Migrating your Oracle database to Amazon Aurora using DMS and SCT

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Agenda

What to expect from this session

1. Introduction
2. Migration Playbook
3. Common Oracle to Aurora PostgreSQL Feature Comparison with Examples
4. Schema Conversion Tool

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Introduction - Database Migration Service (DMS) & Schema Conversion Tool (SCT)

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What are DMS and SCT?

AWS Database Migration Service (DMS) easily and securely migrates and/or replicate your databases *and* data warehouses to AWS

AWS Schema Conversion Tool (SCT) converts your commercial database and data warehouse schemas to open-source engines or AWS-native services, such as Amazon Aurora and Redshift

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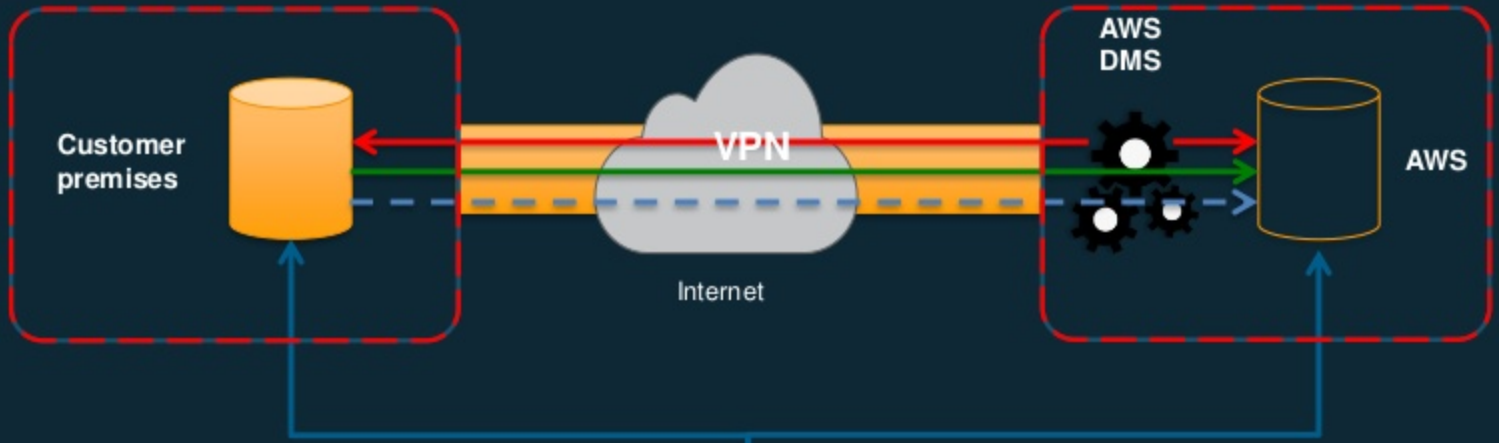
Database Migration Process

Step 1: Convert or Copy your Schema

Step 2: Move your data

How does DMS work?



Start a replication instance

Connect to source and target databases

Create Tasks

- Let AWS DMS create tables, load data, and keep them in sync
- Switch applications over to the target at your convenience

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Oracle to Aurora Migration Playbook

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Oracle to Aurora Migration Playbook

- Topic-by-topic overview of Oracle to Aurora PostgreSQL migrations and “hand-on” best practices
- How to migrate from proprietary features and the different database objects
- Migration best practices

