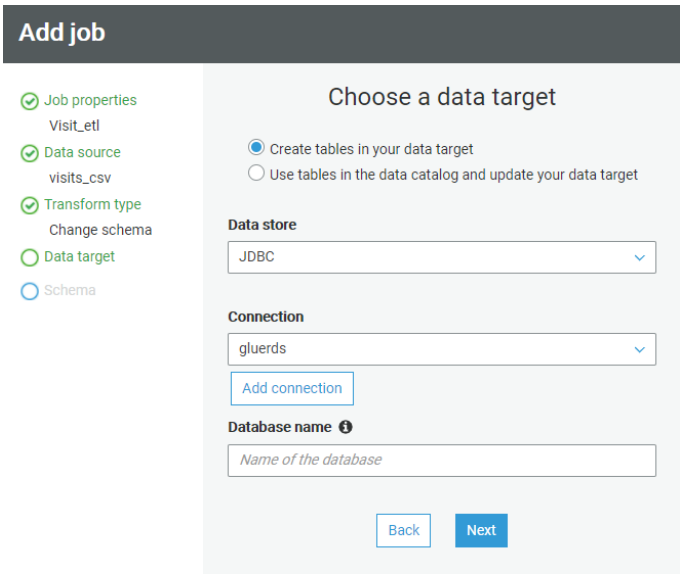
Select the data source for the job (in this example, there is only one). Click **Next**.



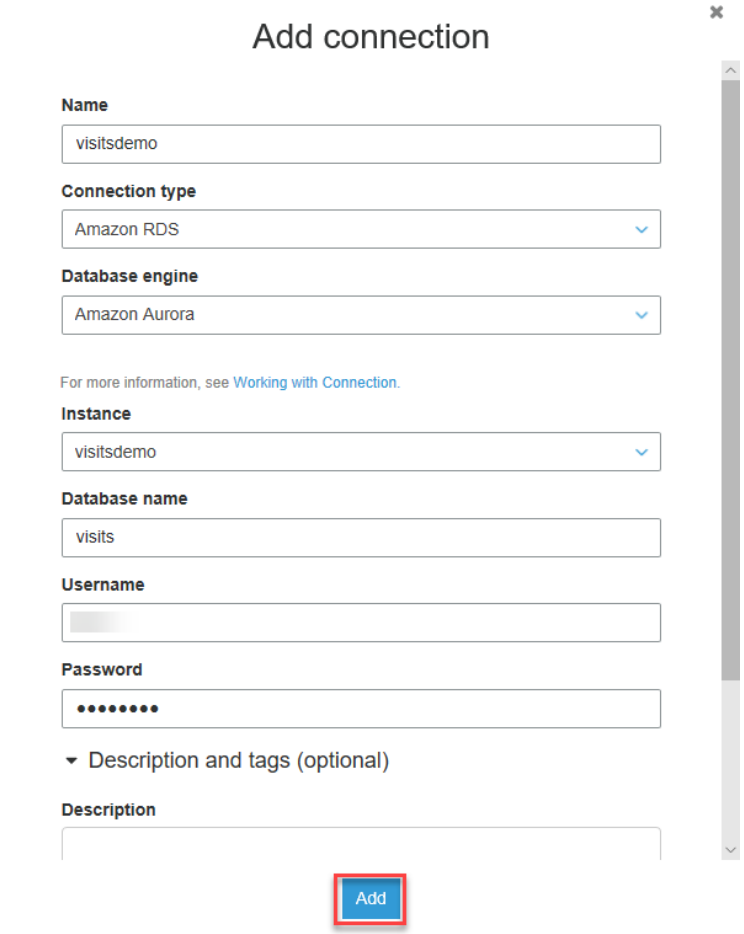
Choose transform type.



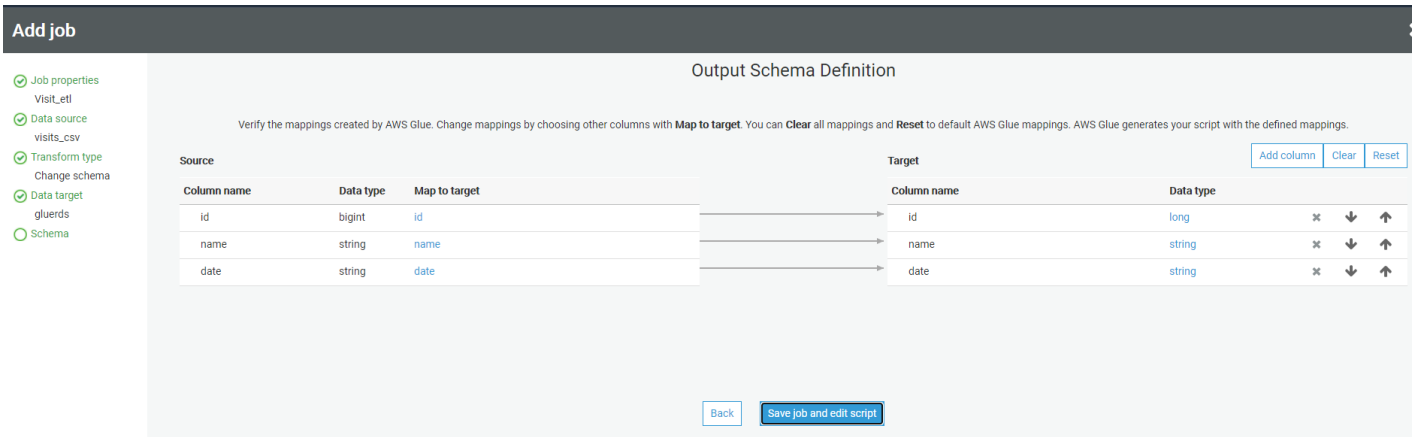
On the **Data Target** page, select **Create tables in your data target**, use the JDBC Data store, and the gluerds connection type. **Click Add Connection**.



On the **Add connection** page, enter the access details for the Aurora Instance and lick **Add**.



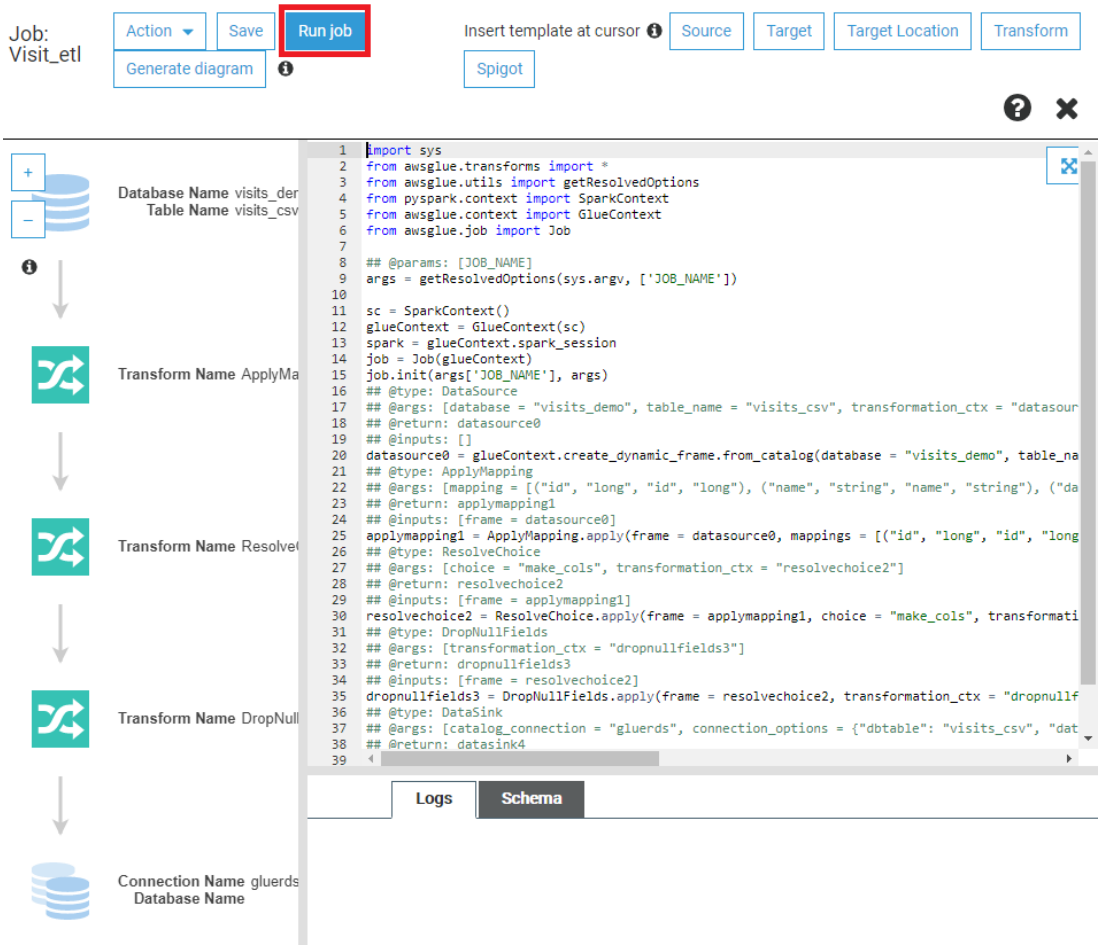
Click **Next** to display the column mapping between the source and target. For this example, leave the default mapping and data types. Click **Next**.



Review the job properties and click **Save job and edit script**.

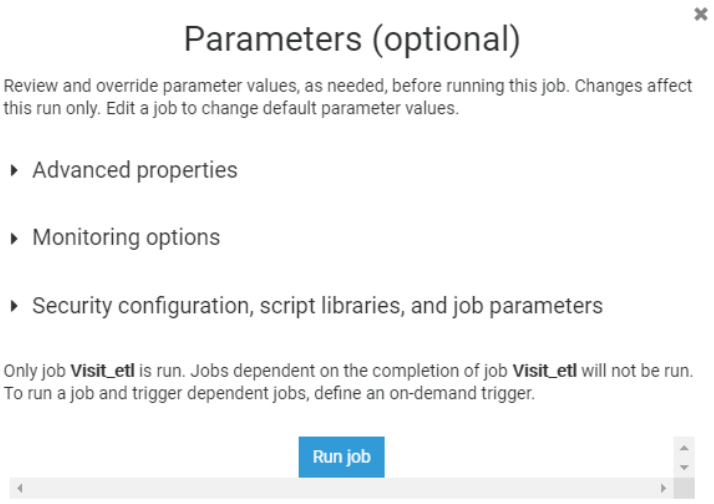
Review the generated script and make manual changes as needed. You can use the built-in templates for source, target, target location, transform, and spigot using the buttons at the top right section of the screen.

For this example, run the script as-is. Click **Run Job**.



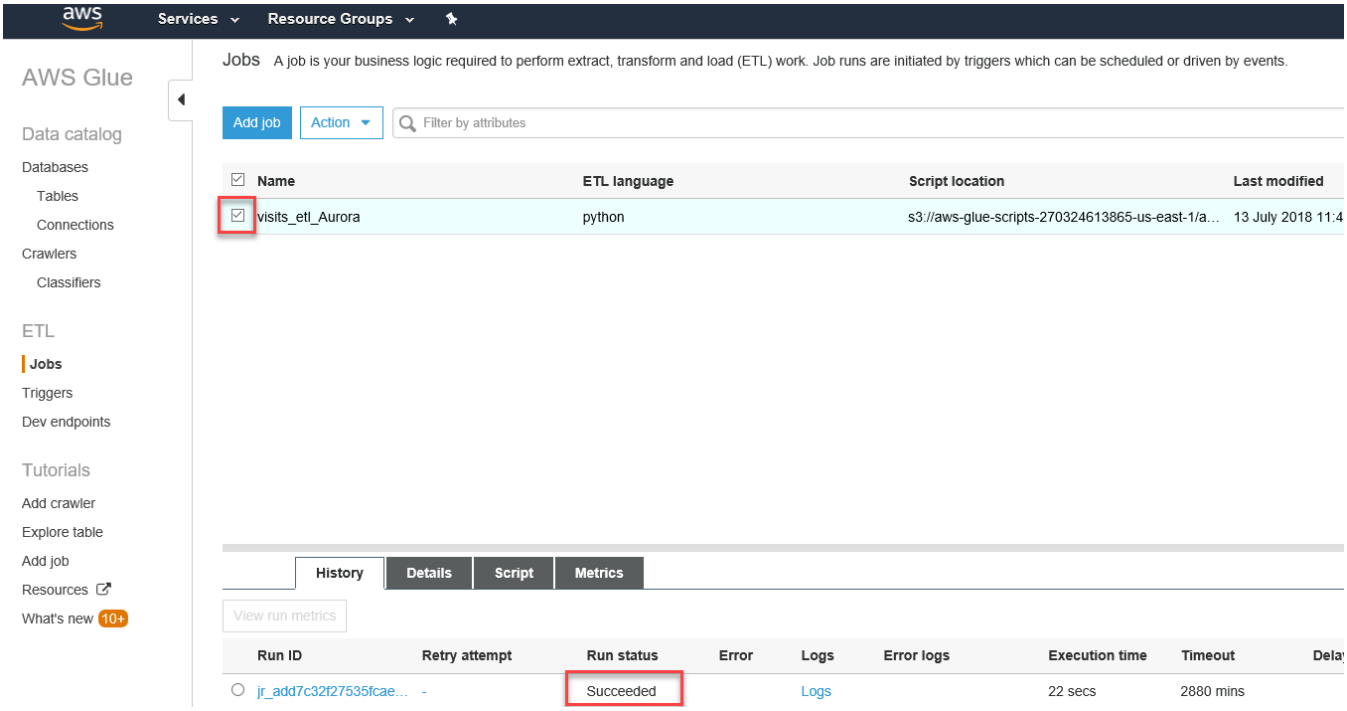

```
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)
## @type: DataSource
## @args: [database = "visits_demo", table_name = "visits_csv", transformation_ctx = "datasour
## @return: datasource0
## @inputs: []
datasource0 = glueContext.create_dynamic_frame.from_catalog(database = "visits_demo", table_na
## @type: ApplyMapping
## @args: [mapping = [("id", "long", "id", "long"), ("name", "string", "name", "string"), ("da
## @return: applymapping1
## @inputs: [frame = datasource0]
applymapping1 = ApplyMapping.apply(frame = datasource0, mappings = [("id", "long", "id", "long
## @type: ResolveChoice
## @args: [choice = "make_cols", transformation_ctx = "resolvechoice2"]
## @return: resolvechoice2
## @inputs: [frame = applymapping1]
resolvechoice2 = ResolveChoice.apply(frame = applymapping1, choice = "make_cols", transformati
## @type: DropNullFields
## @args: [transformation_ctx = "dropnullfields3"]
## @return: dropnullfields3
## @inputs: [frame = resolvechoice2]
dropnullfields3 = DropNullFields.apply(frame = resolvechoice2, transformation_ctx = "dropnullf
## @type: DataSink
## @args: [catalog_connection = "gluerds", connection_options = {"dbtable": "visits_csv", "dat
## @return: datasink4
```

The optional parameters window displays. Click **Run Job**.

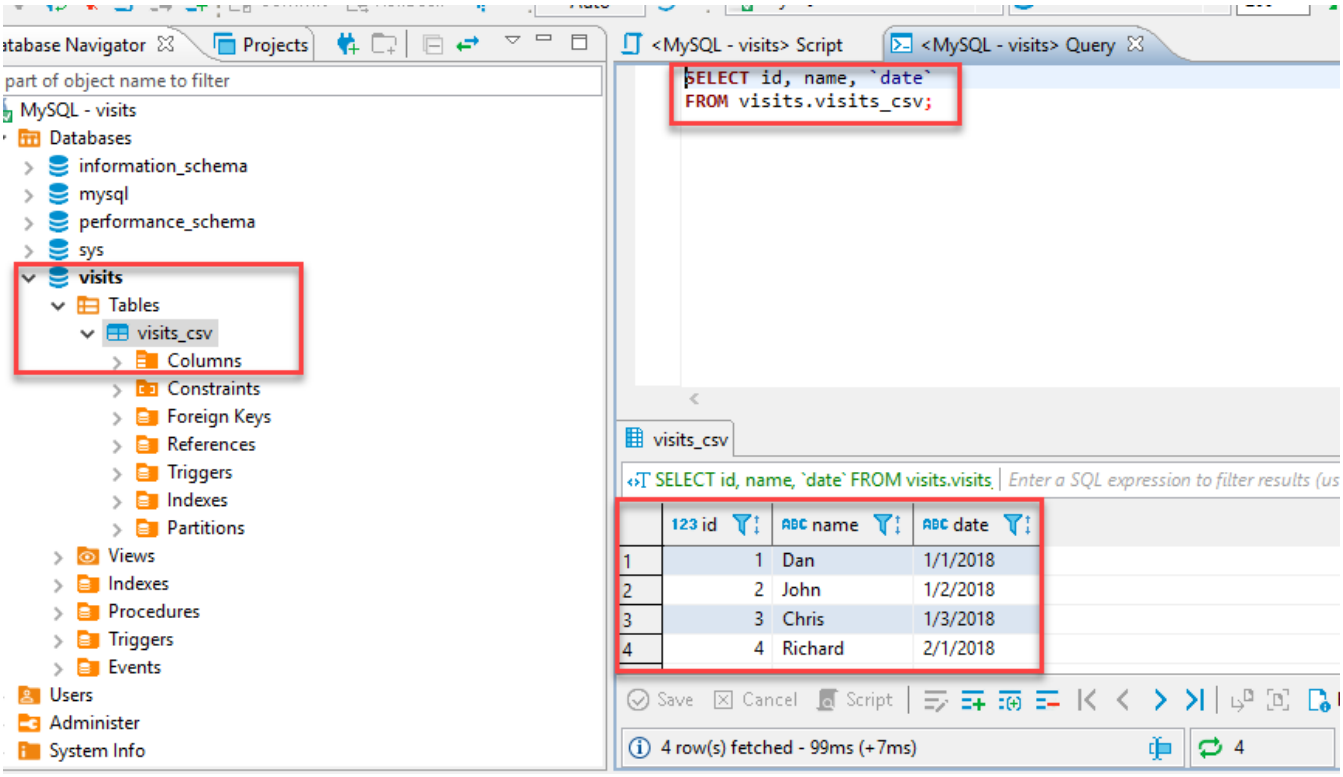


Navigate back to the glue management console jobs page at https://console.aws.amazon.com/glue/home?etl:tab=jobs.

On the history tab, verify the job status as **Succeeded** and view the logs if needed.



Now open your query IDE, connect to the Aurora PostgreSQL cluster, and query the visits database to make sure the data has been transferred successfully.



For more information, see

- https://docs.aws.amazon.com/glue/latest/dg/what-is-glue.html
- https://aws.amazon.com/glue/developer-resources/

SQL Server Export and Import with Text files vs. PostgreSQL pg_dump and pg_restore

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Non-compatible tool

SQL Server Usage

SQL Server provides many options for exporting and importing text files. These operations are commonly used for data migration, scripting, and backup.

- **Save results to a file in SQL Server Management Studio (SSMS):** https://support.microsoft.com/en-us/help/860545/how-to-create-csv-or-rpt-files-from-an-sql-statement-in-microsoft-sql
- **SQLCMD:** https://docs.microsoft.com/en-us/sql/relational-databases/scripting/sqlcmd-run-transact-sql-script-files?view=sql-server-ver15#save-the-output-to-a-text-file
- **PowerShell wrapper for SQLCMD**
- **SSMS Import/Export Wizard:** https://docs.microsoft.com/en-us/sql/integration-services/import-export-data/start-the-sql-server-import-and-export-wizard?view=sql-server-ver15
- **SQL Server Reporting Services (SSRS)**
- **Bulk Copy Program (BCP):** https://docs.microsoft.com/en-us/sql/relational-databases/import-export/import-and-export-bulk-data-by-using-the-bcp-utility-sql-server?view=sql-server-ver15

All of the options described above required additional tools to export data. Most of the tools are open source and provide support for a variety of databases.

SQLCMD is a command line utility for executing T-SQL statements, system procedures, and script files. It uses ODBC to execute T-SQL batches. For example:

```
SQLCMD -i C:\sql\myquery.sql -o C:\sql\output.txt
```

SQLCMD utility syntax:

```
sqlcmd
   -a packet_size
   -A (dedicated administrator connection)
   -b (terminate batch job if there is an error)
   -c batch_terminator
   -C (trust the server certificate)
   -d db_name
   -e (echo input)
   -E (use trusted connection)
   -f codepage | i:codepage[,o:codepage] | o:codepage[,i:codepage]
   -g (enable column encryption)
   -G (use Azure Active Directory for authentication)
   -h rows_per_header
   -H workstation_name
   -i input_file
   -I (enable quoted identifiers)
```

```
   -j (Print raw error messages)
   -k[1 | 2] (remove or replace control characters)
   -K application_intent
   -l login_timeout
   -L[c] (list servers, optional clean output)
   -m error_level
   -M multisubnet_failover
   -N (encrypt connection)
   -o output_file
   -p[1] (print statistics, optional colon format)
   -P password
   -q "cmdline query"
   -Q "cmdline query" (and exit)
   -r[0 | 1] (msgs to stderr)
   -R (use client regional settings)
   -s col_separator
   -S [protocol:]server[instance_name][,port]
   -t query_timeout
   -u (unicode output file)
   -U login_id
   -v var = "value"
   -V error_severity_level
   -w column_width
   -W (remove trailing spaces)
   -x (disable variable substitution)
   -X[1] (disable commands, startup script, environment variables, optional exit)
   -y variable_length_type_display_width
   -Y fixed_length_type_display_width
   -z new_password
   -Z new_password (and exit)
   -? (usage)
```

Examples

Connect to a named instance using Windows Authentication and specify input and output files.

```
sqlcmd -S MyMSSQLServer\MyMSSQLInstance -i query.sql -o outputfile.txt
```

If the file is needed for import to another database, query the data as INSERT commands and CREATE for the object.

You can export data with SQLCMD and import with Export/Import wizard.

For more information, see: https://docs.microsoft.com/en-us/sql/tools/sqlcmd-utility?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL provides the native utilities pg_dump and pg_restore to perform logical database exports and imports with comparable functionality to the SQl Server SQLCMD utility. For example, moving data between two databases and creating logical database backups.

- **pg_dump:** Export data
- **pg_restore:** Import data

The binaries for both utilities must be installed on your local workstation or on an Amazon EC2 server as part of the PostgreSQL client binaries.

PostgreSQL dump files created using pg_dump can be copied, after export, to an Amazon S3 bucket as cloud backup storage or for maintaining the desired backup retention policy. Later, when dump files are needed for database restore, the dump files can be copied back to a desktop or server that has a PostgreSQL client (such as your workstation or an Amazon EC2 server) to issue the pg_restore command.

Since PostgreSQL 10, these capabilities were added:

- A schema can be excluded in pg_dump/pg_restore commands
- Can create dumps with no blobs
- Allow to run pg_dumpall by non-superusers, using the --no-role-passwords option
- Create additional integrity option to ensure that the data is stored in disk using fsync() method

Since PostgreSQL 11, the following capabilities were added:

- pg_dump/pg_restore now exports/imports relationships between extensions and database objects established with ALTER ... DEPENDS ON EXTENSION, which allows these objects to be dropped when extension is dropped with CASCADE option.