	Oracle Feature	PostgreSQL Feature	Compatibility
Link	Index Organized Tables (IOTs)	PostgreSQL "Cluster" Tables	Yes*
Link	Common Data Types	Common Data Types	Yes
Link	Table Constraints	Table Constraints	Yes
Link	Table Partitioning including: RANGE, LIST, HASH, COMPOSITE, Automatic LIST	Table Partitioning including: RANGE, LIST	Yes*
Link	Exchange & Split Partitions	N/A	None
Link	Temporary Tables	Temporary Tables	Yes*
Link	Unused Columns	ALTER TABLE DROP COLUMN	Yes
Link	Virtual Columns	Views and/or Function as a Column	Yes*
Link	User Defined Types (UDTs)	User Defined Types (UDTs)	Yes
Link	Read Only Tables & Table Partitions	Read Only Roles and/or Triggers	Yes*
Link	Index Types	Index Types	Yes*
Link	Recovery Manager (RMAN)	AWS Aurora Snapshots	Yes
Link	Flashback Database	AWS Aurora Snapshots	Yes
Link	12c Multi-tenant architecture: PDBs and CDB	Databases	Yes*
Link	Tablespaces & DataFiles	Tablespaces	Yes*
Link	Data Pump	pg_dump & pg_restore	Yes
Link	Resource Manager	Separate AWS Aurora Clusters	Yes
Link	Database Users	Database Roles	Yes
Link	Database Roles	Database Roles	Yes
Link	SGA & PGA Memory	Memory Buffers	Yes
Link	V$ Views & Data Dictionary	System Catalog Tables, Statistics Collector, AWS Aurora Performance Insights	Yes*
Link	Log Miner	Logging Options	Yes
Link	Instance & Database Parameters (SPFILE)	AWS Aurora Parameter Groups	Yes
Link	Session Parameters	Session Parameters	Yes
Link	Alert.log (error log)	Error Log via AWS Console	Yes
Link	Automatic and Manual Statistics Collection	Automatic and Manual Statistics Collection	Yes
Link	Viewing Execution Plans	Viewing Execution Plans	Yes

Schema + Data + Best Practices

SCT DMS Playbook

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Top Oracle to Aurora PostgreSQL Feature Comparison

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Materialized Views

	Oracle	PostgreSQL
Creation	CREATE MATERIALIZED VIEW mv1 AS SELECT * FROM employees;	CREATE MATERIALIZED VIEW mv1 AS SELECT * FROM employees;
Manual Refresh	DBMS_MVIEW.REFRESH('mv1', 'cf'); The --cf parameter configured the refresh method: c is complete and f is fast	REFRESH MATERIALIZED VIEW mv1;

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Materialized Views

```
CREATE MATERIALIZED VIEW mv1
REFRESH FAST ON COMMIT AS
SELECT * FROM employees;
```

- Supports automatic incremental refresh
- Supports DML on the materialized view

Create a trigger that will initiate 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 or update or
delete or truncate
on employees for each
statement
execute procedure
```


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Partitioning

- PostgreSQL started supporting declarative partitioning from version 10.
- Prior to PostgreSQL 10, partitions could be used via inheritance.
- Oracle supports various partitioning mechanisms (hash, range, list, composite) whereas PostgreSQL currently supports list and range partitioning.

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Partitioning

Oracle example: List Partitioning

```
SQL> CREATE TABLE SYSTEM_LOGS
 (EVENT_NO NUMBER NOT NULL,
 EVENT_DATE DATE NOT NULL,
 EVENT_STR VARCHAR2(500),
ERROR_CODE VARCHAR2(10))
 PARTITION BY LIST (ERROR_CODE)
 (PARTITION warning VALUES ('err1', 'err2', 'err3') TABLESPACE TB1,
PARTITION critical VALUES ('err4', 'err5', 'err6') TABLESPACE TB2);
```


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Partitioning

PostgreSQL example: List Partitioning

It is a 5 step process using inheritance prior to PostgreSQL 10:

1. Create parent table
2. Create child tables with check constraints
3. Create indexes on child tables
4. Create a function to redirect data inserted into the parent table
5. Create trigger to execute function on DML event

Partitioning

1. Create Parent table:

```
demo=# CREATE TABLE SYSTEM_LOGS
 (EVENT_NO NUMERIC NOT NULL,
 EVENT_DATE DATE NOT NULL,
 EVENT_STR VARCHAR(500),
 ERROR_CODE VARCHAR(10));
```

2. Create Child tables with check constraints:

```
demo=# CREATE TABLE SYSTEM_LOGS_WARNING (
CHECK (ERROR_CODE IN('err1', 'err2', 'err3')))
INHERITS (SYSTEM_LOGS);
demo=# CREATE TABLE SYSTEM_LOGS_CRITICAL (
CHECK (ERROR_CODE IN('err4', 'err5', 'err6')))
 INHERITS (SYSTEM_LOGS);
```


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Partitioning

3. Create indexes on each of the child tables (“partitions”):