Notes:

- **pg_dump** creates consistent backups even if the database is being used concurrently.
- **pg_dump** does not block other users accessing the database (readers or writers).
- **pg_dump** only exports a single database. To backup global objects common to all databases in a cluster (such as roles and tablespaces), use **pg_dumpall**.
- PostgreSQL dump files can be both plain-text and custom format files.

Another option to export and import data from PostgreSQL database is to use COPY TO/COPY FROM commands. Starting with PostgreSQL 12 COPY FROM command, that can be used to load data into DB, has support for filtering incoming rows with WHERE condition

```
CREATE TABLE tst_copy(v TEXT);

COPY tst_copy FROM '/home/postgres/file.csv' WITH (FORMAT CSV) WHERE v LIKE '%apple%';
```

Examples

Export data using pg_dump. Use a workstation or server with the PostgreSQL client installed to connect to the Aurora PostgreSQL instance in AWS. Issue the pg_dump command providing the hostname (-h), database user name (-U), and database name (-d).

```
$ pg_dump -h hostname.rds.amazonaws.com -U username -d db_name
  -f dump_file_name.sql
```

> **Note:** The output file, dump_file_name.sql, is stored on the server where the pg_dump command executes. You can later copy the outfile to an S3 Bucket if needed.

Run pg_dump and copy the backup file to an Amazon S3 bucket using a pipe and the AWS CLI.

```
$ pg_dump -h hostname.rds.amazonaws.com -U username -d db_name -f dump_file_name.sql |
aws s3 cp - s3://pg-backup/pg_bck-$(date"+%Y-%m-%d-%H-%M-%S")
```

Restore data using pg_restore. Use a workstation or server with the PostgreSQL client installed to connect to the Aurora PostgreSQL instance. Issue the pg_restore command providing the hostname (-h), database user name (-U), database name (-d), and the dump file.

```
$ pg_restore -h hostname.rds.amazonaws.com -U username -d dbname_restore dump_file_
name.sql
```

Copy the output file from the local server to an Amazon S3 Bucket using the AWS CLI. Upload the dump file to an S3 bucket.

```
$ aws s3 cp /usr/Exports/hr.dmp s3://my-bucket/backup-$(date "+%Y-
  %m-%d-%H-%M-%S")
```

Note: The {-$(date "+%Y-%m-%d-%H-%M-%S")} format is valid on Linux servers only.

Download the output file from the S3 bucket.

```
$ aws s3 cp s3://my-bucket/backup-2017-09-10-01-10-10 /usr/Exports/hr.dmp
```

Note: You can create a copy of an existing database without having to use pg_dump or pg_restore. Instead, use the template keyword to specify the source database.

```
CREATE DATABASE mydb_copy TEPLATE mydb;
```

Summary

Description	SQL Server export / import	PostgreSQL Dump
Export data to a file	using SQLCMD or Export/Import Wizard SQLCMD -i C:\sql\myquery.sql -o C:\sql\output.txt	pg_dump -F c -h host-name.rds.amazonaws.com -U username -d hr -p 5432 > c:\Export\hr.dmp
Import data to a new database with a new name	Run SQLCMD with objects and data cre-ation script SQLCMD -i C:\sql\myquery.sql	pg_restore -h hostname.rds.amazonaws.com -U hr -d hr_restore -p 5432 c:\Expor\hr.dmp

For more details, see:

- *https://www.postgresql.org/docs/13/static/backup-dump.html*
- *https://www.postgresql.org/docs/13/static/app-pgrestore.html*

SQL Server Viewing Server Logs vs. PostgreSQL Viewing Server Logs

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	View logs from the Amazon RDS console, the Amazon RDS API, the AWS CLI, or the AWS SDKs

SQL Server Usage

SQL Server logs system and user generated events to the *SQL Server Error Log* and to the *Windows Application Log*. It logs recovery messages, kernel messages, security events, maintenance events, and other general server level error and informational messages. The Windows Application Log contains events from all windows applications including SQL Server and SQL Server agent.

SQL Server Management Studio Log Viewer unifies all logs into a single consolidated view. You can also view the logs with any text editor.

Administrators typically use the SQL Server Error Log to confirm successful completion of processes, such as backup or batches, and to investigate the cause of run time errors. These logs can help detect current risks or potential future problem areas.

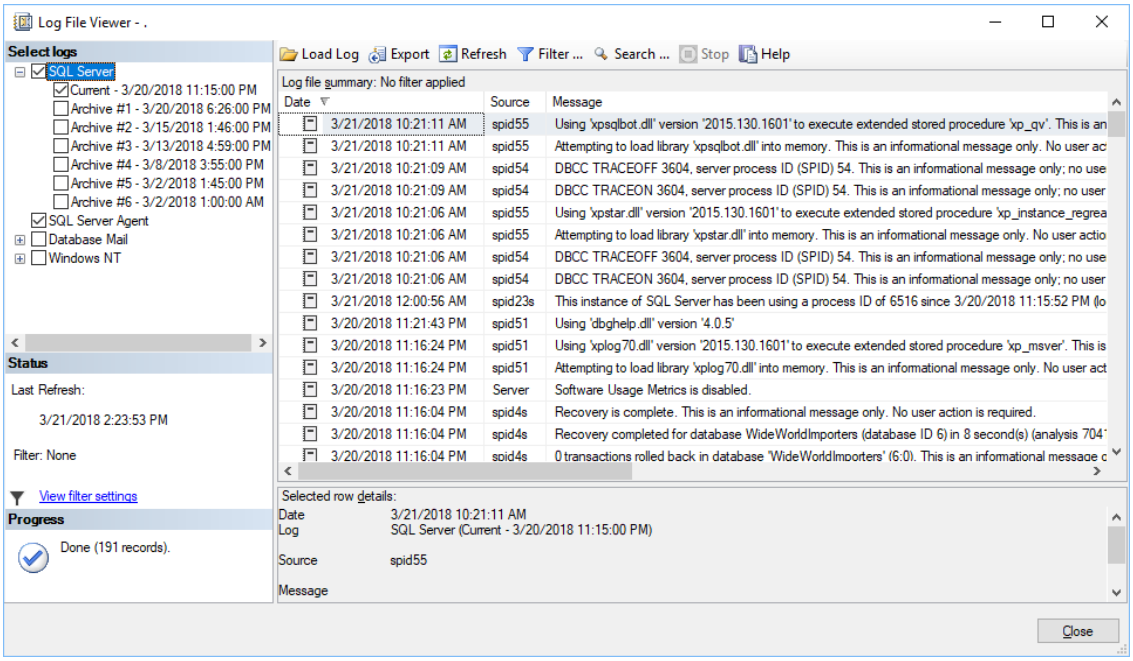
To view the log for SQL Server, SQL Server Agent, Database Mail, and Windows applications, open the SQL Server Management Studio Object Explorer pane, navigate to **Management > SQL Server Logs** , and double-click the current log.

The following table identifies some common error codes database administrators typically look for in the error logs:

Error Code	Error Message
1105	Could not allocate space
3041	Backup Failed
9002	Transaction Log Full
14151	Replication agent failed
17053	Operating System Error
18452	Login Failed
9003	Possible database corruption

Examples

The following screenshot shows typical Log File Viewer content:



For more information, see [Microsoft-us/sql/tools/configuration-manager/monitoring-the-error-logs?view=sql-server-ver15]

PostgreSQL Usage

Aurora PostgreSQL provides administrators with access to the PostgreSQL error log.

The PostgreSQL Error Log is generated by default. To generate the slow query and general logs, set the corresponding parameters in the database parameter group. For more details about parameter groups, see Server Options.

You can view Aurora PostgreSQL logs directly from the Amazon RDS console, the Amazon RDS API, the AWS CLI, or the AWS SDKs. You can also direct the logs to a database table in the main database and use SQL queries to view the data. To download a binary log, use the AWS Console.

Several parameters control how and where PostgreSQL log and errors files are placed:

Parameter	Description
log_filename	Sets the file name pattern for log files. Modifiable via an Aurora Database Parameter Group.
log_rotation_age	(min) Automatic log file rotation will occur after N minutes. Modifiable via an Aurora Database Parameter Group.
log_rotation_size	(kB) Automatic log file rotation will occur after N kilobytes. Modifiable via an Aurora Database Parameter Group.
log_min_messages	Sets the message levels that are logged (DEBUG, ERROR, INFO, etc....). Modifiable via an Aurora Database Parameter Group.
log_min_error_statement	Causes all statements generating errors at or above this level to be logged (DEBUG, ERROR, INFO, etc....). Modifiable via an Aurora Database Parameter Group.
log_min_duration_	Sets the minimum execution time above which statements will be logged (ms).

Parameter	Description
statement	Modifiable via an Aurora Database Parameter Group.

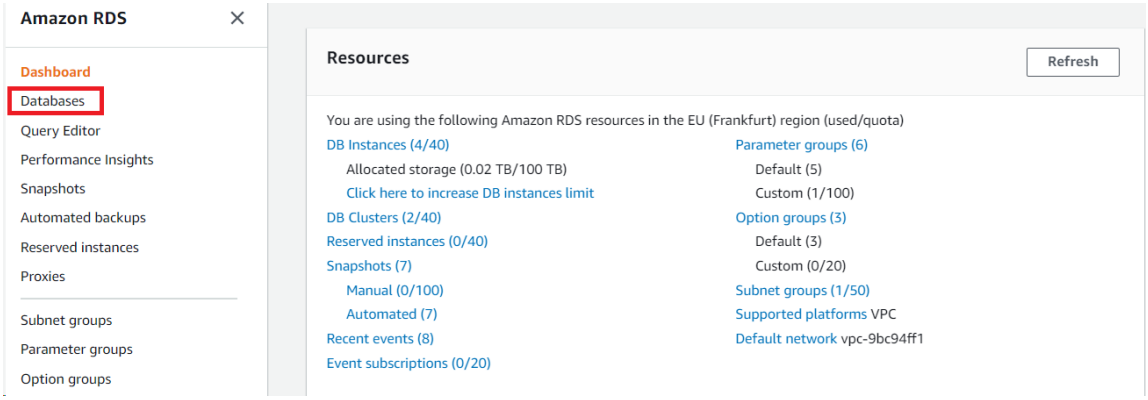
Note: Modifications to certain parameters, such as log_directory (which sets the destination directory for log files) or logging_collector (which starts a sub-process to capture stderr output and/or csvlogs into log files) are disabled for Aurora PostgreSQL instances.

For more information, see https://www.postgresql.org/docs/13/static/runtime-config-logging.html

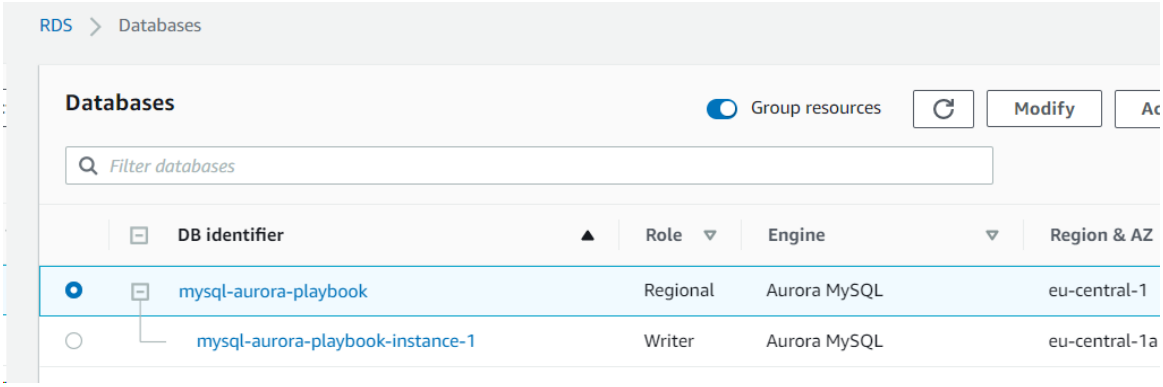
Examples

The following walk-through demonstrates how to view the Aurora PostgreSQL error logs in the RDS console.

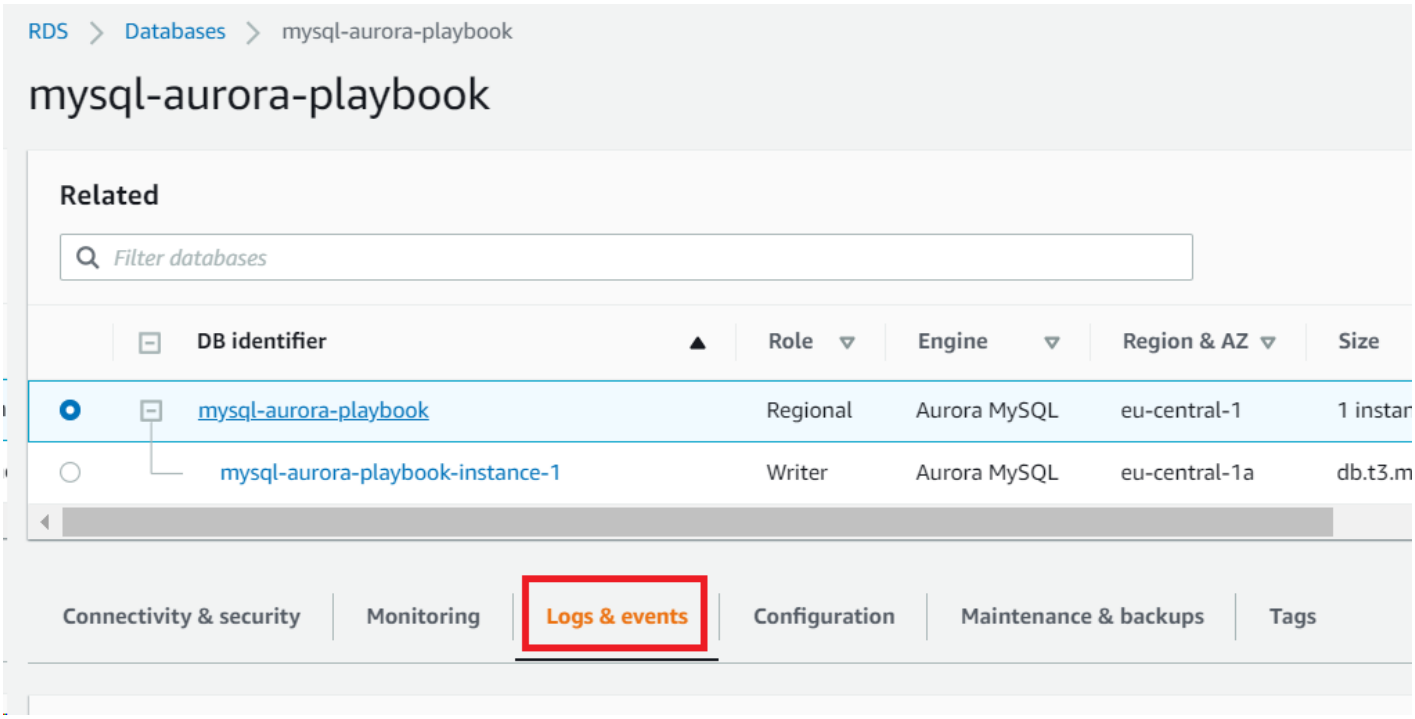
Using a web browser, navigate to https://console.aws.amazon.com/rds/home and click **Databases**.



Click the instance for which you want to view the error log.



Scroll down to the logs section and click the log name.



The log viewer displays the log content.

For more information, see
https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_LogAccess.Concepts.PostgreSQL.html

SQL Server Maintenance Plans vs. PostgreSQL Viewing Server Logs

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Backups via the RDS services Table maintenance via SQL

SQL Server Usage

A Maintenance plan is a set of automated tasks used to optimize a database, performs regular backups, and ensure it is free of inconsistencies. Maintenance plans are implemented as SQL Server Integration Services (SSIS) packages and are executed by SQL Server Agent jobs. They can be run manually or automatically at scheduled time intervals.

SQL Server provides a variety of pre-configured maintenance tasks. You can create custom tasks using T-SQL scripts or operating system batch files.

Maintenance plans are typically used for the following tasks:

- Backing up database and transaction log files.
- Performing cleanup of database backup files in accordance with retention policies.
- Performing database consistency checks.

- Rebuilding or reorganizing indexes.
- Decreasing data file size by removing empty pages (shrink a database).
- Updating statistics to help the query optimizer obtain updated data distributions.
- Running SQL Server Agent jobs for custom actions.
- Executing a T-SQL task.

Maintenance plans can include tasks for operator notifications and history/maintenance cleanup. They can also generate reports and output the contents to a text file or the maintenance plan tables in msdb.

Maintenance plans can be created and managed using the maintenance plan wizard in SQL Server Management Studio, Maintenance Plan Design Surface (provides enhanced functionality over the wizard), Management Studio Object Explorer, and T-SQL system stored procedures.

For more information about SQL Server Agent migration, see SQL Server Agent.

Deprecated DBCC Index and Table Maintenance Commands

The DBCC DBREINDEX, INDEXDEFRAG, and SHOWCONTIG commands have been deprecated as of SQL Server 2008R2 in accordance with https://docs.microsoft.com/en-us/previous-versions/sql/sql-server-2008-r2/ms143729(v=sql.105).

In place of the deprecated DBCC, SQL Server provides newer syntax alternatives as detailed in the following table.

Deprecated DBCC Command	Use Instead
DBCC DBREINDEX	ALTER INDEX ... REBUILD
DBCC INDEXDEFRAG	ALTER INDEX ... REORGANIZE
DBCC SHOWCONTIG	sys.dm_db_index_physical_stats

For the Aurora PostgreSQL alternatives to these maintenance commands, see Aurora PostgreSQL Maintenance Plans.

Examples

Enable Agent XPs, which are disabled by default.

```
EXEC [sys].[sp_configure] @configname = 'show advanced options', @configvalue = 1
RECONFIGURE ;
```

```
EXEC [sys].[sp_configure] @configname = 'agent xps', @configvalue = 1
RECONFIGURE;
```

Create a T-SQL maintenance plan for a single index rebuild.

```
USE msdb;
```

Add the `Index Maintenance` IDX1 job to SQL Server Agent.

```
EXEC dbo.sp_add_job @job_name = N'Index Maintenance IDX1', @enabled = 1, @description
= N'Optimize IDX1 for INSERT' ;
```

Add the T-SQL job step "Rebuild IDX1 to 50 percent fill".

```
EXEC dbo.sp_add_jobstep @job_name = N'Index Maintenance IDX1', @step_name = N'Rebuild
IDX1 to 50 percent fill', @subsystem = N'TSQL',
@command = N'Use MyDatabase; ALTER INDEX IDX1 ON Shcema.Table REBUILD WITH ( FILL_
FACTOR = 50), @retry_attempts = 5, @retry_interval = 5;
```

Add a schedule to run every day at 01:00 AM.

```
EXEC dbo.sp_add_schedule @schedule_name = N'Daily0100', @freq_type = 4, @freq_interval
= 1, @active_start_time = 010000;
```

Associate the schedule Daily0100 with the job Index Maintenance IDX1.

```
EXEC sp_attach_schedule @job_name = N'Index Maintenance IDX1' @schedule_name =
N'Daily0100' ;
```

For more information, see https://docs.microsoft.com/en-us/sql/relational-databases/maintenance-plans/maintenance-plans?view=sql-server-ver15

PostgreSQL Usage

Amazon RDS performs automated database backups by creating storage volume snapshots that back up entire instances, not individual databases.

RDS creates snapshots during the backup window for individual database instances and retains snapshots in accordance with the backup retention period. You can use the snapshots to restore a database to any point in time within the backup retention period.

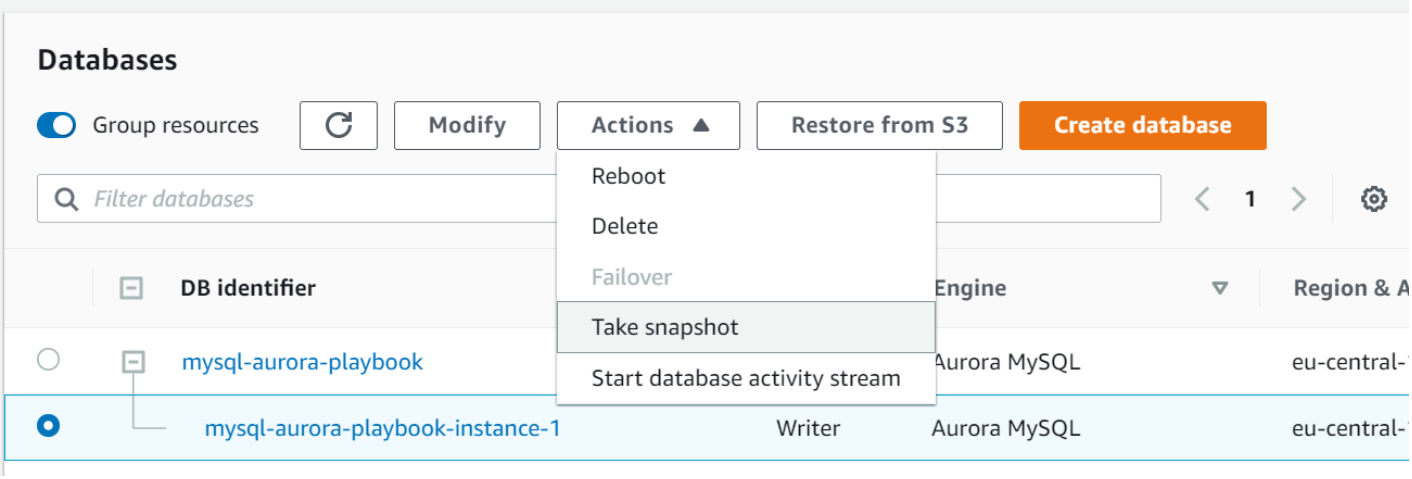
> **Note:** The state of a database instance must be ACTIVE for automated backups to occur.

You can backup database instances manually by creating an explicit database snapshot. Use the AWS console, the AWS CLI, or the AWS API to take manual snapshots.