```
demo=# CREATE INDEX IDX_SYSTEM_LOGS_WARNING ON
SYSTEM_LOGS_WARNING(ERROR_CODE);
demo=# CREATE INDEX IDX_SYSTEM_LOGS_CRITICAL ON
 SYSTEM_LOGS_CRITICAL(ERROR_CODE);
```


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Partitioning

4. Create a function to redirect data inserted into the parent table

```
demo=# 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;
```


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Partitioning

4. Create trigger to execute function on DML

```
demo=# CREATE TRIGGER SYSTEM_LOGS_ERR_TRIG
BEFORE INSERT ON SYSTEM_LOGS FOR EACH ROW
EXECUTE PROCEDURE SYSTEM_LOGS_ERR_CODE_INS();
```


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Triggers

Oracle	PostgreSQL
Triggers can be executed after: a. DML b. DDL c. Certain database operations	Triggers can be execute: a. DML b. Event (DDL is also covered in this)
Different types: a. DML trigger b. Instead of trigger c. System event trigger	Different types: a. BEFORE OR AFTER events b. INSTEAD OF c. For each row or statement

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PostgreSQL triggers

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	—	—

DML Trigger Example - Oracle

```
SQL> CREATE OR REPLACE TRIGGER PROJECTS_SET_NULL
     AFTER DELETE OR UPDATE OF PROJECTNO ON PROJECTS
     FOR EACH ROW
     BEGIN
         IF UPDATING AND :OLD.PROJECTNO != :NEW.PROJECTNO OR DELETING THEN
               UPDATE EMP SET EMP.PROJECTNO = NULL
               WHERE EMP.PROJECTNO = :OLD.PROJECTNO;
         END IF;
     END;
/

Trigger created.

SQL> DELETE FROM PROJECTS WHERE PROJECTNO=123;
SQL> SELECT PROJECTNO FROM EMP WHERE PROJECTNO=123;

PROJECTNO
----------
NULL
```


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DML Trigger Example - PostgreSQL

```
psql=> 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
```

```
psql=> CREATE TRIGGER TRG_PROJECTS_SET_NULL
       AFTER UPDATE OF PROJECTNO OR DELETE
       ON PROJECTS
       FOR EACH ROW
       EXECUTE PROCEDURE PROJECTS_SET_NULL();

CREATE TRIGGER
```


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Sequences

Parameter/Feature	Compatibility with PostgreSQL	Comments
Create sequence syntax	Full, with minor differences	See Exceptions
`INCREMENT BY`	Full	
`START WITH`	Full	
`MAXVALUE | NOMAXVALUE`	Full	Use "`NO MAXVALUE`"
`MINVALUE | NOMINVALUE`	Full	Use "`NO MINVALUE`"
`CYCLE | NOCYCLE`	Full	USE "`NO CYCLE`"
`CACHE | NOCACHE`	PostgreSQL does not support the `NOCACHE` parameter but the default behavior is identical. The `CACHE` parameter is compatible with Oracle.	
Default values using sequences (Oracle 12c)	Supported by PostgreSQL	`CREATE TABLE TBL( COL1 NUMERIC DEFAULT NEXTVAL('SEQ_1')…`
Session sequences (session / global), Oracle 12c	Supported by PostgreSQL by using the `TEMPORARY` sequence parameter to Oracle `SESSION` sequence	
Oracle 12c identity columns	Supported by PostgreSQL by using the `SERIAL` data type as sequence	

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Sequence caching in PostgreSQL per session

```
In Oracle
---------


SQL> create sequence MySeqOracle start with 100 increment by 1 cache 20;
Sequence created.

-Session A
SQL> select sys.MySeqOracle.nextval from dual;
   NEXTVAL
----------
       100

# Open a new session B and generate the next value of sequence
-Session B
SQL> select sys.MySeqOracle.nextval from dual;
   NEXTVAL
----------
       101

# Lets go back to session A and generate the next value
-Session A
SQL> select sys.MySeqOracle.nextval from dual;
   NEXTVAL
----------
       102
```

```
1  In PostgreSQL
2  ----------------
3
4  psql=> create sequence myseqpostgre start with 100 increment by 1 cache 20;
5  CREATE SEQUENCE
6
7  -Session A
8  psql=> select nextval('public.myseqpostgre');
9   nextval
10 ---------
11      100
12
13 # Open a new session B and generate the next value of sequence
14 -Session B
15 psql=> select nextval('public.myseqpostgre');
16  nextval
17 ---------
18      120
19
20 # Lets go back to session A and generate the next value
21 -Session A
22 psql=> select nextval('public.myseqpostgre');
23  nextval
24 ---------
25      101
```


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Virtual Columns

Oracle	PostgreSQL
Oracle Virtual Columns appear as normal columns but their values are calculated instead of being stored in the database.	No virtual column support. It can be created through views or function as a column.
Virtual Columns cannot be created based on other Virtual Columns and can only reference columns from the same table	NA
When creating a Virtual Column, you can explicitly specify the datatype or let the database choose the datatype based on the expression.	If the column needs to be part of the object, a view must be created. If not, function as a column can be used as part of the select statement.

Virtual Columns - Oracle

```
SQL> CREATE TABLE EMPLOYEES (
      EMPLOYEE_ID NUMBER,
      FIRST_NAME   VARCHAR2(20),
      LAST_NAME    VARCHAR2(25),
      USER_NAME    VARCHAR2(25),
      EMAIL        AS (LOWER(USER_NAME) || '@aws.com'),
      HIRE_DATE    DATE,
      BASE_SALARY  NUMBER,
      SALES_COUNT  NUMBER,
      FINEL_SALARY NUMBER GENERATED ALWAYS AS
      (CASE WHEN SALES_COUNT >= 10 THEN BASE_SALARY + (BASE_SALARY *
      (SALES_COUNT * 0.05)) END) VIRTUAL);
```


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Virtual Columns - PostgreSQL

1.

```
demo=> CREATE TABLE EMPLOYEES (
        EMPLOYEE_ID NUMERIC PRIMARY KEY,
        FIRST_NAME   VARCHAR(20),
        LAST_NAME    VARCHAR(25),
        USER_NAME    VARCHAR(25));
```

2.

```
demo=> CREATE OR REPLACE FUNCTION USER_EMAIL(EMPLOYEES)
       RETURNS text AS $$
       SELECT (LOWER($1.USER_NAME) || '@aws.com')
       $$ STABLE LANGUAGE SQL;
```

3.

```
demo=> INSERT INTO EMPLOYEES
       (EMPLOYEE_ID, FIRST_NAME, LAST_NAME, USER_NAME)
       VALUES(1, 'John', 'Smith', 'jsmith'),
             (2, 'Steven', 'King', 'sking');
```


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Virtual Columns - PostgreSQL

```
demo=> SELECT EMPLOYEE_ID,
              FIRST_NAME,
              LAST_NAME,
              USER_NAME,
              USER_EMAIL(EMPLOYEES)
       FROM EMPLOYEES;

 employee_id | first_name | last_name | user_name |   user_email
-------------+------------+-----------+-----------+----------------
           1 | John       | Smith     | jsmith    | jsmith@aws.com
           2 | Steven     | King      | sking     | sking@aws.com
```

OR