Examples

Create a Manual Database Snapshot Using the RDS Console

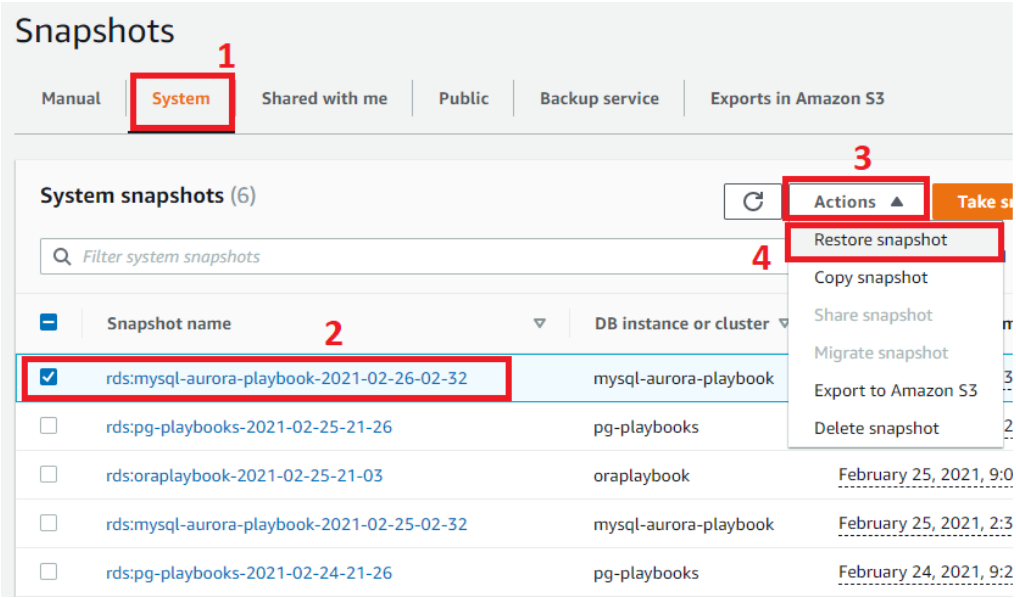
1. Navigate to the RDS Databases Page.
2. Select an Aurora MySQL instance, click **Instance actions** and select **Take Snapshot**.



Restoring Snapshots on the RDS Console

Follow the steps below to restore an Aurora database from a snapshot.

1. Navigate to the RDS System Snapshots (link will refer to System snapshots but another tab can be used to view Manual snapshots).
2. Select the snapshot to restore, click **Actions** on the context menu, and select **Restore snapshot**. This action creates a new instance.



3. The web page displays a wizard for creating a new Aurora database instance from the selected snapshot. Enter the required configuration options and click **Restore DB Instance**.

You can also restore a database instance to a point-in-time. For more details see Backup and Restore.

For all other tasks, use a third-party or a custom application scheduler.

Rebuild and Reorganize a table

Aurora PostgreSQL supports the VACUUM, ANALYZE and REINDEX commands, which are similar to the REORGANIZE option of SQL Server indexes.

```
VACUUM MyTable;
ANALYZE MyTable;
REINDEX TABLE MyTable;
```

- **VACUUM:** Reclaims storage
- **ANALYZE:** Collect statistics
- **REINDEX:** Recreate all indexes

For more information see

- *https://www.postgresql.org/docs/13/static/sql-analyze.html*
- *https://www.postgresql.org/docs/13/static/sql-vacuum.html*
- *https://www.postgresql.org/docs/13/static/sql-reindex.html*

Converting Deprecated DBCC Index and Table Maintenance Commands

Deprecated DBCC Command	Aurora PostgreSQL Equivalent
DBCC DBREINDEX	REINDEX INDEX or REINDEX TABLE
DBCC INDEXDEFRAG	VACUUM table_name or VACUUM table_name column_name

Update Statistics to Help the Query Optimizer Get Updated Data Distribution

For more information, see Managing Statistics.

Summary

The following table summarizes the key tasks that use SQL Server maintenance Plans and a comparable Aurora PostgreSQL solutions.

Task	SQL Server	Aurora PostgreSQL
Rebuild or reorganize indexes	ALTER INDEX / ALTER TABLE	REINDEX INDEX / REINDEX TABLE
Decrease data file size by removing empty pages	DBCC SHRINKDATABASE / DBCC SHRINKFILE	VACUUM
Update statistics to help the query optimizer get updated data distribution	UPDATE STATISTICS / sp_updatestats	ANALYZE

Task	SQL Server	Aurora PostgreSQL
Perform database consistency checks	DBCC CHECKDB / DBCC CHECKTABLE	N/A
Back up the database and transaction log files	BACKUP DATABASE / BACKUP LOG	Automatically (can be use with CLI)
Run SQL Server Agent jobs for custom actions	sp_start_job, scheduled	N/A

For more information, see
https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_WorkingWithAutomatedBackups.html

SQL Server Monitoring vs. PostgreSQL Monitoring

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Use Amazon Cloud Watch service

SQL Server Usage

Monitoring server performance and behavior is a critical aspect of maintaining service quality and includes ad-hoc data collection, ongoing data collection, root cause analysis, preventative actions, and reactive actions. SQL Server provides an array of interfaces to monitor and collect server data.

SQL Server 2017 introduces several new dynamic management views:

- sys.dm_db_log_stats exposes summary level attributes and information on transaction log files, helpful for monitoring transaction log health.
- sys.dm_tran_version_store_space_usage tracks version store usage per database, useful for proactively planning tempdb sizing based on the version store usage per database.
- sys.dm_db_log_info exposes VLF information to monitor, alert, and avert potential transaction log issues.
- sys.dm_db_stats_histogram is a new dynamic management view for examining statistics.
- sys.dm_os_host_info provides operating system information for both Windows and Linux.

SQL Server 2019 adds new configuration parameter, LIGHTWEIGHT_QUERY_PROFILING. It enables or disables the lightweight query profiling infrastructure. The lightweight query profiling infrastructure (LWP) provides query performance data more efficiently than standard profiling mechanisms and is enabled by default. For more information see Lightweight Query Profiling Infrastructure

Windows Operating System Level Tools

The Windows Scheduler can be used to trigger execution of script files(CMD, Powershell etc) to collect, store, and process performance data.

System Monitor is a graphical tool for measuring and recording performance of SQL Server and other windows related metrics using the Windows Management Interface (WMI) performance objects.

> **Note:** Performance objects can also be accessed directly from T-SQL using the SQL Server Operating System Related DMVs. For a full list of the DMVs, see: sql-server-operating-system-related-dynamic-management-views-transact-sql

Performance counters exist for both real time measurements such as CPU Utilization and for aggregated history such as average active transactions.

For a full list of the object hierarchy, see: https://docs.microsoft.com/en-us/sql/relational-databases/performance-monitor/use-sql-server-objects?view=sql-server-ver15

SQL Server Extended Events

SQL Server's latest tracing framework provides very lightweight and robust event collection and storage. SQL Server Management Studio features the New Session Wizard and New Session graphic user interfaces for managing and analyzing captured data. SQL Server Extended Events consists of the following items:

- **SQL Server Extended Events Package** is a logical container for Extended Events objects.
- **SQL Server Extended Events Targets** are consumers of events. Targets include Event File, which writes data to the file Ring Buffer for retention in memory, or for processing aggregates such as Event Counters and Histograms.
- **SQL Server Extended Events Engine** is a collection of services and tools that comprise the framework.
- **SQL Server Extended Events Sessions** are logical containers mapped many-to-many with packages, events, and filters.

The following example creates a session that logs lock escalations and lock timeouts to a file.

```
CREATE EVENT SESSION Locking_Demo
ON SERVER
    ADD EVENT sqlserver.lock_escalation,
    ADD EVENT sqlserver.lock_timeout
    ADD TARGET package0.etw_classic_sync_target
        (SET default_etw_session_logfile_path = N'C:\ExtendedEvents\Locking\Demo_
20180502.etl')
    WITH (MAX_MEMORY=8MB, MAX_EVENT_SIZE=8MB);
GO
```

SQL Server Tracing Framework and the SQL Server Profiler Tool

The SQL Server trace framework is the predecessor to the Extended Events framework and remains popular among database administrators. The lighter and more flexible Extended Events Framework is recommended for development of new monitoring functionality. For more information about SQL Server Profiler Tool, see : sql-server-profiler

SQL Server Management Studio

SQL Server management studio provides several monitoring extensions:

- **SQL Server Activity Monitor** is an in-process, real-time, basic high-level information graphical tool.
- **Query Graphical Show Plan** provides easy exploration of estimated and actual query execution plans.

- **Query Live Statistics** displays query execution progress in real time.
- **Replication Monitor** presents a Publisher-focused view or Distributor-focused view of all replication activity. For more details, see: overview-of-the-replication-monitor-interface
- **Log Shipping Monitor** displays the status of any log shipping activity whose status is available from the server instance to which you are connected. For more details, see: view-the-log-shipping-report-sql-server-management-studio
- **Standard Performance Reports** SSMS provides a set of reports, there are more than 20 reports that show the most important performance metrics, change history, memory usage, activity, transactions, HA, and more.

T-SQL

From the T-SQL interface, SQL Server provides many system stored procedures, system views, and functions for monitoring data.

System stored procedures such as sp_who and sp_lock provide real-time information. sp_monitor provides aggregated data.

Built in functions such as @@CONNECTIONS, @@IO_BUSY, @@TOTAL_ERRORS, and others provide high level server information.

A rich set of System Dynamic Management functions and views are provided for monitoring almost every aspect of the server. These functions reside in the sys schema and are prefixed with dm_string. For more information about Dynamic Management Views, see https://docs.microsoft.com/en-us/sql/relational-databases/system-dynamic-management-views/system-dynamic-management-views?view=sql-server-ver15

Trace Flags

Trace flags can be set to log events. For example, set trace flag 1204 to log deadlock information. For more information about Trace flags, see: dbcc-traceon-trace-flags-transact-sql

SQL Server Query Store

Query Store is a database level framework supporting automatic collection of queries, execution plans, and run time statistics. This data is stored in system tables and can be used to diagnose performance issues, understand patterns, and understand trends. It can also be set to automatically revert plans when a performance regression is detected.

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/performance/monitoring-performance-by-using-the-query-store?view=sql-server-ver15

PostgreSQL Usage

Amazon RDS provide a rich monitoring infrastructure for Aurora PostgreSQL clusters and instances with the native Cloud Watch service. See the following up-to-date articles that include examples and walkthroughs for monitoring Aurora PostgreSQL clusters and instances:

- https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/CHAP_Monitoring.html
- https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_Monitoring.OS.html

You can also use the Performance Insights AWS tool to monitor PostgreSQL.

PostgreSQL can also be monitored by querying system catalog table and views.

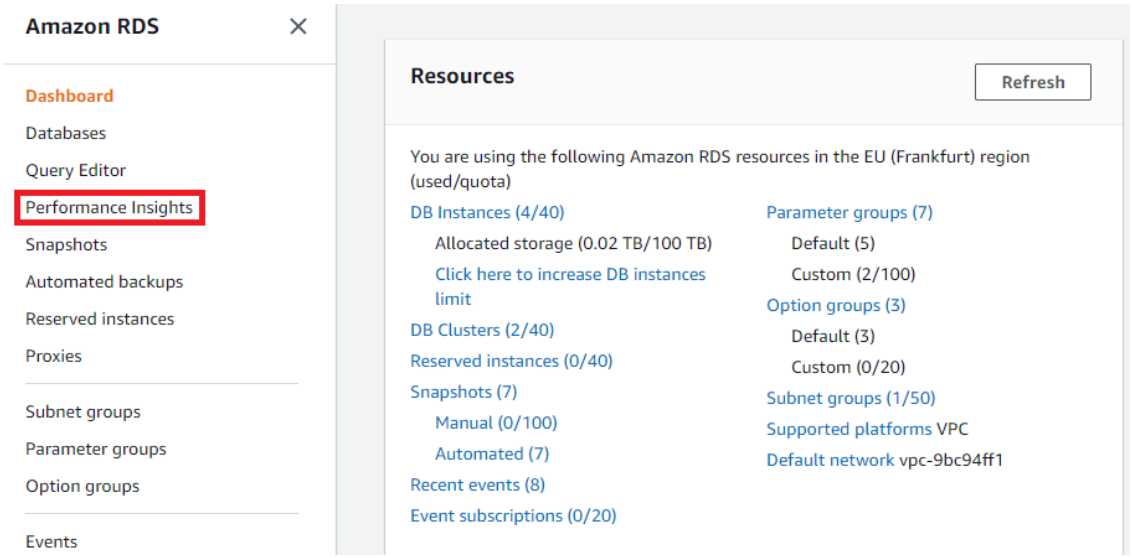
Starting with PostgreSQL 12 it is now possible to monitor progress of CREATE INDEX and REINDEX and CLUSTER and VACUUM FULL operations by querying system views pg_stat_progress_create_index and pg_stat_progress_cluster.

> **RDS ONLY:** Starting with PostgreSQL 13 following features have been added:
> 1. It is now possible to monitor progress of ANALYZE operations by querying system view pg_stat_progress_analyze
> 2. It is now possible to monitor shared memory usage with system view pg_shmem_allocations

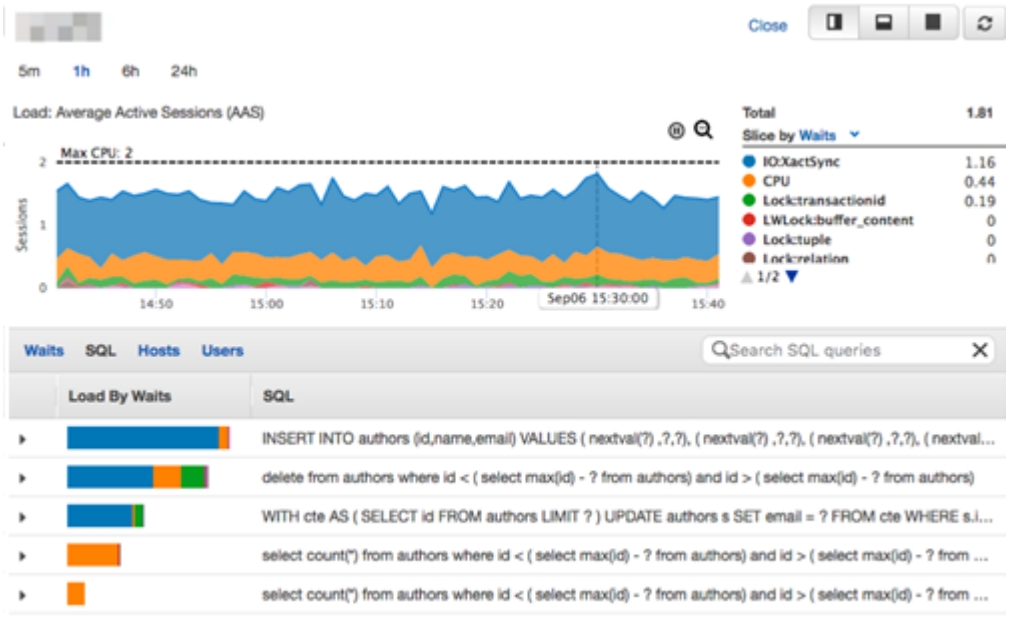
Example

The following walk-through demonstrates how to access the Amazon Aurora Performance Insights Console:

Navigate to the RDS section of the AWS Console, and select **Performance Insights**.



The web page displays a dashboard containing current and past database performance metrics. You can choose the period of the displayed performance data (5m, 1h, 6h or 24h) as well as different criteria to filter and slice the information (waits, SQL, Hosts or Users, etc.).



Enabling Performance Insights

Performance Insights is enabled by default for Amazon Aurora clusters. If you have more than one database in your Aurora cluster, performance data for all databases is aggregated. Database performance data is retained for 24 hours.

For additional details, see http://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_PerfInsights.html

SQL Server Resource Governor vs. PostgreSQL Dedicated Amazon Aurora Clusters or Aurora Read-Replicas

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Distribute load/applications/users across multiple instances

SQL Server Usage

SQL Server Resource Governor provides the capability to control and manage resource consumption. Administrators can specify and enforce workload limits on CPU, physical I/O, and Memory. Resource configurations are dynamic and can be changed in real time.

In SQL Server 2019 configurable value for the REQUEST_MAX_MEMORY_GRANT_PERCENT option of CREATE WORKLOAD GROUP and ALTER WORKLOAD GROUP has been changed from an integer to a float

data type to allow more granular control of memory limits. See ALTER WORKLOAD GROUP and CREATE WORKLOAD GROUP

Use Cases

The following list identifies typical Resource Governor use cases:

- **Minimize performance bottlenecks and inconsistencies** to better support Service Level Agreements (SLA) for multiple workloads and users.
- **Protect against runaway queries** that consume a large amount of resources or explicitly throttle I/O intensive operations. For example, consistency checks with DBCC that may bottleneck the I/O subsystem and negatively impact concurrent workloads.
- **Allow tracking and control for resource-based pricing** scenarios to improve predictability of user charges.

Concepts

The three basic concepts in Resource Governor are *Resource Pools*, *Workload Groups*, and *Classification*.

- **Resource Pools** represent physical resources. Two built-in resource pools, internal and default, are created when SQL Server is installed. You can create custom user-defined resource pools for specific workload types.
- **Workload Groups** are logical containers for session requests with similar characteristics. Workload Groups allow aggregate resource monitoring of multiple sessions. Resource limit policies are defined for a Workload Group. Each Workload Group belongs to a Resource Pool.
- **Classification** is a process that inspects incoming connections and assigns them to a specific Workload Group based on the common attributes. User-defined functions are used to implement Classification. For more information, see User Defined Functions.

Examples

Enable the Resource Governor.

```
ALTER RESOURCE GOVERNOR RECONFIGURE;
```

Create a Resource Pool.

```
CREATE RESOURCE POOL ReportingWorkloadPool
WITH (MAX_CPU_PERCENT = 20);
```

```
ALTER RESOURCE GOVERNOR RECONFIGURE;
```

Create a Workload Group.

```
CREATE WORKLOAD GROUP ReportingWorkloadGroup USING poolAdhoc;
```

```
ALTER RESOURCE GOVERNOR RECONFIGURE;
```

Create a classifier function.

```
CREATE FUNCTION dbo.WorkloadClassifier()
RETURNS sysname WITH SCHEMABINDING
```

```
AS
BEGIN
 RETURN (CASE
           WHEN HOST_NAME()= 'ReportServer'
            THEN 'ReportingWorkloadGroup'
           ELSE 'Default'
          END)
END;
```

Register the classifier function.

```
ALTER RESOURCE GOVERNOR with (CLASSIFIER_FUNCTION = dbo.WorkloadClassifier);
```

```
ALTER RESOURCE GOVERNOR RECONFIGURE;
```

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/resource-governor/resource-governor?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL does not have built-in resource management capabilities equivalent to the functionality provided by SQL Server's Resource Governor. However, due to the elasticity and flexibility provided by “cloud economics”, workarounds could be applicable and such capabilities might not be as of similar importance to monolithic on-premises databases.

The SQL Server's Resource Governor primarily exists because traditionally, SQL Server instances were installed on very powerful monolithic servers that powered multiple applications simultaneously. The monolithic model made the most sense in an environment where the licensing for the SQL Server database was per-CPU and where SQL Server instances were deployed on physical hardware. In these scenarios, it made sense to consolidate as many workloads as possible into fewer servers. With cloud databases, the strict requirement to maximize the usage of each individual “server” is often not as important and a different approach can be employed.

Individual Amazon Aurora clusters can be deployed, with varying sizes, each dedicated to a specific application or workload. Additional read-only Aurora Replica servers can be used to offload any reporting workloads from the master instance.

With Amazon Aurora, separate and dedicated database clusters can be deployed, each dedicated to a specific application/workload creating isolation between multiple connected sessions and applications.

Each Amazon Aurora instance (Primary/Replica) can scale independently in terms of CPU and memory resources using different *instance types*. Because multiple Amazon Aurora Instances can be instantly deployed and much less overhead is associated with the deployment and management of Aurora instances when compared to physical servers, separating different workloads to different instance classes could be a suitable solution for controlling resource management.

For more information about instance types and resources, see
https://aws.amazon.com/ec2/instance-types/

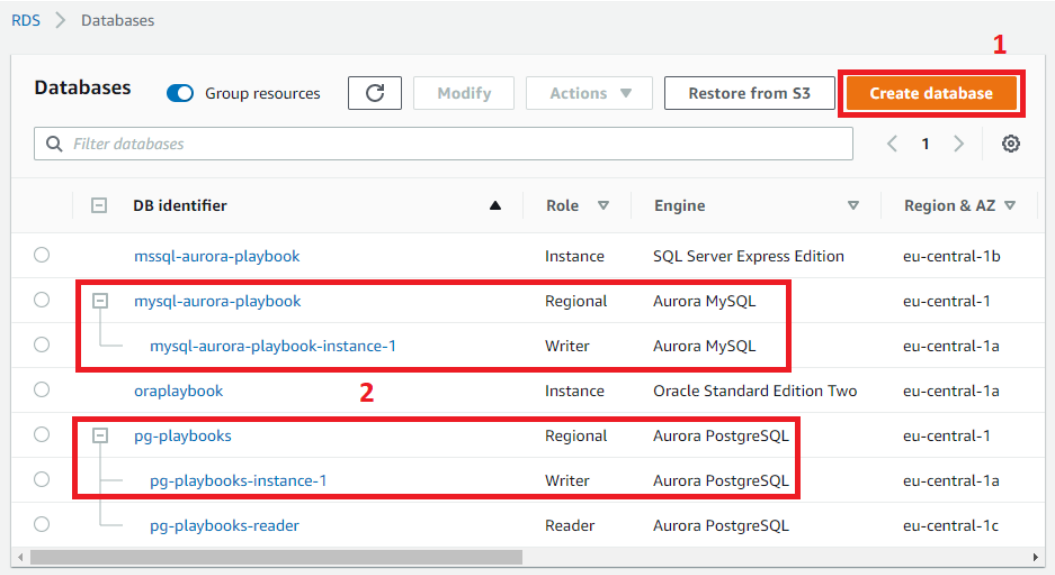
In addition, each Amazon Aurora instance can also be directly accessed from your applications using its own endpoint. This capability is especially useful if you have multiple Aurora read-replicas for a given cluster and you want to use different Aurora replicas to segment your workload.

You can adjust the resources and some parameters for Aurora read-replicas in the same cluster to avoid having additional cluster, however, this will allow to be used only for read operations.

Examples

To create an Aurora cluster please follow this steps:

Navigate to the Databases section under RDS and click on "Create database", follow the wizrd, click on "Create database", and then your cluster will appear in the Databases section

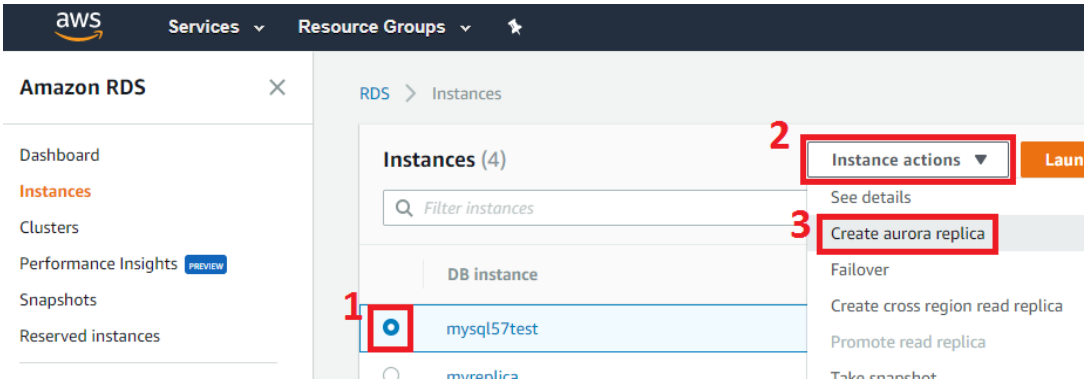


Suppose that you were using a single SQL Server instance for multiple separate applications and used SQL Server's Resource Governor to enforce a workload separation, allocating a specific amount of server resources for each application. With Amazon Aurora, you might want to create multiple separate databases for each individual application.