```
demo=> CREATE VIEW employees_function AS
SELECT EMPLOYEE_ID,
              FIRST_NAME,
              LAST_NAME,
              USER_NAME,
              USER_EMAIL(EMPLOYEES)
       FROM EMPLOYEES;
```


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Number in Oracle vs integer or bigint in PostgreSQL

- The limit for numbers in Postgres (up to 131072 digits before the decimal point; up to 16383 digits after the decimal point) is much higher than in Oracle.
- The appropriate data type for NUMBER in Oracle might seem to be NUMERIC in PostgreSQL. However, PostgreSQL Numeric field is less efficient than native integer / bigint fields.
- Given the implementation differences, we have many customers who reduced CPU usage on Aurora from 100% to 20% by changing the generated column data types from Numeric to Bigint on Primary keys.
- If a number field in Oracle is being used as a PK or FK (relating to another table), we should look at using integer or bigint in Aurora PostgreSQL.

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Character Sets

Oracle	PostgreSQL
Supports most national and international character sets including Unicode.	PostgreSQL supports a variety of different character sets, also known as encoding, including support for both single-byte and multi-byte languages.
Supports VARCHAR2 (for non-Unicode) and NVARCHAR2 (for UTF-16).	Does not natively support NVARCHAR2 or UTF-16.