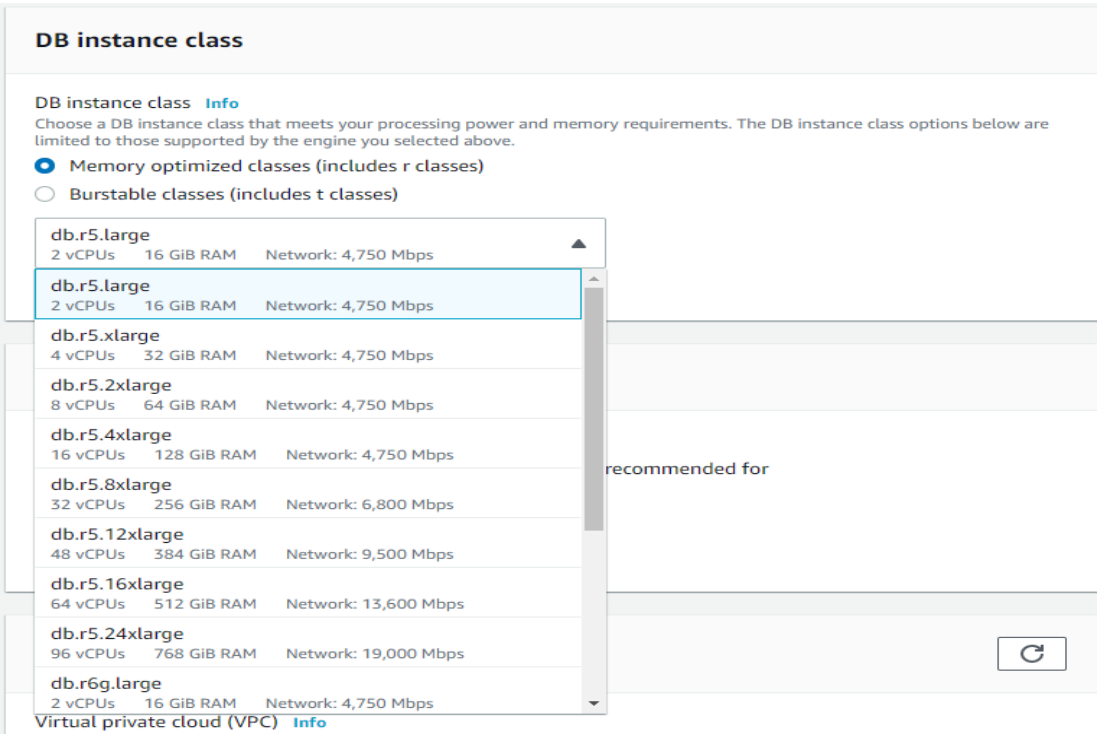
Follow these steps to add additional replica instances to an existing Amazon Aurora cluster:

Navigate to the Databases section under RDS.

Select the Amazon Aurora cluster that you want to scale-out by adding an additional read Replica, click the **Instance Actions** button, and click **Create Aurora Replica**.



Select the instance class depending on the amount of compute resources your application requires.



Click **Create Aurora Replica**.

Dedicated Aurora PostgreSQL Instances

Feature	Amazon Aurora Instances
Set the maximum CPU usage for a resource group	Create a dedicated Aurora Instance for a specific application.
Limit the degree of parallelism for specific queries	SET max_parallel_workers_per_gather TO x; Setting the PostgreSQL max_parallel_workers_per_gather parameter should be done as part of your application database connection.
Limit parallel execution	SET max_parallel_workers_per_gather TO 0; OR SET max_parallel_workers TO x; -- for the whole system (since PostgreSQL 10)
Limit the number of active sessions	Manually detect the number of connections that are open from a specific application and restrict connectivity either via database procedures or within the application DAL itself. select pid from pg_stat_activity where usename in(select usename from pg_stat_activity where state = 'active' group by usename having count(*) > 10) and state = 'active' order by query_Start;
Restrict maximum runtime of queries	Manually terminate sessions that exceed the required threshold. You can detect the length of running queries using SQL commands and restrict max execution duration using either database procedures or within the application DAL itself.

Feature	Amazon Aurora Instances
	SELECT pg_terminate_backend(pid) FROM pg_stat_activity WHERE now()-pg_stat_activity.query_start > interval '5 minutes';
Limit the maximum idle time for sessions	Manually terminate sessions that exceed the required threshold. You can detect the length of your idle sessions using SQL queries and restrict maximum execution using either database procedures or within the application DAL itself. SELECT pg_terminate_backend(pid) FROM pg_stat_activity WHERE datname = 'regress' AND pid <> pg_backend_pid() AND state = 'idle' AND state_change < current_timestamp - INTERVAL '5' MINUTE;
Limit the time that an idle session holding open locks can block other sessions	Manually terminate sessions that exceed the required threshold. You can detect the length of blocking idle sessions using SQL queries and restrict max execution duration using either database procedures or within the application DAL itself. SELECT pg_terminate_backend(blocking_locks.pid) FROM pg_catalog.pg_locks AS blocked_locks JOIN pg_catalog.pg_stat_activity AS blocked_activity ON blocked_activity.pid = blocked_locks.pid JOIN pg_catalog.pg_locks AS blocking_locks ON blocking_locks.locktype = blocked_locks.locktype AND blocking_locks.DATABASE IS NOT DISTINCT FROM blocked_locks.DATABASE AND blocking_locks.relation IS NOT DISTINCT FROM blocked_locks.relation AND blocking_locks.page IS NOT DISTINCT FROM blocked_locks.page AND blocking_locks.tuple IS NOT DISTINCT FROM blocked_locks.tuple AND blocking_locks.virtualxid IS NOT DISTINCT FROM blocked_locks.virtualxid AND blocking_locks.transactionid IS NOT DISTINCT FROM blocked_locks.transactionid AND blocking_locks.classid IS NOT DISTINCT FROM blocked_locks.classid AND blocking_locks.objid IS NOT DISTINCT FROM blocked_locks.objid AND blocking_locks.objsubid IS NOT DISTINCT FROM blocked_locks.objsubid AND blocking_locks.pid != blocked_locks.pid JOIN pg_catalog.pg_stat_activity AS blocking_activity ON blocking_activity.pid = blocking_locks.pid WHERE NOT blocked_locks.granted and blocked_activity.state_change < current_timestamp - INTERVAL '5' minute;

For additional details, see:https://www.postgresql.org/docs/13/static/runtime-config-resource.html

SQL Server Linked Servers vs. PostgreSQL DBLink and FDWrapper

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	Linked Servers	Syntax and option differences, similar functionality

SQL Server Usage

Linked Servers enable the database engine to connect to external Object Linking and Embedding for Data Bases (OLE-DB) sources. They are typically used to execute T-SQL commands and include tables in other instances of

SQL Server, or other RDBMS engines such as Oracle. SQL Server supports multiple types of OLE-DB sources as linked servers, including Microsoft Access, Microsoft Excel, text files and others.

The main benefits of using linked servers are:

- Reading external data for import or processing.
- Executing distributed queries, data modifications, and transactions for enterprise-wide data sources.
- Querying heterogeneous data source using the familiar T-SQL API.

Linked servers can be configured using either SQL Server Management Studio, or the system stored procedure sp_addlinkedserver. The available functionality and the specific requirements vary significantly between the various OLE-DB sources. Some sources may allow read only access, others may require specific security context settings, etc.

The Linked Server Definition contains the linked server alias, the OLE DB provider, and all the parameters needed to connect to a specific OLE-DB data source.

The OLE-DB provider is a .Net Dynamic Link Library (DLL) that handles the interaction of SQL Server with all data sources of its type. For example, OLE-DB Provider for Oracle. The OLE-DB data source is the specific data source to be accessed, using the specified OLE-DB provider.

> **Note:** SQL Server distributed queries can be used with any custom OLE DB provider as long as the required interfaces are implemented correctly.

SQL Server parses the T-SQL commands that access the linked server and sends the appropriate requests to the OLE-DB provider. There are several access methods for remote data, including opening the base table for read or issuing SQL queries against the remote data source.

Linked servers can be managed using SQL Server Management Studio graphical user interface or T-SQL system stored procedres.

- `EXECUTE sp_addlinkedserver` to add new server definitions.
- `EXECUTE sp_addlinkedserverlogin` to define security context.
- `EXECUTE sp_linkedservers or SELECT * FROM sys.servers` system catalog view to retrieve meta data.
- `EXECUTE sp_dropserver` to delete a linked server.

Linked server data sources are accessed from T-SQL using a fully qualified, four part naming scheme: <Server Name>.<Database Name>.<Schema Name>.<Object Name>.

Additionally, the OPENQUERY row set function can be used to explicitly invoke pass-through queries on the remote linked server, and the OPENROWSET and OPENDATASOURCE row set functions can be used for ad-hoc remote data access without defining the linked server in advance.

Syntax

```
EXECUTE sp_addlinkedserver
    [ @server= ] <Linked Server Name>
[ , [ @srvproduct= ] <Product Name>]
[ , [ @provider= ] <OLE DB Provider>]
[ , [ @datasrc= ] <Data Source>]
[ , [ @location= ] <Data Source Address>]
[ , [ @provstr= ] <Provider Connection String>]
[ , [ @catalog= ] <Database>];
```

Examples

Create a linked server to a local text file.

```
EXECUTE sp_addlinkedserver MyTextLinkedServer, N'Jet 4.0',
   N'Microsoft.Jet.OLEDB.4.0',
   N'D:\TextFiles\MyFolder',
   NULL,
   N'Text';
```

Define security context.

```
EXECUTE sp_addlinkedsrvlogin MyTextLinkedServer, FALSE, Admin, NULL;
```

Use sp_tables_ex to list tables in folder.

```
EXEC sp_tables_ex MyTextLinkedServer;
```

Issue a SELECT query using 4 part name.

```
SELECT *
FROM MyTextLinkedServer...[FileName#text];
```

For more information, see

- https://docs.microsoft.com/en-us/sql/relational-databases/system-stored-procedures/sp-addlinkedserver-transact-sql?view=sql-server-ver15
- https://docs.microsoft.com/en-us/sql/relational-databases/system-stored-procedures/distributed-queries-stored-procedures-transact-sql?view=sql-server-ver15

PostgreSQL Usage

Querying data in remote databases is available via two primary options:

- dblink database link function
- postgresql_fdw (Foreign Data Wrapper, FDW) extension

The Postgres foreign data wrapper extension is new to PostgreSQL and provides functionality similar to dblink. However, the Postgres foreign data wrapper aligns closer with the SQL standard and can provide improved performance.

Examples

Load the dblink extension into PostgreSQL.

```
CREATE EXTENSION dblink;
```

Create a persistent connection to a remote PostgreSQL database using the dblink_connect function specifying a connection name (myconn), database name (postgresql), port (5432), host (hostname), user (username), and password (password).

```
SELECT dblink_connect
('myconn', 'dbname=postgres port=5432 host=hostname user=username password=password');
```

The connection can be used to execute queries against the remote database.

Execute a query using the previously created connection (myconn) via the dblink function. The query returns the id and name columns from the employees table. On the remote database, you must specify the connection name and the SQL query to execute as well as parameters and datatypes for selected columns (id and name in this example).

```
SELECT * from dblink
('myconn', 'SELECT id, name FROM EMPLOYEES') AS p(id int,fullname text);
```

Close the connection using the dblink_disconnect function.

```
SELECT dblink_disconnect('myconn');
```

Alternatively, you can use the dblink function specifying the full connection string to the remote PostgreSQL database including the database name, port, hostname, username, and password. This can be done instead of using a previously defined connection. You must also specify the SQL query to execute as well as parameters and datatypes for the selected columns (id and name, in this example).

```
SELECT * from dblink
('dbname=postgres port=5432 host=hostname user=username password=password',
'SELECT id, name FROM EMPLOYEES') AS p(id int,fullname text);
```

DML commands are supported on tables referenced via the dblink function. For example, you can insert a new row and then delete it from the remote table.

```
SELECT * FROM dblink('myconn',$$INSERT into employees VALUES (3,'New Employees No.
3!')$$) AS t(message text);

SELECT * FROM dblink('myconn',$$DELETE FROM employees WHERE id=3$$) AS t(message
text);
```

Create a new local table (new_employees_table) by querying data from a remote table.

```
SELECT emps.* INTO new_employees_table FROM dblink('myconn','SELECT * FROM employees')
AS emps(id int, name varchar);
```

Join remote data with local data.

```
SELECT local_emps.id , local_emps.name, s.sale_year, s.sale_amount
FROM local_emps INNER JOIN
dblink('myconn','SELECT * FROM working_hours') AS s(id int, hours worked int)
ON local_emps.id = s.id;
```

Execute DDL statements in the remote database.

```
SELECT * FROM dblink('myconn',$$CREATE table new_remote_tbl (a int, b text)$$) AS t(a
text);
```

For additional details, see https://www.postgresql.org/docs/13/static/dblink.html

SQL Server Scripting vs. PostgreSQL Scripting

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Non-compatible tool sets and scripting languages Use PostgreSQL pgAdmin, Amazon RDS API, AWS Management Console, and Amazon CLI

SQL Server Usage

SQL Server supports T-SQL and XQuery scripting within multiple execution frameworks such as SQL Server Agent, and stored procedures.

The SQLCMD command line utility can also be used to execute T-SQL scripts. However, the most extensive and feature-rich scripting environment is PowerShell.

SQL Server provides two PowerShell snap-ins that implement a provider exposing the entire SQL Server Management Object Model (SMO) as PowerShell paths. Additionally, a SQL Server cmd can be used to execute specific SQL Server commands.

> **Note:** Invoke-Sqlcmd can be used to execute scripts using the SQLCMD utility.

The sqlps utility launches the PowerShell scripting environment and automatically loads the SQL Server modules. sqlps can be launched from a command prompt or from the Object Explorer pane of SQL Server Management Studio. You can execute ad-hoc PowerShell commands and script files (for example, .\SomeFolder\SomeScript.ps1).

> **Note:** SQL Server Agent supports executing PowerShell scripts in job steps. For more information, see SQL Server Agent.

SQL Server also supports three types of direct database engine queries: T-SQL, XQuery, and the SQLCMD utility. T-SQL and XQuery can be called from stored procedures, SQL Server Management Studio (or other IDE), and SQL Server agent Jobs. The SQLCMD utility also supports commands and variables.

Examples

Backup a database with PowerShell using the default backup options.

```
PS C:\> Backup-SqlDatabase -ServerInstance "MyServer\SQLServerInstance" -Database
"MyDB"
```

Get all rows from the MyTable table in they MyDB database.

```
PS C:\> Read-SqlTableData -ServerInstance MyServer\SQLServerInstance" -DatabaseName
"MyDB"  -TableName "MyTable"
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/powershell/sql-server-powershell?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/scripting/database-engine-scripting?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/tools/sqlcmd-utility?view=sql-server-ver15*

PostgreSQL Usage

As a Platform as a Service (PaaS), Aurora PostgreSQL accepts connections from any compatible client, but you cannot access the PostgreSQL command line utility typically used for database administration. However, you can use PostgreSQL tools installed on a network host and the Amazon RDS API. The most common tools for Aurora PostgreSQL scripting and automation include PostgreSQL pgAdmin, PostgreSQL Utilities, and the Amazon RDS API. The following sections describe each tool.

PostgreSQL pgAdmin

PostgreSQL pgAdmin is the most commonly used tool for development and administration of PostgreSQL servers. It is available as a free Community Edition and paid support is available.

The PostgreSQL pgAdmin also supports a Python scripting shell that you can use interactively and programmatically. For more information see: https://www.pgadmin.org/

Amazon RDS API

The Amazon RDS API is a web service for managing and maintaining Aurora PostgreSQL (and other) relational databases. It can be used to setup, operate, scale, backup, and perform many common administration tasks. The RDS API supports multiple database platforms and can integrate administration seamlessly for heterogeneous environments.

> **Note:** The Amazon RDS API is asynchronous. Some interfaces may require polling or callback functions to receive command status and results.

You can access Amazon RDS using the AWS Management Console, the AWS Command Line Interface (CLI), and the Amazon RDS Progammatic API as described in the following sections.

AWS Management Console

The AWS Management Console is a simple web-based set of tools for interactive management of Aurora PostgreSQL and other RDS services. It can be accessed at https://console.aws.amazon.com/rds/

AWS Command Line Interface (CLI)

The Amazon AWS Command Line Interface is an open source tool that runs on Linux, Windows, or MacOS having Python 2 version 2.6.5 and higher or Python 3 version 3.3 and higher.

The AWS CLI is built on top of the AWS SDK for Python (Boto), which provides commands for interacting with AWS services. With minimal configuration, you can start using all AWS Management Console functionality from your favorite terminal application.

- **Linux shells:** Use common shell programs such as Bash, Zsh, or tsch.
- **Windows command line:** Run commands in PowerShell or the Windows Command Processor.
- **Remotely:** Run commands on Amazon EC2 instances through a remote terminal such as PuTTY or SSH.

The AWS Tools for Windows PowerShell and AWS Tools for PowerShell Core are PowerShell modules built on the functionality exposed by the AWS SDK for .NET. These Tools enable scripting operations for AWS resources using the PowerShell command line.

> Note: You cannot use SQL Server cmdlets in PowerShell.

Amazon RDS Programmatic API

The Amazon RDS API can be used to automate management of DB instances and other Amazon RDS objects.

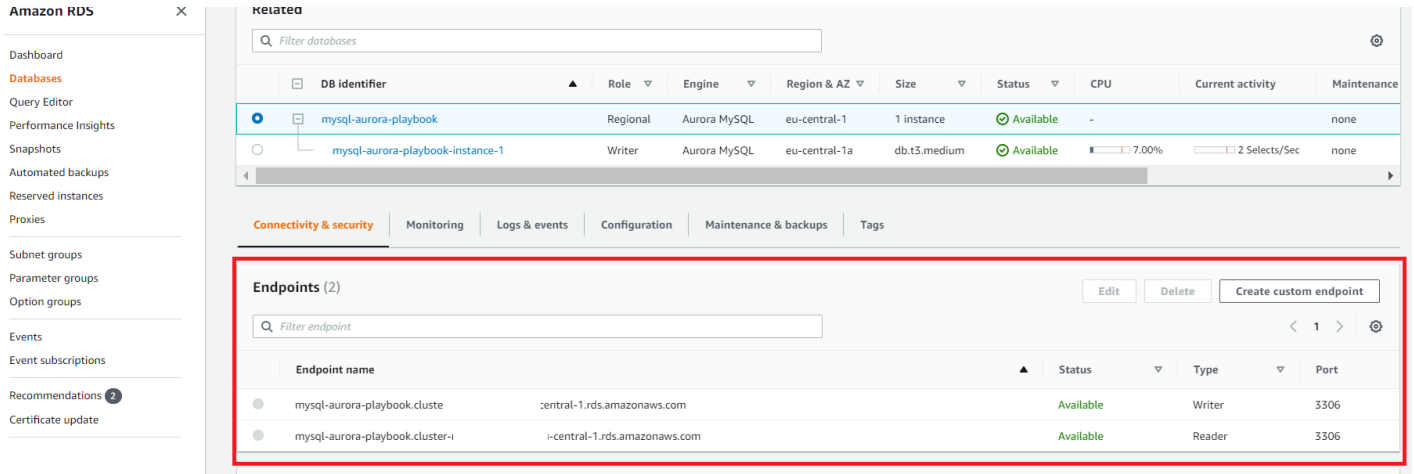
For more information about Amazon RDS API, see:

- ***API actions:*** *http://docs.aws.amazon.com/AmazonRDS/latest/APIReference/API_Operations.html*
- ***Data Types:*** *http://docs.aws.amazon.com/AmazonRDS/latest/APIReference/API_Types.html*
- ***Common query parameters:*** *http://-docs.aws.amazon.com/AmazonRDS/latest/APIReference/CommonParameters.html*
- ***Error codes:*** *http://docs.aws.amazon.com/AmazonRDS/latest/APIReference/CommonErrors.html*

Examples

The following walk-through describes how to connect to an Aurora PostgreSQL DB instance using the PostgreSQL Utility:

Log on to the Amazon RDS Console and select PostgreSQL database you want to connect to.



Copy the cluster endpoint address.

Note: You can also connect to individual DB instances. For more information, see High Availability Essentials.

From a command shell, type the following:

```
psql --host=mypostgresql.c6c8mwvfdgv0.us-west-2.rds.amazonaws.com --port=5432 --user-
name=awsuser --password --dbname=mypgdb
```

- The --host parameter is the endpoint DNS name of the Aurora PostgreSQL DB cluster.
- The --port parameter is the port number .

For more information, see

- *https://docs.aws.amazon.com/cli/latest/reference/*
- *https://docs.aws.amazon.com/AmazonRDS/latest/APIReference/Welcome.html*

Performance Tuning

SQL Server Execution Plans vs. PostgreSQL Execution Plans

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Syntax differences Completely different optimizer with different operators and rules

SQL Server Usage

Execution plans provide users detailed information about the data access and processing methods chosen by the SQL Server Query Optimizer. They also provide estimated or actual costs of each operator and sub-tree. Execution plans provide critical data for troubleshooting query performance issues.

SQL Server creates execution plans for most queries and returns them to client applications as plain text or XML documents. SQL Server produces an execution plan when a query executes, but it can also generate estimated plans without executing a query.

SQL Server Management Studio provides a graphical view of the underlying XML plan document using icons and arrows instead of textual information. This graphical view is extremely helpful when investigating the performance aspects of a query.

To request an estimated execution plan, use the SET SHOWPLAN_XML, SHOWPLAN_ALL, or SHOWPLAN_TEXT statements.

SQL Server 2017 introduces automatic tuning, which notifies users whenever a potential performance issue is detected and lets them apply corrective actions, or lets the Database Engine automatically fix performance problems. Automatic tuning SQL Server enables users to identify and fix performance issues caused by query execution plan choice regressions. See *Automatic tuning*.

Examples

Show the estimated execution plan for a query.

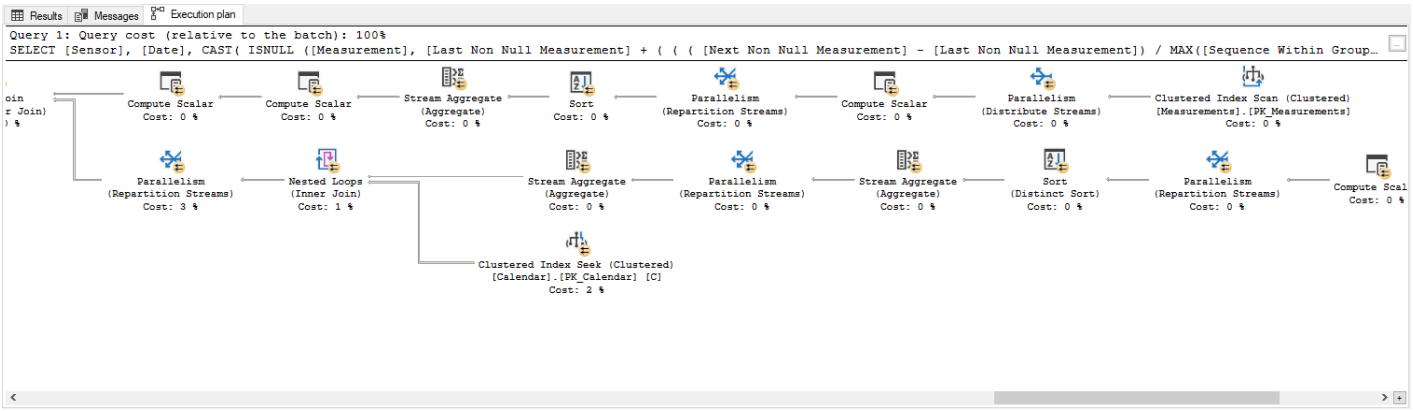
```
SET SHOWPLAN_XML ON;
SELECT *
FROM MyTable
WHERE SomeColumn = 3;
SET SHOWPLAN_XML OFF;
```

Actual execution plans return after execution of the query or batch of queries completes. Actual execution plans include run-time statistics about resource usage and warnings. To request the actual execution plan, use the SET STATISTICS XML statement to return the XML document object. Alternatively, use the STATISTICS PROFILE statement, which returns an additional result set containing the query execution plan.

Show the actual execution plan for a query.

```
SET STATISTICS XML ON;
SELECT *
FROM MyTable
WHERE SomeColumn = 3;
SET STATISTICS XML OFF;
```

The following example shows a (partial) graphical execution plan from SQL Server Management Studio.



For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/performance/display-and-save-execution-plans?view=sql-server-ver15

PostgreSQL Usage

When using the EXPLAIN command, PostgreSQL will generate the estimated execution plan for actions, such as SELECT, INSERT, UPDATE and DELETE. EXPLAIN builds a structured tree of plan nodes representing the different actions taken (the sign "->" represents a root line in the PostgreSQL execution plan). In addition, the EXPLAIN statement will provide statistical information regarding each action, such as cost, rows, time and loops.

When using the EXPLAIN command as part of a SQL statement, the statement will not execute, and the execution plan will be an estimation. By using the EXPLAIN ANALYZE command, the statement will execute in addition to displaying the execution plan.

PostgreSQL EXPLAIN Synopsis:

```
EXPLAIN [ ( option value[, ...] ) ] statement
EXPLAIN [ ANALYZE ] [ VERBOSE ] statement

where option and values can be one of:

    ANALYZE [ boolean ]
    VERBOSE [ boolean ]
    COSTS   [ boolean ]
    BUFFERS [ boolean ]
    TIMING  [ boolean ]
    SUMMARY [ boolean ] (since PostgreSQL 10)
    FORMAT { TEXT | XML | JSON | YAML }
```

By default, planning and execution time are displayed when using EXPLAIN ANALYZE, but not in other cases. A new option "SUMMARY" allows explicit control of this information. Use SUMMARY to include planning and execution time metrics in your output.

PostgreSQL provides configurations options that will cancel SQL statements running longer than provided time limit. To use this option, you can set the statement_timeout instance-level parameter.
If value is specified without units, it is taken as milliseconds. A value of zero (the default) disables the timeout.

Third-party connection pooler solutions like Pgbouncer and PgPool build on that and allow more flexibility in controlling how long connection to DB can run, be in idle state etc.

Aurora PostgreSQL Query Plan Management

The Aurora PostgreSQL Query Plan Management (QPM) feature solves the problem of plan instability by allowing database users to maintain stable, yet optimal, performance for a set of managed SQL statements. QPM primarily serves two main objectives:

Plan Stability. QPM prevents plan regression and improves plan stability when any of the above changes occur in the system.

Plan Adaptability. QPM automatically detects new minimum-cost plans and controls when new plans may be used and adapts to the changes.

The quality and consistency of query optimization have a major impact on the performance and stability of any relational database management system (RDBMS). Query optimizers create a query execution plan for a SQL statement at a specific point in time. As conditions change, the optimizer might pick a different plan that makes performance better or worse. In some cases, a number of changes can all cause the query optimizer to choose a different plan and lead to performance regression. These changes include changes in statistics, constraints, environment settings, query parameter bindings, and software upgrades. Regression is a major concern for high-performance applications.

With query plan management, you can control execution plans for a set of statements that you want to manage. You can do the following:

- Improve plan stability by forcing the optimizer to choose from a small number of known, good plans.
- Optimize plans centrally and then distribute the best plans globally.
- Identify indexes that aren't used and assess the impact of creating or dropping an index.

- Automatically detect a new minimum-cost plan discovered by the optimizer.
- Try new optimizer features with less risk, because you can choose to approve only the plan changes that improve performance.

Examples

1. Displaying the execution plan of a SQL statement using the EXPLAIN command:

```
EXPLAIN
       SELECT EMPLOYEE_ID, LAST_NAME, FIRST_NAME FROM EMPLOYEES
       WHERE LAST_NAME='King' AND FIRST_NAME='Steven';

------------------------------------------------------------------------------
----
 Index Scan using idx_emp_name on employees  (cost=0.14..8.16 rows=1 width=18)
   Index Cond: (((last_name)::text = 'King'::text) AND ((first_name)::text =
'Steven'::text))
(2 rows)
```

2. Running the same statement with the ANALYZE keyword:

```
EXPLAIN ANALYZE
       SELECT EMPLOYEE_ID, LAST_NAME, FIRST_NAME FROM EMPLOYEES
       WHERE LAST_NAME='King' AND FIRST_NAME='Steven';

------------------------------------------------------------------------------
----
 Seq Scan on employees  (cost=0.00..3.60 rows=1 width=18) (actual
                         time=0.012..0.024 rows=1 loops=1)
   Filter: (((last_name)::text = 'King'::text) AND ((first_name)::text =
              'Steven'::text))
   Rows Removed by Filter: 106
 Planning time: 0.073 ms
 Execution time: 0.037 ms
(5 rows)
```

By adding the ANALYZE keyword and executing the statement, we get additional information in addition to the execution plan.

3. Viewing a PostgreSQL execution plan showing a FULL TABLE SCAN:

```
EXPLAIN ANALYZE
       SELECT EMPLOYEE_ID, LAST_NAME, FIRST_NAME FROM EMPLOYEES
       WHERE SALARY > 10000;

------------------------------------------------------------------------------
------
 Seq Scan on employees  (cost=0.00..3.34 rows=15 width=18) (actual time=0.012..0.036
rows=15 loops=1)
   Filter: (salary > '10000'::numeric)
   Rows Removed by Filter: 92
 Planning time: 0.069 ms
 Execution time: 0.052 ms
(5 rows)
```

PostgreSQL can perform several scan types for processing and retrieving data from tables including sequential scans, index scans, and bitmap index scans. The sequential scan ("Seq Scan") is PostgreSQL equivalent for SQL Server "Table Scan" (full table scan).

For additional information see: *https://www.postgresql.org/docs/13/static/sql-explain.html*

SQL Server Query Hints and Plan Guides vs. PostgreSQL DB Query Planning

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Very limited set of hints - Index hints and optimizer hints as comments Syntax differences

SQL Server Usage

SQL Server *hints* are instructions that override automatic choices made by the query processor for DML and DQL statements. The term *hint* is misleading because, in reality, it forces an override to any other choice of execution plan.

JOIN Hints

LOOP, HASH, MERGE, and REMOTE hints can be explicitly added to a JOIN. For example, ... Table1 INNER LOOP JOIN Table2 ON .... These hints force the optimizer to use Nested Loops, Hash Match, or Merge physical join algorithms. REMOTE enables processing a join with a remote table on the local server.

Table Hints

Table hints override the default behavior of the query optimizer. Table hints are used to explicitly force a particular locking strategy or access method for a table operation clause. These hints do not modify the defaults and apply only for the duration of the DML or DQL statement.

Some common table hints are INDEX = <Index value>, FORCESEEK, NOLOCK, and TABLOCKX.

Query Hints

Query hints affect the entire set of query operators, not just the individual clause in which they appear. Query hints may be JOIN Hints, Table Hints, or from a set of hints that are only relevant for Query Hints.

Some common table hints include OPTIMIZE FOR, RECOMPILE, FORCE ORDER, FAST <rows>.

Query hints are specified after the query itself following the WITH options clause.

Plan Guides

Plan guides provide similar functionality to query hints in the sense they allow explicit user intervention and control over query optimizer plan choices. Plan guides can use either query hints or a full fixed, pre-generated plan

attached to a query. The difference between query hints and plan guides is the way they are associated with a query.

While query or table hints need to be explicitly stated in the query text, they are not an option if you have no control over the source code generating these queries. If an application uses ad-hoc queries instead of stored procedures, views, and functions, the only way to affect query plans is to use plan guides. They are often used to mitigate performance issues with third-party software

A plan guide consists of the statement whose execution plan needs to be adjusted and either an OPTION clause that lists the desired query hints or a full XML query plan that is enforced as long it is valid.

At run time, SQL Server matches the text of the query specified by the guide and attaches the OPTION hints. Alternatively, it assigns the provided plan for execution.

SQL Server supports three types of Plan Guides:

- **Object Plan Guides** target statements that run within the scope of a code object such as a stored procedure, function, or trigger. If the same statement is found in another context, the plan guide is not be applied.
- **SQL Plan Guides** are used for matching general ad-hoc statements not within the scope of code objects. In this case, any instance of the statement regardless of the originating client is assigned the plan guide.
- **Template Plan Guides** can be used to abstract statement templates that differ only in parameter values. It can be used to override the PARAMETERIZATION database option setting for a family of queries.

Syntax

Query Hints:

> **Note:** The following syntax is for SELECT. Query hints can be used in all DQL and DML statements.

```
SELECT <statement>
OPTION
(
{{HASH|ORDER} GROUP
|{CONCAT |HASH|MERGE} UNION
|{LOOP|MERGE|HASH} JOIN
|EXPAND VIEWS
|FAST <Rows>
|FORCE ORDER
|{FORCE|DISABLE} EXTERNALPUSHDOWN
|IGNORE_NONCLUSTERED_COLUMNSTORE_INDEX
|KEEP PLAN
|KEEPFIXED PLAN
|MAX_GRANT_PERCENT = <Percent>
|MIN_GRANT_PERCENT = <Percent>
|MAXDOP <Number of Processors>
|MAXRECURSION <Number>
|NO_PERFORMANCE_SPOOL
|OPTIMIZE FOR (@<Variable> {UNKNOWN|= <Value>}[,...])
|OPTIMIZE FOR UNKNOWN
|PARAMETERIZATION {SIMPLE|FORCED}
|RECOMPILE
|ROBUST PLAN
|USE HINT ('<Hint>' [,...])
|USE PLAN N'<XML Plan>'
```

```
|TABLE HINT (<Object Name> [,<Table Hint>[[,...]])
});
```

Create a Plan Guide:

```
EXECUTE sp_create_plan_guide @name = '<Plan Guide Name>'
    ,@stmt = '<Statement>'
    ,@type = '<OBJECT|SQL|TEMPLATE>'
    ,@module_or_batch = 'Object Name>'|'<Batch Text>'| NULL
    ,@params = '<Parameter List>'|NULL }
    ,@hints = 'OPTION(<Query Hints>'|'<XML Plan>'|NULL;
```

Examples

Limit parallelism for a sales report query.

```
EXEC sp_create_plan_guide
    @name = N'SalesReportPlanGuideMAXDOP',
    @stmt = N'SELECT *
              FROM dbo.fn_SalesReport(GETDATE())
    @type = N'SQL',
    @module_or_batch = NULL,
    @params = NULL,
    @hints = N'OPTION (MAXDOP 1)';
```

Use table and query hints.

```
SELECT *
FROM MyTable1 AS T1
    WITH (FORCESCAN)
    INNER LOOP JOIN
    MyTable2 AS T2
    WITH (TABLOCK, HOLDLOCK)
    ON T1.Col1 = T2.Col1
WHERE T1.Date BETWEEN DATEADD(DAY, -7, GETDATE()) AND GETDATE()
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/t-sql/queries/hints-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/performance/plan-guides?view=sql-server-ver15*

PostgreSQL Usage

PostgreSQL does not support database hints to influence the behavior of the query planner, and you cannot influence how execution plans are generated from within SQL queries. Although database hints are not directly supported, session parameters (also known as Query Planning Parameters) can influence the behavior of the query optimizer at the session level.

Example

Configure the query planner to use indexes instead of full table scans (disable SEQSCAN).

```
SET ENABLE_SEQSCAN=FALSE;
```

Set the query planner's estimated "cost" of a disk page fetch that is part of a series of sequential fetches (SEQ_PAGE_COST) and set the planner's estimate of the cost of a non-sequentially-fetched disk page (RANDOM_PAGE_COST). Reducing the value of RANDOM_PAGE_COST relative to SEQ_PAGE_COST causes the query planner to prefer index scans, while raising the value makes index scans more "expensive".

```
SET SEQ_PAGE_COST to 4;
SET RANDOM_PAGE_COST to 1;
```

Enable or disable the query planner's use of nested-loops when performing joins. While it is impossible to completely disable the usage of nested-loop joins, setting the ENABLE_NESTLOOP to OFF discourages the query planner from choosing nested-loop joins compared to alternative join methods.

```
SET ENABLE_NESTLOOP to FALSE;
```

For additional details, see https://www.postgresql.org/docs/13/static/runtime-config-query.html

SQL Server Managing Statistics vs. PostgreSQL Table Statistics

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Syntax and option differences, similar functionality

SQL Server Usage

Statistics objects in SQL Server are designed to support SQL Server's cost-based query optimizer. It uses statistics to evaluate the various plan options and choose an optimal plan for optimal query performance.

Statistics are stored as BLOBs in system tables and contain histograms and other statistical information about the distribution of values in one or more columns. A histogram is created for the first column only and samples the occurrence frequency of distinct values. Statistics and histograms are collected by either scanning the entire table or by sampling only a percentage of the rows.

You can view Statistics manually using the DBCC SHOW_STATISTICS statement or the more recent sys.dm_db_stats_properties and sys.dm_db_stats_histogram system views.

SQL Server provides the capability to create filtered statistics containing a WHERE predicate. Filtered statistics are useful for optimizing histogram granularity by eliminating rows whose values are of less interest, for example NULLs.

SQL Server can manage the collection and refresh of statistics automatically (the default). Use the AUTO_CREATE_STATISTICS and AUTO_UPDATE_STATISTICS database options to change the defaults.

When a query is submitted with AUTO_CREATE_STATISTICS on and the query optimizer may benefit from a statistics that do not yet exist, SQL Server creates the statistics automatically. You can use the AUTO_UPDATE_STATISTICS_ASYNC database property to set new statistics creation to occur immediately (causing queries to

wait) or to run asynchronously. When run asynchronously, the triggering execution cannot benefit from optimizations the optimizer may derive from it.

After creation of a new statistics object, either automatically or explicitly using the CREATE STATISTICS statement, the refresh of the statistics is controlled by the AUTO_UPDATE_STATISTICS database option. When set to ON, statistics are recalculated when they are stale, which happens when significant data modifications have occurred since the last refresh.

Syntax

```
CREATE STATISTICS <Statistics Name>
ON <Table Name> (<Column> [,...])
[WHERE <Filter Predicate>]
[WITH <Statistics Options>;
```

Examples

Create new statistics on multiple columns. Set to use a full scan and to not refresh.

```
CREATE STATISTICS MyStatistics
ON MyTable (Col1, Col2)
WITH FULLSCAN, NORECOMPUTE;
```

Update statistics with a 50% sampling rate.

```
UPDATE STATISTICS MyTable(MyStatistics)
WITH SAMPLE 50 PERCENT;
```

View the statistics histogram and data.

```
DBCC SHOW_STATISTICS ('MyTable','MyStatistics');
```

Turn off automatic statistics creation for a database.

```
ALTER DATABASE MyDB SET AUTO_CREATE_STATS OFF;
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/statistics/statistics?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-statistics-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/database-console-commands/dbcc-show-statistics-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Use the ANALYZE command to collect statistics about a database, a table, or a specific table column. The PostgreSQL ANALYZE command collects table statistics that support the generation of efficient query execution plans by the query planner.

- **Histograms:** ANALYZE collects statistics on table column values and creates a histogram of the approximate data distribution in each column.
- **Pages and Rows:** ANALYZE collects statistics on the number of database pages and rows from which each table is comprised.
- **Data Sampling:** For large tables, the ANALYZE command takes random samples of values rather than examining each row. This allows the ANALYZE command to scan very large tables in a relatively small amount of time.
- **Statistic Collection Granularity:** Executing the ANALYZE command without parameters instructs PostgreSQL to examine every table in the current schema. Supplying the table name or column name to ANALYZE instructs the database to examine a specific table or table column.

Automatic Statistics Collection

By default, PostgreSQL is configured with an autovacuum daemon which automates the execution of statistics collection via the ANALYZE commands (in addition to automation of the VACUUM command). The autovacuum daemon scans for tables that show signs of large modifications in data to collect the current statistics. Autovacuum is controlled by several parameters.

Individual tables have several storage parameters which can trigger autovacuum process sooner or later. These parameters, like autovacuum_enabled, autovacuum_vacuum_threshold and others can be set or changed using CREATE TABLE or ALTER TABLE statements.

```
ALTER TABLE custom_autovaccum SET (autovacuum_enabled = true, autovacuum_vacuum_cost_
delay = 10ms, autovacuum_vacuum_scale_factor = 0.01, autovacuum_analyze_scale_factor =
0.005);
```

The command above will enable autovaccum for the custom_autovaccum table and will specify the autovacuum process to sleep for 10 milliseconds each run.
It will also specify a 1% of the table size to be added to autovacuum_vacuum_threshold and 0.5% of the table size to be added to autovacuum_analyze_threshold when deciding whether to trigger a VACUUM

For additional details, see https://www.postgresql.org/docs/13/static/runtime-config-autovacuum.html

Manual Statistics Collection

PostgreSQL allows collecting statistics on-demand using the ANALYZE command at the database level, table-level, or table column-level.

- ANALYZE on indexes is not currently supported.
- ANALYZE requires only a read-lock on the target table. It can run in parallel with other activity on the table.
- For large tables, ANALYZE takes a random sample of the table contents. It is configured via the show default_statistics_target parameter. The default value is 100 entries. Raising the limit might allow more accurate planner estimates to be made at the price of consuming more space in the pg_statistic table.

Since PostgreSQL 10, there is a new command "CREATE STATISTICS", which will create a new extended statistics object tracking data about the specified table.

The STATISTICS object will tell the server to collect more detailed statistics.

Examples

Gather statistics for the entire database.

```
ANALYZE;
```

Gather statistics for a specific table. The VERBOSE keyword displays progress.

```
ANALYZE VERBOSE EMPLOYEES;
```

Gather statistics for a specific column.

```
ANALYZE EMPLOYEES (HIRE_DATE);
```

Specify the default_statistics_target parameter for an individual table column and reset it back to default.

```
ALTER TABLE EMPLOYEES ALTER COLUMN SALARY SET STATISTICS 150;

ALTER TABLE EMPLOYEES ALTER COLUMN SALARY SET STATISTICS -1;
```

Larger values increase the time needed to complete an ANALYZE, but improve the quality of the collected planner's statistics, which can potentially lead to better execution plans.

View the current (session / global) default_statistics_target, modify it to 150, and analyze the EMPLOYEES table:

```
SHOW default_statistics_target ;
SET default_statistics_target to 150;
ANALYZE EMPLOYEES ;
```

View the last time statistics were collected for a table.

```
select relname, last_analyze from pg_stat_all_tables;
```

Summary

Feature	SQL Server	PostgreSQL
Analyze a specific database table	CREATE STATISTICS MyStatistics ON MyTable (Col1, Col2)	ANALYZE EMPLOYEES;
Analyze a database table while only sampling certain rows	UPDATE STATISTICS MyTable(MyStatistics) WITH SAMPLE 50 PERCENT;	Configure via number of entries for the table: SET default_statistics_target to 150; ANALYZE EMPLOYEES ;
View last time statistics were collected	DBCC SHOW_STATISTICS ('MyTable','MyStatistics');	select relname, last_analyze from pg_stat_all_tables;

For additional information, see:

- *https://www.postgresql.org/docs/13/static/sql-analyze.html*
- *https://www.postgresql.org/docs/13/static/routine-vacuuming.html#AUTOVACUUM*

Physical Storage

SQL Server Columnstore Index vs. PostgreSQL Columnstore

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Aurora PostgreSQL offers no comparable feature

SQL Server Usage

SQL Server provides Columnstore Indexes that use column-based data storage to compress data and improve query performance in data warehouses. Columnstore indexes are the preferred data storage format for data warehousing and analytic workloads. As a best practice, use Columnstore indexes with fact tables and large dimension workloads.

Examples

Create a table with a columnar store index.

```
CREATE TABLE products(ID [int] NOT NULL, OrderDate [int] NOT NULL, ShipDate [int] NOT
NULL);
GO

CREATE CLUSTERED COLUMNSTORE INDEX cci_T1 ON products;
GO
```

For more information, see :
https://docs.microsoft.com/en-us/sql/relational-databases/indexes/columnstore-indexes-overview?view=sql-server-ver15

PostgreSQL Usage

Amazon Aurora PostgreSQL does not currently provide a directly comparable alternative for SQL Server's Columstore Index.

SQL Server Indexed Views vs. PostgreSQL Materialized Views

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		N/A	Different paradigm and syntax will require rewriting the application

SQL Server Usage

The first index created on a view must be a clustered index. Subsequent indexes can be non-clustered indexes. For more information about clustered and non-clustered indexes, see: https://docs.microsoft.com/en-us/sql/relational-databases/indexes/clustered-and-nonclustered-indexes-described?view=sql-server-ver15

Before creating an index on a view, the following requirements must be met:

- The WITH SCHEMABINDING option must be used when creating the view.
- Verify the SET options are correct for all existing tables referenced in the view and for the session (the the link at the end of this section for required values).
- Ensure that a clustered index on the view is exists.

Note: Indexed views cannot be used with temporal queries (FOR SYSTEM_TIME).

Examples

Set the required SET options, create a view (with the WITH SCHEMABINDING option), and create an index on this view.

```
SET NUMERIC_ROUNDABORT OFF;
SET ANSI_PADDING, ANSI_WARNINGS, CONCAT_NULL_YIELDS_NULL, ARITHABORT,
    QUOTED_IDENTIFIER, ANSI_NULLS ON;
GO

CREATE VIEW Sales.Ord_view
WITH SCHEMABINDING
AS
    SELECT SUM(Price*Qty*(1.00-Discount)) AS Revenue,
        OrdTime, ID, COUNT_BIG(*) AS COUNT
    FROM Sales.OrderDetail AS ordet, Sales.OrderHeader AS ordhead
    WHERE ordet.SalesOrderID = ordhead.SalesOrderID
    GROUP BY OrdTime, ID;
GO
```

```
CREATE UNIQUE CLUSTERED INDEX IDX_V1
    ON Sales.Ord_view (OrdTime, ID);
GO
```

For more information, see :
https://docs.microsoft.com/en-us/sql/relational-databases/views/create-indexed-views?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL does not support view indexes, but does provide similar functionality with Materialized Views. Queries associated with Materialized Views are executed and the view data is populated when the REFRESH command is issued.

The PostgreSQL implementation of Materialized Views has three primary limitations:

- PostgreSQL Materialized Views may be refreshed either manually or using a job running the REFRESH MATERIALIZED VIEW command. Automatic refresh of Materialized Views require the creation of a trigger.
- PostgreSQL Materialized Views only support complete (full) refresh.
- DML on Materialized Views is not supported.

In some cases, when the tables are big, full REFRESH can cause performance issues, in this case, triggers can be used to sync between one table to the new table (the new table can be used as a view) that can indexed.

Examples

Create a Materialized View named sales_summary using the sales table as the source.