Can be defined at the instance level or pluggable database level.	Called encoding at database level and locale at table/column level.
Changing character set might require an export/import or use database migration assistant for Unicode.	Changing character set requires export/import to a new database.

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Schema Conversion Tool (SCT)

When to use SCT?

Modernize

Modernize your database tier

ORACLE

Microsoft SQL Server

Amazon Aurora

PostgreSQL

MySQL

Modernize and **Migrate** your Data Warehouse to Amazon Redshift

VERTICA

Microsoft SQL Server

TERADATA

NETEZZA

Greenplum

ORACLE

Amazon Redshift

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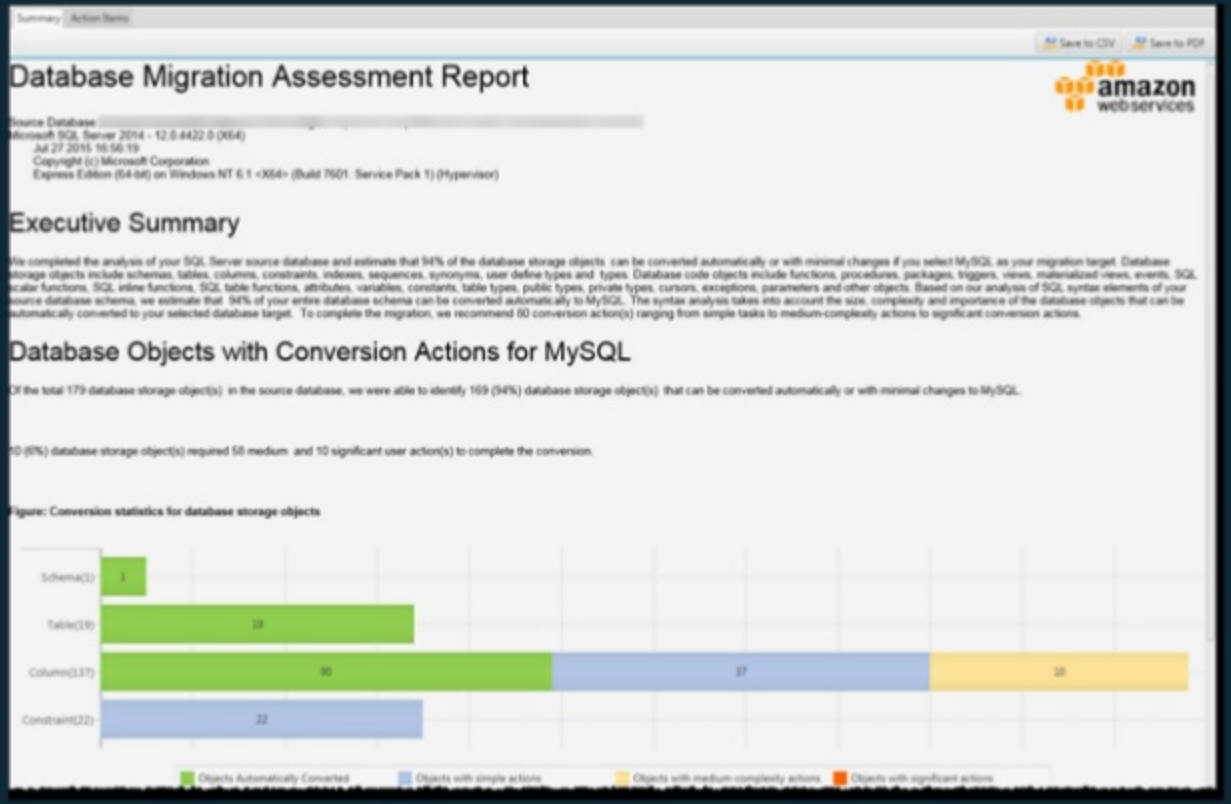
SCT Migration Assessment Report



- Assessment of migration compatibility of source databases with open-source database engines – RDS MySQL, RDS PostgreSQL and Aurora
- Recommends best target engine
- Provides details level of efforts to complete migration

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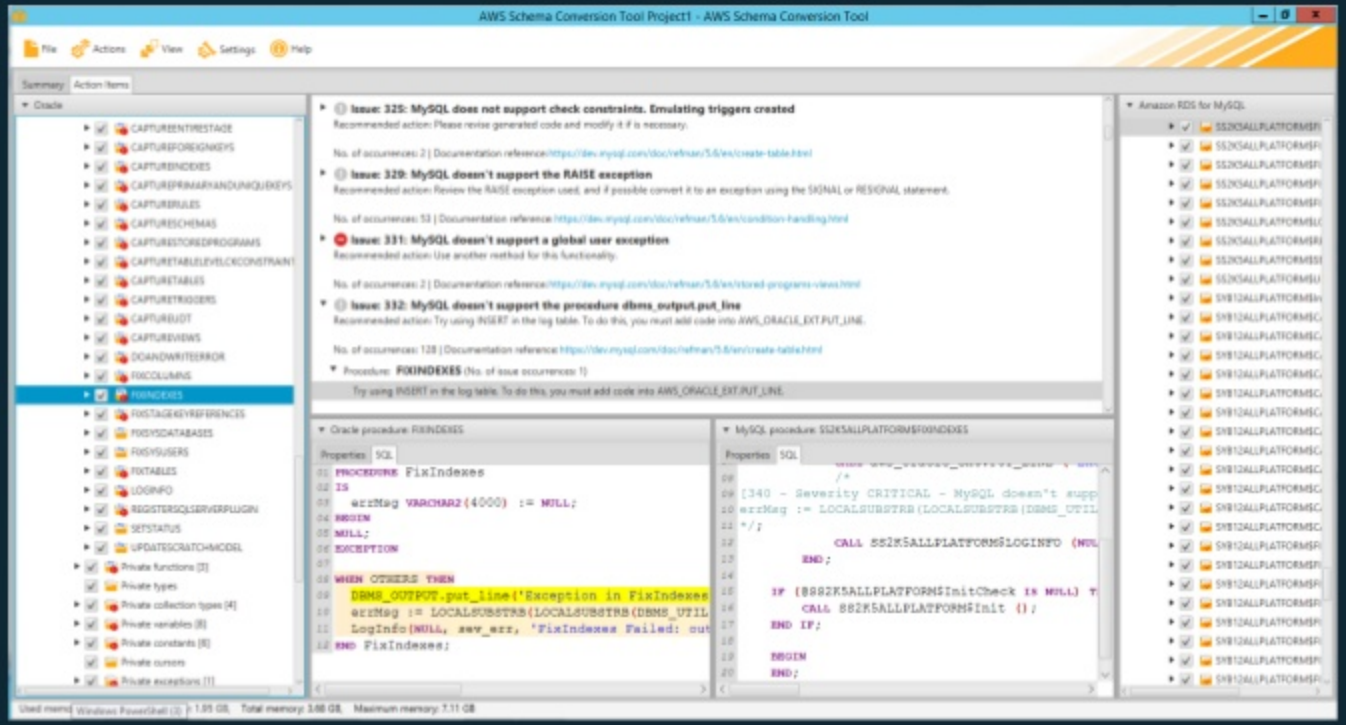
SCT helps with converting tables, views, and code



- Sequences
- User-defined types
- Synonyms
- Packages
- Stored procedures
- Functions
- Triggers
- Schemas
- Tables
- Indexes
- Views
- Sort and distribution keys

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Thank you!

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