```
CREATE MATERIALIZED VIEW sales_summary AS
SELECT seller_no,sale_date,sum(sale_amt)::numeric(10,2) as sales_amt
FROM sales
WHERE sale_date < CURRENT_DATE
GROUP BY seller_no, sale_date
ORDER BY seller_no, sale_date;
```

Execute a manual refresh of the Materialized View:

```
REFRESH MATERIALIZED VIEW sales_summary;
```

> **Note:** The Materialized View data is not refreshed automatically if changes occur to its underlying tables. For automatic refresh of materialized view data, a trigger on the underlying tables must be created.

Creating a Materialized View

When you create a Materialized View in PostgreSQL, it uses a regular database table underneath. You can create database indexes on the Materialized View directly and improve performance of queries that access the Materialized View.

Example

Create an index on the sellerno and sale_date columns of the sales_summary Materialized View.

```
CREATE UNIQUE INDEX sales_summary_seller
ON sales_summary (seller_no, sale_date);
```

Summary

	Indexed views	Materialized view
Create Materialized View	SET NUMERIC_ROUNDABORT OFF; SET ANSI_PADDING, ANSI_ WARNINGS, CONCAT_NULL_ YIELDS_NULL, ARITHABORT, QUOTED_IDENTIFIER, ANSI_NULLS ON; GO CREATE VIEW Sales.Ord_view WITH SCHEMABINDING AS SELECT SUM (Price*Qty*(1.00-Discount)) AS Revenue, OrdTime, ID, COUNT_BIG(*) AS COUNT FROM Sales.OrderDetail AS ordet, Sales.OrderHeader AS ordhead WHERE ordet.SalesOrderID = ordhead.SalesOrderID GROUP BY OrdTime, ID; GO CREATE UNIQUE CLUSTERED INDEX IDX_V1 ON Sales.Ord_view (OrdTime, ID); GO	CREATE MATERIALIZED VIEW mv1 AS SELECT * FROM employees;
Indexed refreshed	Automatic	Manual. You can automate refreshes using triggers: Create a trigger that initiates a refresh after every DML command on the underlying tables: CREATE OR REPLACE FUNCTION refresh_mv1() returns trigger language plpgsql as $$ begin refresh materialized view mv1; return null; end $$; Create trigger refresh_ mv1 after insert, update, delete or truncate on employees for each statement execute procedure refresh_mv1();
DML	Supported	Not Supported

For more details, see: https://www.postgresql.org/docs/13/static/rules-materializedviews.htm

SQL Server Partitioning vs. PostgreSQL Partitions or Table Inheritance

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
		SCT Action Codes - Partitions	Does not support LEFT partition or foreign keys referencing partitioned tables

SQL Server Usage

SQL Server provides a logical and physical framework for partitioning table and index data. SQL Server 2017 supports up to 15,000 partitions.

Partitioning separates data into logical units that can be stored in more than one file group. SQL Server partitioning is horizontal, where data sets of rows are mapped to individual partitions. A partitioned table or index is a single object and must reside in a single schema within a single database. Objects composed of disjointed partitions is not allowed.

All DQL and DML operations are partition agnostic except for the special predicate $partition, which can be used for explicit partition elimination.

Partitioning is typically needed for very large tables to address the following management and performance challenges:

- Deleting or inserting large amounts of data in a single operation with partition switching instead of individual row processing while maintaining logical consistency.
- Maintenance operations can be split and customized per partition. For example, older data partitions can be compressed and more active partitions can be rebuilt or reorganized more frequently.
- Partitioned tables may use internal query optimization techniques such as collocated and parallel partitioned joins.
- Physical storage performance can be optimized by distributing IO across partitions and physical storage channels.
- Concurrency improvements due to the engine's ability to escalate locks to the partition level rather than the whole table.

Partitioning in SQL Server uses the following three objects:

- **Partitioning Column:** A Partitioning column is the column (or columns) used by the partition function to partition the table or index. The value of this column determines the logical partition to which it belongs. You can use computed columns in a partition function as long as they are explicitly PERSISTED. Partitioning columns may be any data type that is a valid index column with less than 900 bytes per key except timestamp and LOB data types.
- **Partition Function:** A Partition function is a database object that defines how the values of the partitioning columns for individual tables or index rows are mapped to a logical partition. The partition function describes the partitions for the table or index and their boundaries.
- **Partition Scheme:** A partition scheme is a database object that maps individual logical partitions of a table or an index to a set of file groups, which in turn consist of physical operating system files. Placing individual partitions on individual file groups enables backup operations for individual partitions (by backing their associated file groups).

Syntax

```
CREATE PARTITION FUNCTION <Partition Function>(<Data Type>)
AS RANGE [ LEFT | RIGHT ]
FOR VALUES (<Boundary Value 1>,...)[;]
```

```
CREATE PARTITION SCHEME <Partition Scheme>
AS PARTITION <Partition Function>
[ALL] TO (<File Group> | [ PRIMARY ] [,...])[;]
```

```
CREATE TABLE <Table Name> (<Table Definition>)
ON <Partition Schema> (<Partitioning Column>);
```

Examples

Create a partitioned table.

```
CREATE PARTITION FUNCTION PartitionFunction1 (INT)
AS RANGE LEFT FOR VALUES (1, 1000, 100000);
```

```
CREATE PARTITION SCHEME PartitionScheme1
AS PARTITION PartitionFunction1
ALL TO (PRIMARY);
```

```
CREATE TABLE PartitionTable (
Col1 INT NOT NULL PRIMARY KEY,
Col2 VARCHAR(20)
)
ON PartitionScheme1 (Col1);
```

For more information, see

- *https://docs.microsoft.com/en-us/sql/relational-databases/partitions/partitioned-tables-and-indexes?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-table-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-partition-scheme-transact-sql?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/t-sql/statements/create-partition-function-transact-sql?view=sql-server-ver15*

PostgreSQL Usage

Starting with PostgreSQL 10, there is an equivalent option to the SQL Server Partitions when using RANGE or LIST partitions. Support for HASH partitions is expected to be included in PostgreSQL 11.

Prior to PostgreSQL 10, the table partitioning mechanism in PostgreSQL differed from SQL Server. Partitioning in PostgreSQL was implemented using “table inheritance”. Each table partition was represented by a child table which was referenced to a single parent table. The parent table remained empty and was only used to represent the entire table data set (as a meta-data dictionary and as a query source).

In PostgreSQL 10, you still need to create the partition tables manually, but you do not need to create triggers or functions to redirect data to the right partition.

Some of the Partitioning management operations are performed directly on the sub-partitions (sub-tables). Querying can be performed directly on the partitioned table itself.

Starting with PostgreSQL 11 following features were added:

- For partitioned tables, a default partition can now be created that will store data which can't be redirected to any other explicit partitions
- In addition to partitioning by ranges and lists, tables can now be partitioned by a hashed key.
- When UPDATE changes values in a column that's used as partition key in partitioned table, data is moved to proper partitions.
- An index can now be created on a partitioned table. Corresponding indexes will be automatically created on individual partitions.
- Foreign keys can now be created on a partitioned table. Corresponding foreign key constraints will be propagated to individual partitions
- Triggers FOR EACH ROW can now be created on a partitioned table. Corresponding triggers will be automatically created on individual partitions as well.
- When attaching or detaching new partition to a partitioned table with the foreign key, foreign key enforcement triggers are correctly propagated to a new partition.

For more information, see:
https://www.postgresql.org/docs/13/static/ddl-inherit.htm
https://www.postgresql.org/docs/13/ddl-partitioning.html

Using The Partition Mechanism

List Partition

```
CREATE TABLE emps (
    emp_id      SERIAL NOT NULL,
    emp_name        VARCHAR(30) NOT NULL)
PARTITION BY LIST (left(lower(emp_name), 1));

CREATE TABLE emp_abc
    PARTITION OF emps (
    CONSTRAINT emp_id_nonzero CHECK (emp_id != 0)
) FOR VALUES IN ('a', 'b', 'c');

CREATE TABLE emp_def
    PARTITION OF emps (
    CONSTRAINT emp_id_nonzero CHECK (emp_id != 0)
) FOR VALUES IN ('d', 'e', 'f');

INSERT INTO emps VALUES (DEFAULT, 'Andrew');

row inserted.

INSERT INTO emps VALUES (DEFAULT, 'Chris');

row inserted.

INSERT INTO emps VALUES (DEFAULT, 'Frank');

row inserted.

INSERT INTO emps VALUES (DEFAULT, 'Pablo');

SQL Error [23514]: ERROR: no partition of relation "emps" found for row
  Detail: Partition key of the failing row contains ("left"(lower(emp_name::text), 1))
= (p).
```

Note: To prevent the above error, ensure that all partitions exist for all possible values in the column that partitions the table. The default partition feature was added in PostgreSQL 11.

Note: Use the MAXVALUE and MINVALUE in your FROM/TO clause. This can help you get all values with RANGE partitions without the risk of creating new partitions.

Range Partition

```
CREATE TABLE sales (
    saledate   DATE NOT NULL,
    item_id    INT,
    price      FLOAT
) PARTITION BY RANGE (saledate);

CREATE TABLE sales_2018q1
    PARTITION OF sales (
    price DEFAULT 0
) FOR VALUES FROM ('2018-01-01') TO ('2018-03-31');

CREATE TABLE sales_2018q2
    PARTITION OF sales (
    price  DEFAULT 0
) FOR VALUES FROM ('2018-04-01') TO ('2018-06-30');

CREATE TABLE sales_2018q3
    PARTITION OF sales (
    price  DEFAULT 0
) FOR VALUES FROM ('2018-07-01') TO ('2018-09-30');


INSERT INTO sales VALUES (('2018-01-08'),3121121, 100);

row inserted.

INSERT INTO sales VALUES (('2018-04-20'),4378623);

row inserted.

INSERT INTO sales VALUES (('2018-08-13'),3278621, 200);

row inserted.
```

When creating a table with PARTITION OF clause, you can still use the "PARTITION BY" clause with it. Using the "PARTITION BY" clause will create a sub-partition.

A sub-partition can be the same type as the partition table it is related to, or another partition type.

List Combined With Range Partition

This is an example of creating a LIST partition and sub partitions by RANGE.

```
CREATE TABLE salers (
    emp_id          serial not null,
    emp_name        varchar(30) not null,
    sales_in_usd    int not null,
    sale_date       date not null
) PARTITION BY LIST (left(lower(emp_name), 1));

CREATE TABLE emp_abc
    PARTITION OF salers (
    CONSTRAINT emp_id_nonzero CHECK (emp_id != 0)
) FOR VALUES IN ('a', 'b', 'c') PARTITION BY RANGE (sale_date);

CREATE TABLE emp_def
    PARTITION OF salers (
    CONSTRAINT emp_id_nonzero CHECK (emp_id != 0)
) FOR VALUES IN ('d', 'e', 'f') PARTITION BY RANGE (sale_date);

CREATE TABLE sales_abc_2018q1
    PARTITION OF emp_abc (
    sales_in_usd DEFAULT 0
) FOR VALUES FROM ('2018-01-01') TO ('2018-03-31');

CREATE TABLE sales_abc_2018q2
    PARTITION OF emp_abc (
    sales_in_usd  DEFAULT 0
) FOR VALUES FROM ('2018-04-01') TO ('2018-06-30');

CREATE TABLE sales_abc_2018q3
    PARTITION OF emp_abc (
    sales_in_usd  DEFAULT 0
) FOR VALUES FROM ('2018-07-01') TO ('2018-09-30');

CREATE TABLE sales_def_2018q1
    PARTITION OF emp_def (
    sales_in_usd DEFAULT 0
) FOR VALUES FROM ('2018-01-01') TO ('2018-03-31');

CREATE TABLE sales_def_2018q2
    PARTITION OF emp_def (
    sales_in_usd  DEFAULT 0
) FOR VALUES FROM ('2018-04-01') TO ('2018-06-30');

CREATE TABLE sales_def_2018q3
    PARTITION OF emp_def (
    sales_in_usd  DEFAULT 0
) FOR VALUES FROM ('2018-07-01') TO ('2018-09-30');
```

Implementing List “Table Partitioning” with inheritance tables

For older PostgreSQL versions, follow these steps to implement list table partitioning using inherited tables:

1. Create a parent table (“master table”) from which all child tables (“partitions”) will inherit.
2. Create child tables that inherit from the parent table (this is similar to Table Partitions). The child tables should have an identical structure to the parent table.
3. Create Indexes on each child table. Optionally, add constraints to define allowed values in each table (for example, primary keys or check constraints).
4. Create a database trigger to redirect data inserted into the parent table to the appropriate child table.
5. Ensure the PostgreSQL constraint_exclusion parameter is enabled and set to partition. This parameter ensures the queries are optimized for working with table partitions.

```
show constraint_exclusion;

constraint_exclusion
----------------------
partition
```

For additional information on PostgreSQL constraint_exclusion parameter:
https://www.postgresql.org/docs/13/static/runtime-config-query.html#GUC-CONSTRAINT-EXCLUSION

PostgreSQL 9.6 does not support “declarative partitioning”, nor several of the table partitioning features available in SQL Server.

Note:
• PostgreSQL 9.6 Table Partitioning does not support the creation of foreign keys on the parent table. Alternative solutions include application-centric methods such as using triggers/functions or creating these on the individual tables .
• PostgreSQL does not support SPLIT and EXCHANGE of table partitions. For these actions, you will need to plan your data migrations manually (between tables) to re-place the data into the right partition.

Examples

Create a PostgreSQL “list-partitioned table”:

Create the parent table.

```
CREATE TABLE SYSTEM_LOGS
        (EVENT_NO    NUMERIC NOT NULL,
         EVENT_DATE  DATE    NOT NULL,
         EVENT_STR   VARCHAR(500),
         ERROR_CODE VARCHAR(10));
```

Create child tables (“partitions”) with check constraints.

```
CREATE TABLE SYSTEM_LOGS_WARNING (
           CHECK (ERROR_CODE IN('err1', 'err2', 'err3'))) INHERITS (SYSTEM_LOGS);

CREATE TABLE SYSTEM_LOGS_CRITICAL (
           CHECK (ERROR_CODE IN('err4', 'err5', 'err6'))) INHERITS (SYSTEM_LOGS);
```

Create indexes on each of the child tables (“partitions”).

```
CREATE INDEX IDX_SYSTEM_LOGS_WARNING ON SYSTEM_LOGS_WARNING(ERROR_CODE);

CREATE INDEX IDX_SYSTEM_LOGS_CRITICAL ON SYSTEM_LOGS_CRITICAL(ERROR_CODE);
```

Create a function to redirect data inserted into the Parent Table.

```
CREATE OR REPLACE FUNCTION SYSTEM_LOGS_ERR_CODE_INS()
         RETURNS TRIGGER AS
          $$
          BEGIN
             IF (NEW.ERROR_CODE IN('err1', 'err2', 'err3')) THEN
                     INSERT INTO SYSTEM_LOGS_WARNING VALUES (NEW.*);
             ELSIF (NEW.ERROR_CODE IN('err4', 'err5', 'err6')) THEN
                     INSERT INTO SYSTEM_LOGS_CRITICAL VALUES (NEW.*);
             ELSE
    RAISE EXCEPTION 'Value out of range, check SYSTEM_LOGS_ERR_CODE_INS () Function!';
             END IF;
              RETURN NULL;
           END;
          $$
          LANGUAGE plpgsql;
```

Attach the trigger function created above to log to the table.

```
CREATE TRIGGER SYSTEM_LOGS_ERR_TRIG
         BEFORE INSERT ON SYSTEM_LOGS
         FOR EACH ROW EXECUTE PROCEDURE SYSTEM_LOGS_ERR_CODE_INS();
```

Insert data directly into the parent table.

```
INSERT INTO SYSTEM_LOGS VALUES(1, '2015-05-15', 'a...', 'err1');
INSERT INTO SYSTEM_LOGS VALUES(2, '2016-06-16', 'b...', 'err3');
INSERT INTO SYSTEM_LOGS VALUES(3, '2017-07-17', 'c...', 'err6');
```

View results from across all the different child tables.

```
SELECT * FROM SYSTEM_LOGS;
       event_no | event_date | event_str
      ----------+------------+-----------
              1 | 2015-05-15 | a...
              2 | 2016-06-16 | b...
              3 | 2017-07-17 | c...

SELECT * FROM SYSTEM_LOGS_WARNING;
       event_no | event_date | event_str | error_code
      ----------+------------+-----------+------------
              1 | 2015-05-15 | a...      | err1
              2 | 2016-06-16 | b...      | err3

SELECT * FROM SYSTEM_LOGS_CRITICAL;
        event_no | event_date | event_str | error_cod
       ----------+------------+-----------+------------
               3 | 2017-07-17 | c...      | err6
```

Create a PostgreSQL “range-partitioned table”:

Create the parent table.

```
CREATE TABLE SYSTEM_LOGS
(EVENT_NO    NUMERIC NOT NULL,
EVENT_DATE  DATE   NOT NULL,
EVENT_STR   VARCHAR(500));
```

Create the child tables (“partitions”) with check constraints.

```
CREATE TABLE SYSTEM_LOGS_2015 (CHECK (EVENT_DATE >= DATE '2015-01-01' AND EVENT_DATE <
DATE '2016- 01-01')) INHERITS (SYSTEM_LOGS);

CREATE TABLE SYSTEM_LOGS_2016 (CHECK (EVENT_DATE >= DATE '2016-01-01' AND EVENT_DATE <
DATE '2017-01-01')) INHERITS (SYSTEM_LOGS);

CREATE TABLE SYSTEM_LOGS_2017 (CHECK (EVENT_DATE >= DATE '2017-01-01' AND EVENT_DATE
<= DATE '2017-12-31')) INHERITS (SYSTEM_LOGS);
```

Create indexes on each child table (“partitions”).

```
CREATE INDEX IDX_SYSTEM_LOGS_2015 ON SYSTEM_LOGS_2015(EVENT_DATE);
CREATE INDEX IDX_SYSTEM_LOGS_2016 ON SYSTEM_LOGS_2016(EVENT_DATE);
CREATE INDEX IDX_SYSTEM_LOGS_2017 ON SYSTEM_LOGS_2017(EVENT_DATE);
```

Create a function to redirect data inserted into the parent table.

```
CREATE OR REPLACE FUNCTION SYSTEM_LOGS_INS ()
        RETURNS TRIGGER AS
        $$
        BEGIN
          IF (NEW.EVENT_DATE >= DATE '2015-01-01' AND
              NEW.EVENT_DATE < DATE '2016-01-01') THEN
              INSERT INTO SYSTEM_LOGS_2015 VALUES (NEW.*);
           ELSIF (NEW.EVENT_DATE >= DATE '2016-01-01' AND
                  NEW.EVENT_DATE < DATE '2017-01-01') THEN
```

```
            INSERT INTO SYSTEM_LOGS_2016 VALUES (NEW.*);
          ELSIF (NEW.EVENT_DATE >= DATE '2017-01-01' AND
                 NEW.EVENT_DATE <= DATE '2017-12-31') THEN
            INSERT INTO SYSTEM_LOGS_2017 VALUES (NEW.*);
        ELSE
              RAISE EXCEPTION 'Date out of range. check SYSTEM_LOGS_INS () function!';
        END IF;
      RETURN NULL;
   END;
$$
LANGUAGE plpgsql;
```

Attach the trigger function created above to log to the SYSTEM_LOGS table.

```
CREATE TRIGGER SYSTEM_LOGS_TRIG BEFORE INSERT ON SYSTEM_LOGS
           FOR EACH ROW EXECUTE PROCEDURE SYSTEM_LOGS_INS ();
```

Insert data directly to the parent table.

```
INSERT INTO SYSTEM_LOGS VALUES (1, '2015-05-15', 'a...');
INSERT INTO SYSTEM_LOGS VALUES (2, '2016-06-16', 'b...');
INSERT INTO SYSTEM_LOGS VALUES (3, '2017-07-17', 'c...');
```

Test the solution by selecting data from the parent and child tables.

```
SELECT * FROM SYSTEM_LOGS;
      event_no | event_date | event_str
     ----------+------------+-----------
             1 | 2015-05-15 | a...
             2 | 2016-06-16 | b...
             3 | 2017-07-17 | c...

SELECT * FROM SYSTEM_LOGS_2015;
       event_no | event_date | event_str
      ----------+------------+-----------
              1 | 2015-05-15 | a...
```

Examples of new partitioning features of PostgreSQL11

Default partitions

```
CREATE TABLE tst_part(i INT) PARTITION BY RANGE(i);
CREATE TABLE tst_part1 PARTITION OF tst_part FOR VALUES FROM (1) TO (5);
CREATE TABLE tst_part_dflt PARTITION OF tst_part DEFAULT; INSERT INTO tst_part SELECT generate_
series(1,10,1);
SELECT * FROM tst_part1;i
---
1
2
3
4
4 rows)

SELECT * FROM tst_part_dflt;
```

```
 i
----
 5
 6
 7
 8
 9
 10
(6 rows)
```

Hash partitioning:

```
CREATE TABLE tst_hash(i INT) PARTITION BY HASH(i);
CREATE TABLE tst_hash_1 PARTITION OF tst_hash FOR VALUES WITH (MODULUS 2, REMAINDER 0);
CREATE TABLE tst_hash_2 PARTITION OF tst_hash FOR VALUES WITH (MODULUS 2, REMAINDER 1);

INSERT INTO tst_hash SELECT generate_series(1,10,1);

SELECT * FROM tst_hash_1;
 i
---
 1
 2
(2 rows)


SELECT * FROM tst_hash_2;
 i
----
  3
  4
  5
  6
  7
  8
  9
 10
(8 rows)
```

UPDATE on partition key:

```
CREATE TABLE tst_part(i INT) PARTITION BY RANGE(i);
CREATE TABLE tst_part1 PARTITION OF tst_part FOR VALUES FROM (1) TO (5);
CREATE TABLE tst_part_dflt PARTITION OF tst_part DEFAULT;

INSERT INTO tst_part SELECT generate_series(1,10,1);

SELECT * FROM tst_part1;
i
---
1
2
3
4
(4 rows)


SELECT * FROM tst_part_dflt;
i
----
```

```
5
6
7
8
9
10
(6 rows)

UPDATE tst_part SET i=1 WHERE i IN (5,6);

SELECT * FROM tst_part_dflt;
i
----
7
8
9
10
(4 rows)

SELECT * FROM tst_part1;
i
---
1
2
3
4
1
1
(6 rows)
```

Index propagation on partitioned tables:

```
CREATE TABLE tst_part(i INT) PARTITION BY RANGE(i);

CREATE TABLE tst_part1 PARTITION OF tst_part FOR VALUES FROM (1) TO (5);

CREATE TABLE tst_part2 PARTITION OF tst_part FOR VALUES FROM (5) TO (10);

CREATE INDEX tst_part_ind ON tst_part(i);

\d+ tst_part
                           Partitioned table "public.tst_part"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition key: RANGE (i)
Indexes:
    "tst_part_ind" btree (i)
Partitions: tst_part1 FOR VALUES FROM (1) TO (5),
            tst_part2 FOR VALUES FROM (5) TO (10)


\d+ tst_part1
                                 Table "public.tst_part1"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (1) TO (5)
Partition constraint: ((i IS NOT NULL) AND (i >= 1) AND (i < 5))
Indexes:
    "tst_part1_i_idx" btree (i)
Access method: heap

\d+ tst_part2
```

```
                                Table "public.tst_part2"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (5) TO (10)
Partition constraint: ((i IS NOT NULL) AND (i >= 5) AND (i < 10))
Indexes:
    "tst_part2_i_idx" btree (i)
Access method: heap
```

Foerign keys propagation on partitioned tables:

```
CREATE TABLE tst_ref(i INT PRIMARY KEY);

ALTER TABLE tst_part ADD CONSTRAINT tst_part_fk FOREIGN KEY (i) REFERENCES tst_ref(i);

\d+ tst_part
                           Partitioned table "public.tst_part"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition key: RANGE (i)
Indexes:
    "tst_part_ind" btree (i)
Foreign-key constraints:
    "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Partitions: tst_part1 FOR VALUES FROM (1) TO (5),
            tst_part2 FOR VALUES FROM (5) TO (10)


\d+ tst_part1
                                Table "public.tst_part1"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (1) TO (5)
Partition constraint: ((i IS NOT NULL) AND (i >= 1) AND (i < 5))
Indexes:
    "tst_part1_i_idx" btree (i)
Foreign-key constraints:
    TABLE "tst_part" CONSTRAINT "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Access method: heap

\d+ tst_part2
                                Table "public.tst_part2"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (5) TO (10)
Partition constraint: ((i IS NOT NULL) AND (i >= 5) AND (i < 10))
Indexes:
    "tst_part2_i_idx" btree (i)
Foreign-key constraints:
    TABLE "tst_part" CONSTRAINT "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Access method: heap
```

Triggers propagation on partitioned tables:

```
CREATE TRIGGER some_trigger AFTER UPDATE ON tst_part FOR EACH ROW EXECUTE FUNCTION some_func();

\d+ tst_part
                            Partitioned table "public.tst_part"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition key: RANGE (i)
Indexes:
    "tst_part_ind" btree (i)
Foreign-key constraints:
    "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Triggers:
    some_trigger AFTER UPDATE ON tst_part FOR EACH ROW EXECUTE FUNCTION some_func()
Partitions: tst_part1 FOR VALUES FROM (1) TO (5),
            tst_part2 FOR VALUES FROM (5) TO (10)

\d+ tst_part1
                                 Table "public.tst_part1"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (1) TO (5)
Partition constraint: ((i IS NOT NULL) AND (i >= 1) AND (i < 5))
Indexes:
    "tst_part1_i_idx" btree (i)
Foreign-key constraints:
    TABLE "tst_part" CONSTRAINT "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Triggers:
    some_trigger AFTER UPDATE ON tst_part1 FOR EACH ROW EXECUTE FUNCTION some_func()
Access method: heap

\d+ tst_part2
                                 Table "public.tst_part2"
 Column |  Type   | Collation | Nullable | Default | Storage | Stats target | Description
--------+---------+-----------+----------+---------+---------+--------------+-------------
 i      | integer |           |          |         | plain   |              |
Partition of: tst_part FOR VALUES FROM (5) TO (10)
Partition constraint: ((i IS NOT NULL) AND (i >= 5) AND (i < 10))
Indexes:
    "tst_part2_i_idx" btree (i)
Foreign-key constraints:
    TABLE "tst_part" CONSTRAINT "tst_part_fk" FOREIGN KEY (i) REFERENCES tst_ref(i)
Triggers:
    some_trigger AFTER UPDATE ON tst_part2 FOR EACH ROW EXECUTE FUNCTION some_func()
Access method: heap
```

Summary

The following table identifies similarities, differences, and key migration considerations.

Feature	SQL Server	Aurora PostgreSQL
Partition types	RANGE only	RANGE, LIST
Partitioned tables scope	All tables are partitioned, some have more than one partition	All tables are partitioned, some have more than one partition
Partition boundary direction	LEFT or RIGHT	RIGHT
Exchange partition	Any partition to any partition	N/A
Partition function	Abstract function object, Independent of individual column	Abstract function object, Independent of individual column
Partition scheme	Abstract partition storage mapping object	Abstract partition storage mapping object
Limitations on partitioned tables	None – all tables are partitioned	Not all commands are compatible with table inheritance

For more information, see https://www.postgresql.org/docs/13/static/ddl-partitioning.html

Security

SQL Server Column Encryption vs. PostgreSQL Column Encryption

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Syntax and option differences, similar functionality

SQL Server Usage

SQL Server provides encryption and decryption functions to secure the content of individual columns. The following list identifies common encryption functions:

- EncryptByKey and DecryptByKey
- EncryptByCert and DecryptByCert
- EncryptByPassPhrase and DecryptByPassPhrase
- EncryptByAsymKey and DecryptByAsymKey

You can use these functions anywhere in your code; they are not limited to encrypting table columns. A common use case is to increase run time security by encrypting of application user security tokens passed as parameters.

These functions follow the general SQL Server encryption hierarchy, which in turn use the Windows Server Data Protection API.

Symmetric encryption and decryption consume minimal resources and can be used for large data sets.

> **Note:** This section does not cover Transparent Data Encryption (TDE) or AlwaysEncrypted end-to-end encryption.

Syntax

General syntax for EncryptByKey and DecryptByKey:

```
EncryptByKey ( <key GUID> , { 'text to be encrypted' }, { <use authenticator flag>}, {
<authenticator> }  );
```

```
DecryptByKey ( 'Encrypted Text' , <use authenticator flag>, { <authenticator> )
```

Examples

The following example demonstrates how to encrypt an employee Social Security Number:

Create a database master key.

```
USE MyDatabase;
CREATE MASTER KEY
ENCRYPTION BY PASSWORD = '<MyPassword>';
```

Create a certificate and a key.

```
CREATE CERTIFICATE Cert01
WITH SUBJECT = 'SSN';
```

```
CREATE SYMMETRIC KEY SSN_Key
WITH ALGORITHM = AES_256
ENCRYPTION BY CERTIFICATE Cert01;
```

Create an employees table.

```
CREATE TABLE Employees
(
EmployeeID INT PRIMARY KEY,
SSN_encrypted VARBINARY(128)  NOT NULL
);
```

Open the symmetric key for encryption.

```
OPEN SYMMETRIC KEY SSN_Key
DECRYPTION BY CERTIFICATE Cert01;
```

Insert the encrypted data.

```
INSERT INTO Employees (EmployeeID, SSN_encrypted)
VALUES
(1, EncryptByKey(Key_GUID('SSN_Key') , '1112223333', 1, HashBytes('SHA1', CONVERT
(VARBINARY, 1)));
```

```
SELECT EmployeeID,
       CONVERT(CHAR(10), DecryptByKey(SSN, 1 , HashBytes('SHA1', CONVERT(VARBINARY,
EmployeeID)))) AS SSN
FROM Employees;

EmployeeID      SSN_Encrypted                       SSN
----------      --------------------                ----------
1               0x00F983FF436E32418132...           1112223333
```

For more information, see:

- *https://docs.microsoft.com/en-us/sql/relational-databases/security/encryption/encrypt-a-column-of-data?view=sql-server-ver15*
- *https://docs.microsoft.com/en-us/sql/relational-databases/security/encryption/encryption-hierarchy?view=sql-server-ver15*

PostgreSQL Usage

Aurora PostgreSQL provides encryption and decryption functions similar to SQL Server using the pgcrypto extension. To use this feature, you must first install the pgcrypto extension.

```
CREATE EXTENSION pgcrypto;
```

Aurora PostgreSQL supports many encryption algorithms:

- MD5
- SHA1
- SHA224/256/384/512
- Blowfish
- AES
- Raw encryption
- PGP Symmetric encryption
- PGP Public-Key encryption

This section describes the use of PGP_SYM_ENCRYPT and PGP_SYM_DECRYPT, but there are many more options available (see at the link and the end of this section).

Syntax

Encrypt columns using PGP_SYM_ENCRYPT.

```
pgp_sym_encrypt(data text, psw text [, options text ]) returns bytea
pgp_sym_decrypt(msg bytea, psw text [, options text ]) returns text
```

Examples

The following example demonstrates how to encrypt an employee's Social Security Number:

Create a users table.

```
CREATE TABLE users (id SERIAL, name VARCHAR(60), pass TEXT);
```

Insert the encrypted data.

```
INSERT INTO users (name, pass) VALUES ('John',PGP_SYM_ENCRYPT('123456', 'AES_KEY'));
```

Verify the data is encrypted.

```
SELECT * FROM users;

id |name |pass
                                                                    |
---|-----|-------------------------------------------------------------------------------
-----------------------------------------------------------------|
2  |John |\x-
c30d04070302c30d07ff8b3b12f26ad233015a72bab4d3b-
b73f5a80d5187b1b043149dd961da58e76440ca9eb4a5f7483cc8ce957b47e39b143cf4b1192bb39 |
```

Query using the encryption key.

```
SELECT name, PGP_SYM_DECRYPT(pass::bytea, 'AES_KEY') as pass
FROM users WHERE (name LIKE '%John%');

name |pass   |
-----|-------|
John |123465 |
```

Update the data.

```
UPDATE users SET (name, pass) = ('John',PGP_SYM_ENCRYPT('0000', 'AES_KEY')) WHERE
id='2';

SELECT name, PGP_SYM_DECRYPT(pass::bytea, 'AES_KEY') as pass
FROM users WHERE (name LIKE '%John%');

name |pass |
-----|-----|
John |0000 |
```

For more information, see https://www.postgresql.org/docs/13/static/pgcrypto.html

SQL Server Data Control Language vs. PostgreSQL Data Control Language

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Similar syntax and similar functionality

SQL Server Usage

The ANSI standard specifies, and most Relational Database Management Systems (RDBMS) use, GRANT and REVOKE commands to control permissions.

However, SQL Server also provides a DENY command to explicitly restrict access to a resource. DENY takes precedence over GRANT and is needed to avoid potentially conflicting permissions for users having multiple logins. For example, if a user has DENY for a resource through group membership but GRANT access for a personal login, the user is denied access to that resource.

SQL Server allows granting permissions at multiple levels from lower-level objects such as columns to higher level objects such as servers. Permissions are categorized for specific services and features such as the service broker.

Permissions are used in conjunction with database users and roles. See Users and Roles for more details.

Syntax

Simplified syntax for SQL Server DCL commands:

```
GRANT { ALL [ PRIVILEGES ] } | <permission>  [ ON <securable> ] TO <principal>

DENY   { ALL [ PRIVILEGES ] } | <permission> [ ON <securable> ] TO <principal>

REVOKE [ GRANT OPTION FOR ] {[ ALL [ PRIVILEGES ] ]|<permission>} [ ON <securable> ] {
TO | FROM } <principal>
```

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/security/permissions-hierarchy-database-engine?view=sql-server-ver15

PostgreSQL Usage

Aurora PostgreSQL supports the ANSI Data Control Language (DCL) commands GRANT and REVOKE.

Administrators can grant or revoke permissions for individual objects such as a column, a stored function, or a table. Permissions can be granted to multiple objects using ALL % IN SCHEMA. % can be TABLES, SEQUENCES or FUNCTIONS.

Use the following command to grant select on all tables in schema to a specific user.

```
GRANT SELECT ON ALL TABLES IN SCHEMA <Schema Name> TO <Role Name>;
```

Aurora PostgreSQL provides a GRANT permission option that is similar to SQL Server's WITH GRANT OPTION clause. This permission grants a user permission to further grant the same permission to other users.

```
GRANT EXECUTE
ON FUNCTION demo.Procedure1
TO UserY
WITH GRANT OPTION;
```

The following table identifies Aurora MyPostgreSQL privileges.

Permissions	Use to
SELECT	Allows to query rows from table.
INSERT	Allows to insert rows into a table.
UPDATE	Allows to update rows in table.
DELETE	Allows to delete rows from table.
TRUNCATE	Allows to truncate a table.

Permissions	Use to
REFERENCES	Allows to create a foreign key constraint.
TRIGGER	Allows the creation of a trigger on the specified table.
CREATE	The purpose of this permission depends on the target object. For more information, see the links at the end of this section.
CONNECT	Allows the role to connect to the specified database.
TEMPORARY / TEMP	Allows creation of temporary tables.
EXECUTE	Allow the user to execute a function.
USAGE	The purpose of this permission depends on the target object. For more information, see the links at the end of this section.
ALL / ALL PRIVILEGES	Grant all available privileges.

Syntax

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | TRIGGER }
    [, ...] | ALL [ PRIVILEGES ] }
    ON { [ TABLE ] table_name [, ...]
         | ALL TABLES IN SCHEMA schema_name [, ...] }
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { { SELECT | INSERT | UPDATE | REFERENCES } ( column_name [, ...] )
    [, ...] | ALL [ PRIVILEGES ] ( column_name [, ...] ) }
    ON [ TABLE ] table_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { { USAGE | SELECT | UPDATE }
    [, ...] | ALL [ PRIVILEGES ] }
    ON { SEQUENCE sequence_name [, ...]
         | ALL SEQUENCES IN SCHEMA schema_name [, ...] }
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { { CREATE | CONNECT | TEMPORARY | TEMP } [, ...] | ALL [ PRIVILEGES ] }
    ON DATABASE database_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { USAGE | ALL [ PRIVILEGES ] }
    ON DOMAIN domain_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { USAGE | ALL [ PRIVILEGES ] }
    ON FOREIGN DATA WRAPPER fdw_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { USAGE | ALL [ PRIVILEGES ] }
    ON FOREIGN SERVER server_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
    ON { FUNCTION function_name ( [ [ argmode ] [ arg_name ] arg_type [, ...] ] ) [,
...]
```

```
          | ALL FUNCTIONS IN SCHEMA schema_name [, ...] }
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { USAGE | ALL [ PRIVILEGES ] }
    ON LANGUAGE lang_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { { SELECT | UPDATE } [, ...] | ALL [ PRIVILEGES ] }
    ON LARGE OBJECT loid [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { { CREATE | USAGE } [, ...] | ALL [ PRIVILEGES ] }
    ON SCHEMA schema_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { CREATE | ALL [ PRIVILEGES ] }
    ON TABLESPACE tablespace_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

GRANT { USAGE | ALL [ PRIVILEGES ] }
    ON TYPE type_name [, ...]
    TO role_specification [, ...] [ WITH GRANT OPTION ]

where role_specification can be:

    [ GROUP ] role_name
  | PUBLIC
  | CURRENT_USER
  | SESSION_USER

GRANT role_name [, ...] TO role_name [, ...] [ WITH ADMIN OPTION ]
```

Examples

Grant SELECT Permission to a user on all tables in the demo database.

```
GRANT SELECT ON ALL TABLES IN SCHEMA emps TO John;
```

Revoke EXECUTE permissions from a user on the `EmployeeReport` stored procedure.

```
REVOKE EXECUTE ON FUNCTION EmployeeReport FROM John;
```

For more information, see https://www.postgresql.org/docs/13/static/sql-grant.html

SQL Server Transparent Data Encryption vs. PostgreSQL Transparent Data Encryption

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Storage level encryption managed by Amazon RDS

SQL Server Usage

Transparent Data Encryption (TDE) is an SQL Server feature designed to protect "data at rest" in the event an attacker obtains the physical media containing database files.

TDE does not require application changes and is completely transparent to users. The storage engine encrypts and decrypts data on-the-fly. Data is not encrypted while in memory or on the network. TDE can be turned on or off individually for each database.

TDE encryption uses a Database Encryption Key (DEK) stored in the database boot record, making it available during database recovery. The DEK is a symmetric key signed with a server certificate from the master system database.

In many instances, security compliance laws require TDE for data at rest.

Examples

The following example demonstrates how to enable TDE for a database:

Create a master key and certificate.

```
USE master;
CREATE MASTER KEY ENCRYPTION BY PASSWORD = 'MyPassword';
CREATE CERTIFICATE TDECert WITH SUBJECT = 'TDE Certificate';
```

Create a database encryption key.

```
USE MyDatabase;
CREATE DATABASE ENCRYPTION KEY
WITH ALGORITHM = AES_128
ENCRYPTION BY SERVER CERTIFICATE TDECert;
```

Enable TDE.

```
ALTER DATABASE MyDatabase SET ENCRYPTION ON;
```

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/security/encryption/transparent-data-encryption?view=sql-server-ver15

PostgreSQL Usage

Amazon Aurora PostgreSQL provides the ability to encrypt data at rest (data stored in persistent storage) for new database instances. When data encryption is enabled, Amazon Relational Database Service (RDS) automatically encrypts the database server storage, automated backups, read replicas, and snapshots using the AES-256 encryption algorithm.

You can manage the keys used for RDS encrypted instances from the Identity and Access Management (IAM) console using the AWS Key Management Service (AWS KMS). If you require full control of a key, you must manage it yourself. You cannot delete, revoke, or rotate default keys provisioned by AWS KMS.

The following limitations exist for Amazon RDS encrypted instances:

- You can only enable encryption for an Amazon RDS database instance when you create it, not afterward. It is possible to encrypt an existing database by creating a snapshot of the database instance and then creating an encrypted copy of the snapshot. You can restore the database from the encrypted snapshot, see: https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/USER_CopySnapshot.html
- Encrypted database instances cannot be modified to disable encryption.
- Encrypted Read Replicas must be encrypted with the same key as the source database instance.
- An unencrypted backup or snapshot can not be restored to an encrypted database instance.
- KMS encryption keys are specific to the region where they are created. Copying an encrypted snapshot from one region to another requires the KMS key identifier of the destination region.

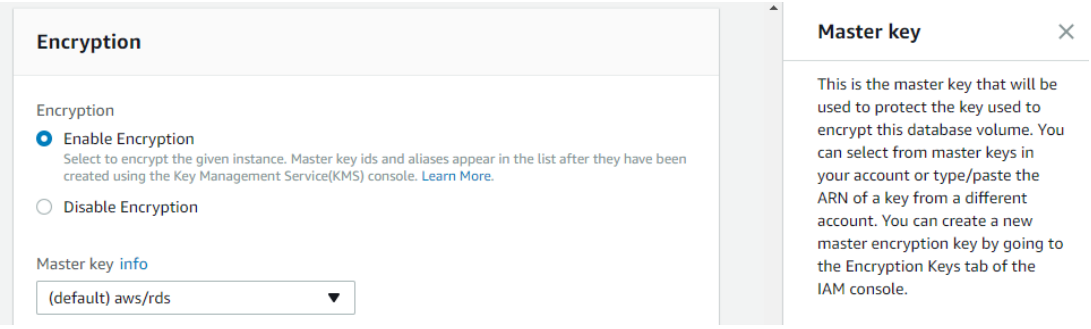
Note: Disabling the key for an encrypted database instance prevents reading from, or writing to, that instance. When Amazon RDS encounters a database instance encrypted by a key to which Amazon RDS does not have access, it puts the database instance into a terminal state. In this state, the database instance is no longer available and the current state of the database can't be recovered. To restore the database instance, you must re-enable access to the encryption key for Amazon RDS and then restore the database instance from a backup.

Examples

The following walk-through demonstrates how to enable TDE.

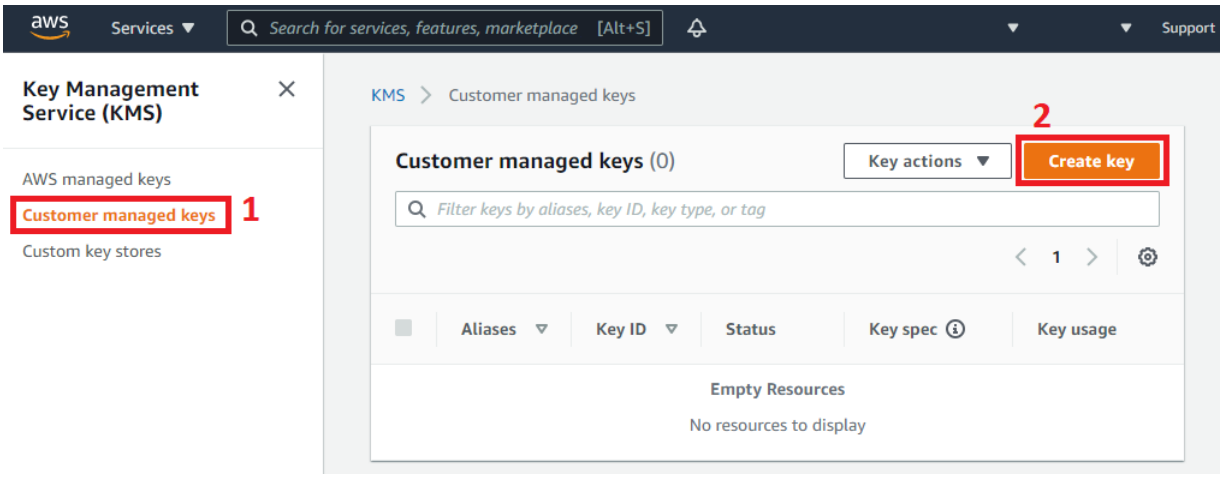
Enable Encryption

In the database settings, enable encryption and choose a master key. You can choose the default key provided for the account or define a specific key based on an IAM KMS ARN from your account or a different account.

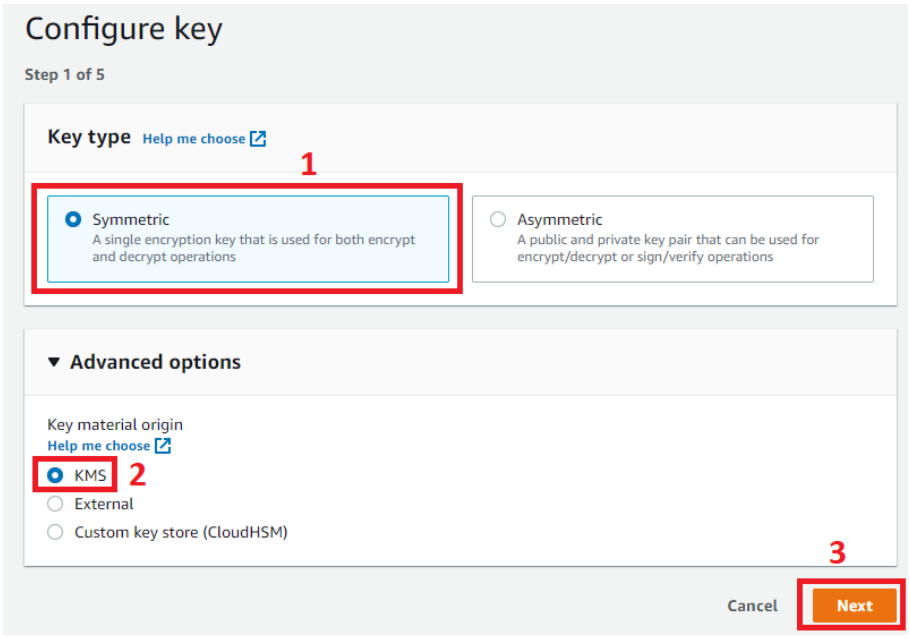


Create an Encryption Key

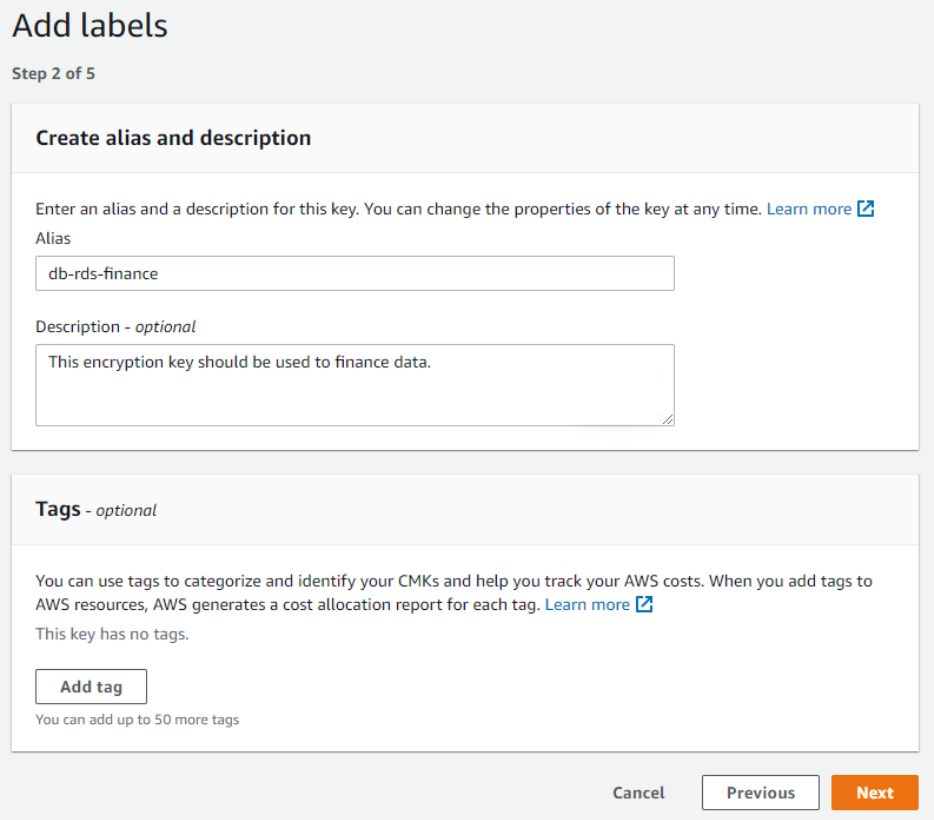
To create your own key, browse to the Key Management Service (KMS) and click on "Customer managed keys" and create a new key.



Choose relevant options and click on “Next”.

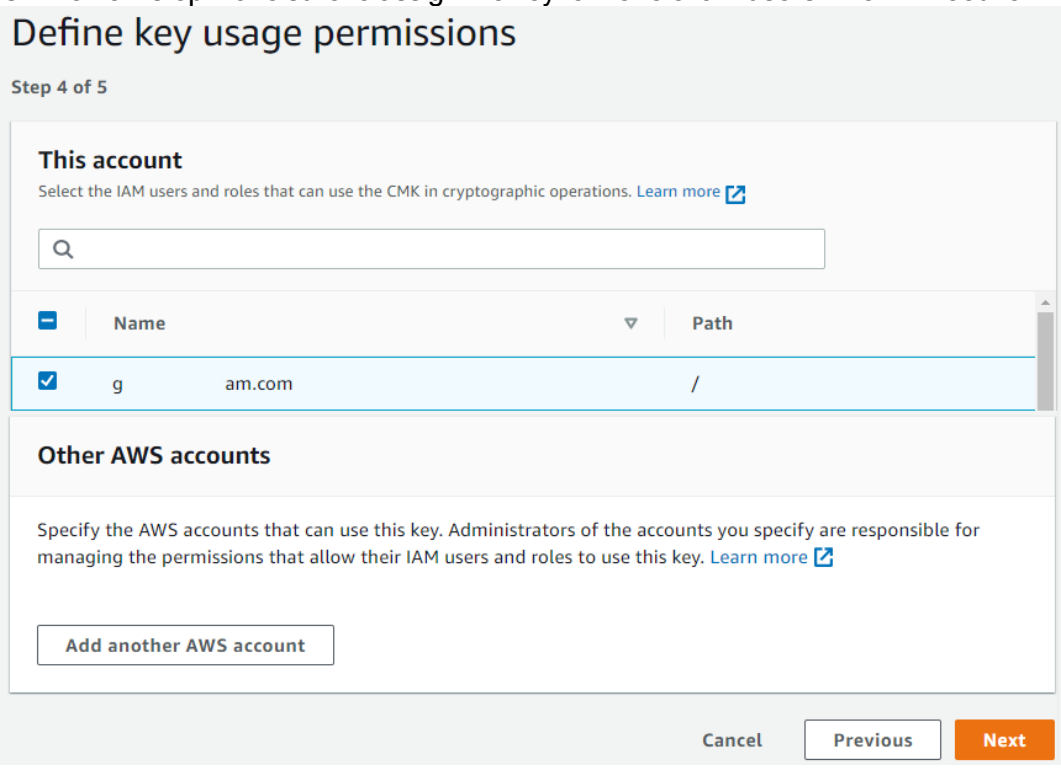


Define Alias as the name of the key, add description and click "Next".

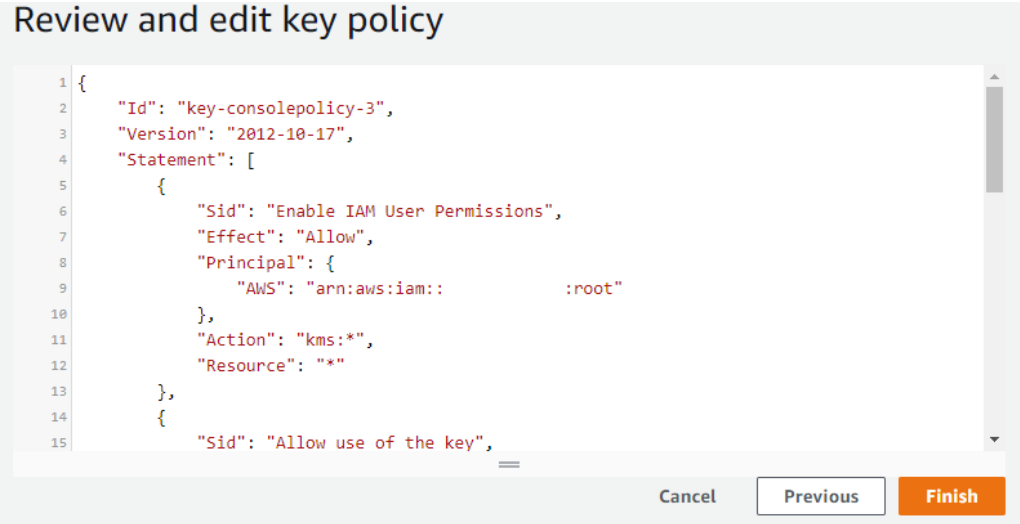


You can skip “Define Key Administrative Permissions” (step 3 of 5), click on “Next”.

On the next step make sure to assign the key to the relevant users who will need to interact with Aurora:

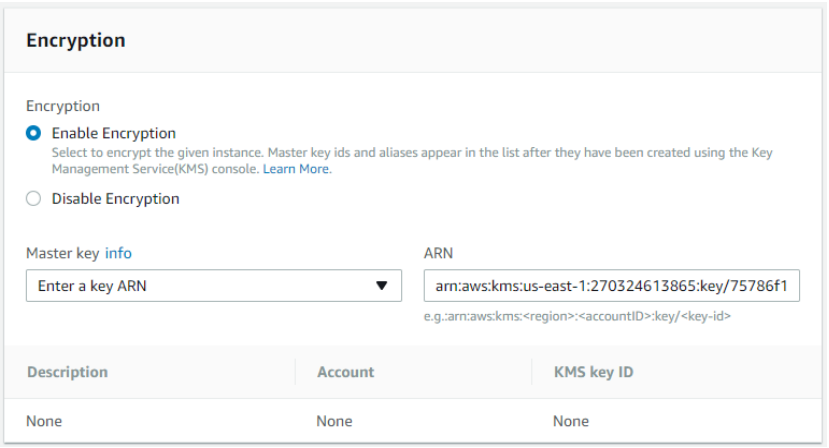


On the last step you will be able to see the ARN of the key and its account.



Click on “Finish” and now this key will be listed in under customer managed keys.

Now you will be able to set Master encryption key by using the ARN of the key that you have created or picking it from the list.



Proceed to finish and launch the instance.

For more information, see
http://docs.aws.amazon.com/AmazonS3/latest/dev/SSEUsingRESTAPI.html and
http://docs.aws.amazon.com/cli/latest/reference/s3/cp.htm

SQL Server Users and Roles vs. PostgreSQL Users and Roles

Feature Compatibility	SCT/DMS Automation Level	SCT Action Code Index	Key Differences
	N/A	N/A	Syntax and option differences, similar functionality There are no users - only roles

SQL Server Usage

SQL Server provides two layers of security principals: *Logins* at the server level and *Users* at the database level. Logins are mapped to users in one or more databases. Administrators can grant logins server-level permissions that are not mapped to particular databases such as Database Creator, System Administrator, and Security Administrator.

SQL Server also supports *Roles* for both the server and the database levels. At the database level, administrators can create custom roles in addition to the general purpose built-in roles.

For each database, administrators can create users and associate them with logins. At the database level, the built-in roles include *db_owner*, *db_datareader*, *db_securityadmin* and others. A database user can belong to one or more roles (users are assigned to the *public* role by default and can't be removed). Administrators can grant permissions to roles and then assign individual users to the roles to simplify security management.

Logins are authenticated using either Windows Authentication, which uses the Windows Server Active Directory framework for integrated single sign-on, or SQL authentication, which is managed by the SQL Server service and requires a password, certificate, or asymmetric key for identification. Logins using windows authentication can be created for individual users and domain groups.

In previous versions of SQL server, the concepts of user and schema were interchangeable. For backward compatibility, each database has several existing schemas, including a default schema named *dbo* which is owned by the *db_owner* role. Logins with system administrator privileges are automatically mapped to the dbo user in each database. Typically, you do not need to migrate these schemas.

Examples

Create a login.

```
CREATE LOGIN MyLogin WITH PASSWORD = 'MyPassword'
```

Create a database user for `MyLogin`.

```
USE MyDatabase; CREATE USER MyUser FOR LOGIN MyLogin;
```

Assign `MyLogin` to a server role.

```
ALTER SERVER ROLE dbcreator ADD MEMBER 'MyLogin'
```

Assign `MyUser` to the `db_datareader` role.

```
ALTER ROLE db_datareader ADD MEMBER 'MyUser';
```

For more information, see
https://docs.microsoft.com/en-us/sql/relational-databases/security/authentication-access/database-level-roles?view=sql-server-ver15

PostgreSQL Usage

PostgreSQL supports only roles; there are no users. However, there is a CREATE USER command, which is an alias for CREATE ROLE that automatically includes the LOGIN permission.

Roles are defined at the database cluster level and are valid in all databases in the PostgreSQL cluster.

Syntax

Simplified syntax for CREATE ROLE in Aurora PostgreSQL:

```
CREATE ROLE name [ [ WITH ] option [ ... ] ]

where option can be:

      SUPERUSER | NOSUPERUSER
    | CREATEDB | NOCREATEDB
    | CREATEROLE | NOCREATEROLE
    | INHERIT | NOINHERIT
    | LOGIN | NOLOGIN
    | REPLICATION | NOREPLICATION
    | BYPASSRLS | NOBYPASSRLS
    | CONNECTION LIMIT connlimit
    | [ ENCRYPTED | UNENCRYPTED ] PASSWORD 'password'
    | VALID UNTIL 'timestamp'
    | IN ROLE role_name [, ...]
    | IN GROUP role_name [, ...]
    | ROLE role_name [, ...]
    | ADMIN role_name [, ...]
    | USER role_name [, ...]
    | SYSID uid
```

Note: The UNENCRYPTED PASSWORD option was dropped in PostgreSQL 10, the password must be kept encrypted.

Example

Create a new database role called "hr_role" that allows users to create new databases in the PostgreSQL cluster. Note that this role is not able to login to the database and act as a “database user”. In addition, grant SELECT, INSERT and DELETE privileges on the hr.employees table to the role.

```
CREATE ROLE hr_role;
GRANT SELECT, INSERT,DELETE on hr.employees to hr_role;
```

Summary

The following table summarizes common security tasks and the differences between SQL Server and Aurora PostgerSQL

Task	SQL Server	Aurora PostgreSQL
View database users	`SELECT Name FROM sys.sysusers`	`SELECT * FROM pg_roles where rolcanlogin = true;`
Create a user and password	`CREATE USER <User Name> WITH PASSWORD = <PassWord>;`	`CREATE USER <User Name> WITH PASSWORD '<PassWord>';`
Create a role	`CREATE ROLE <Role Name>`	`CREATE ROLE <Role Name>`
Change a user's password	`ALTER LOGIN <SQL Login> WITH PASSWORD = <PassWord>;`	`ALTER USER <SQL Login> WITH PASSWORD '<PassWord>';`
External authentication	`Windows Authentication`	`N/A`
Add a user to a role	`ALTER ROLE <Role Name> ADD MEMBER <User Name>`	`ALTER ROLE <Role Name> SET <property and value>`
Lock a user	`ALTER LOGIN <Login Name> DISABLE`	`REVOKE CONNECT ON DATABASE <database_name> from <Role Name>;`
Grant SELECT on a schema	`GRANT SELECT ON SCHEMA::<Schema Name> to <User Name>`	`GRANT SELECT ON ALL TABLES IN SCHEMA <Schema Name> TO <User Name>;`

For more details, see:https://www.postgresql.org/docs/13/static/sql-createrole.html

Appendix A: SQL Server 2018 Deprecated Feature List

SQL Server 2018 Deprecated Feature	Section
TEXT, NTEXT, and IMAGE data types	SQL Server Data Types topic and Aurora PostgreSQL Data Types topic
SET ROWCOUNT for DML	SQL Server Session Options topic and Aurora PostgreSQL Session Options topic
TIMESTAMP syntax for CREATE TABLE	SQL Server Creating Tables topic and Aurora PostgreSQL Creating Tables topic
DBCC DBREINDEX, INDEXDEFRAG, and SHOWCONTIG	SQL Server Maintenance Plans topic
Old SQL Mail	SQL Server Database Mail
IDENTITY Seed, Increment, non PK, and compound	SQL Server Sequences and Identity and Aurora PostgreSQL Sequences and Identity
Stored Procedures RETURN Values	SQL Server Stored Procedures and Aurora PostgreSQL Stored Procedures
GROUP BY ALL, Cube, and Compute By	SQL Server GROUP BY and Aurora PostgreSQL GROUP BY
DTS	SQL Server ETL and Aurora PostgreSQL ETL
Old outer join syntax *= and =*	SQL Server Table JOIN and Aurora PostgreSQL Table JOIN
'String Alias' = Expression	Migration Tips
DEFAULT keyword for INSERT statements	Migration Tips

Migration Quick Tips

Migration Quick Tips

This section provides migration tips that can help save time as you transition from SQL Server to Aurora PostgreSQL. They address many of the challenges faced by administrators new to Aurora PostgreSQL. Some of these tips describe functional differences in similar features between SQL Server and Aurora PostgreSQL.

Management

- The equivalent of SQL Server's CREATE DATABASE... AS SNAPSHOT OF... resembles Aurora PostgreSQL Database cloning. However, unlike SQL Server snapshots, which are read only, Aurora PostgreSQL cloned databases are updatable.
- In Aurora PostgreSQL, the term "Database Snapshot" is equivalent to SQL Server's BACKUP DATABASE... WITH COPY_ONLY.
- Partitioning in Aurora PostgreSQL is called "INHERITS" tables and act completely different in terms of management
- Unlike SQL Server's statistics, Aurora PostgreSQL does not collect detailed key value distribution; it relies on selectivity only. When troubleshooting execution, be aware that parameter values are insignificant to plan choices.
- Many missing features such as sending emails can be achieved with quick implementations of Amazon's services (like Lambda).
- Parameters and backups are managed by Amazon's RDS. It is very useful in terms of checking parameter's value against its default and comparing them to another parameter group.
- High Availability can be implemented in few clicks to create Replicas.
- With Database Links, there are two options. The db_link extension is similar to SQL Server.

SQL

- Triggers work differently in Aurora PostgreSQL. Triggers can be also executed for each row (not just once). The syntax for inserted and deleted is new and old.
- Aurora PostgreSQL does not support the @@FETCH_STATUS system parameter for cursors. When declaring cursors in Aurora PostgreSQL, you must create an explicit HANDLER object.
- To execute a stored procedure (functions), use SELECT instead of EXECUTE.
- To execute a string as a query, use Aurora PostgreSQL Prepared Statements instead of either sp_executesql, or EXECUTE(<String>) syntax.
- In Aurora PostgreSQL, IF blocks must be terminated with END IF. WHILE..LOOP loops must be terminated with END LOOP.
- Aurora PostgreSQL syntax for opening a transaction is START TRANSACTION as opposed to BEGIN TRANSACTION. COMMIT and ROLLBACK are used without the TRANSACTION keyword.
- Aurora PostgreSQL does not use special data types for UNICODE data. All string types may use any character set and any relevant collation.
- Collations can be defined at the server, database, and column level, similar to SQL Server. They cannot be defined at the table level.
- SQL Server's DELETE <Table Name> syntax, which allows omitting the FROM keyword, is invalid in Aurora PostgreSQL. Add the FROM keyword to all delete statements.

- Aurora PostgreSQL allows multiple rows with NULL for a UNIQUE constraint; SQL Server allows only one. Aurora PostgreSQL follows the behavior specified in the ANSI standard.
- Aurora PostgreSQL SERIAL column property is similar to IDENTITY in SQL Server. However, there is a major difference in the way sequences are maintained. While SQL Server caches a set of values in memory, the last allocation is recorded on disk. When the service restarts, some values may be lost, but the sequence continues from where it left off. In Aurora PostgreSQL, each time the service is restarted, the seed value to SERIAL is reset to one increment interval larger than the largest existing value. Sequence position is not maintained across service restarts.
- Parameter names in Aurora PostgreSQL do not require a preceding "@". You can declare local variables such as SET schema.test = 'value' and get the value by SELECT current_setting('username.test');
- Local parameter scope is not limited to an execution scope. You can define or set a parameter in one statement, execute it, and then query it in the following batch.
- Error handling in Aurora PostgreSQL has less features, but for special requirements, you can log or send alerts by inserting into tables or catching errors.
- Aurora PostgreSQL does not support the MERGE statement. Use the REPLACE statement and the INSERT... ON DUPLICATE KEY UPDATE statement as alternatives.
- You cannot concatenate strings in Aurora PostgreSQL using the "+" operator. 'A' + 'B' is not a valid expression. Use the CONCAT function instead. For example, CONCAT('A', 'B').
- Aurora PostgreSQL does not support aliasing in the select list using the 'String Alias' = Expression. Aurora PostgreSQL treats it as a logical predicate, returns 0 or FALSE, and will alias the column with the full expression. USE the AS syntax instead. Also note that this syntax has been deprecated as of SQL Server 2008 R2.
- Aurora PostgreSQL has a large set of string functions that is much more diverse than SQL Server. Some of the more useful string functions are:
    - TRIM is not limited to full trim or spaces. The syntax is TRIM([{BOTH | LEADING | TRAILING} [<remove string>] FROM] <source string>)).
    - LENGTH in PostgreSQL is equivalent to DATALENGTH in T-SQL. CHAR_LENGTH is the equivalent of T-SQL LENGTH.
    - SUBSTRING_INDEX returns a substring from a string before the specified number of occurrences of the delimiter.
    - FIELD returns the index (position) of the first argument in the subsequent arguments.
    - POSITION returns the index position of the first argument within the second argument.
    - REGEXP_MATCHES provides support for regular expressions.
    - For more string functions, see https://www.postgresql.org/docs/13/static/functions-string.html
- The Aurora PostgreSQL CAST function is for casting between collation and not other data types. Use CONVERT for casting data types.
- Aurora PostgreSQL is much stricter than SQL Server in terms of statement terminators. Be sure to always use a semicolon at the end of statements.
- There is no CREATE PROCEDURE syntax; only CREATE FUNCTION. You can create a function that returns void.
- Beware of control characters when copying and pasting a script to Aurora PostgreSQL clients. Aurora PostgreSQL is much more sensitive to control characters than SQL Server and they result in frustrating syntax errors that are hard to find.

Glossary

ACID
Atomicity, Consistency, Isolation, Durability

AES
Advanced Encryption Standard

ANSI
American National Standards Institute

API
Application Programming Interface

ARN
Amazon Resource Name

AWS
Amazon Web Services

BLOB
Binary Large Object

CDATA
Character Data

CLI
Command Line Interface

CLOB
Character Large Object

CLR
Common Language Runtime

CPU
Central Processing Unit

CRI
Cascading Referential Integrity

CSV
Comma Separated Values

CTE
Common Table Expression

DB
Database

DBCC
Database Console Commands

DDL
Data Definition Language

DEK
Database Encryption Key

DES
Data Encryption Standard

DML
Data Manipulation Language

DQL
Data Query Language

FCI
Failover Cluster Instances

HADR
High Availability and Disaster Recovery

IAM
Identity and Access Management

IP
Internet Protocol

ISO
International Organization for Standardization

JSON
JavaScript Object Notation

KMS
Key Management Service

NUMA
Non-Uniform Memory Access

OLE
Object Linking and Embedding

OLTP
Online Transaction Processing

PaaS
Platform as a Service

PDF
Portable Document Format

QA
Quality Assurance

RDMS
Relational Database Management System

RDS
Amazon Relational Database Service

REGEXP
Regular Expression

SCT
Schema Conversion Tool

SHA
Secure Hash Algorithm

SLA
Service Level Agreement

SMB
Server Message Block

SQL
Structured Query Language

SQL/PSM
SQL/Persistent Stored Modules

SSD
Solid State Disk

SSH
Secure Shell

T-SQL
Transact-SQL

TDE
Transparent Data Encryption

UDF
User Defined Function

UDT
User Defined Type

UTC
Universal Time Coordinated

WMI
Windows Management Instumentation

WQL
Windows Management Instrumentation Query Language

WSFC
Windows Server Failover Clustering

XML
Extensible Markup Language