ORACLE

Migrating SAP NetWeaver® Based Systems to Oracle Exadata Cloud Solutions

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DISCLAIMER

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REVISION HISTORY

The following revisions have been made to this document since its initial publication:

DATE	REVISION
February 23, 2021	Initial version

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SCOPE AND ASSUMPTIONS

This document outlines the common methods and necessary steps for migrating systems based on SAP NetWeaver to Exadata Cloud@Customer or Exadata Cloud Service. It is meant as a complementary guide for the following documents:

- SAP NetWeaver® Application Server ABAP/Java on Oracle Exadata Cloud@Customer X8M
- SAP NetWeaver® Application Server ABAP/Java on Oracle Exadata Cloud Service

The focus of this document is on Oracle Database–specific questions and tasks in conjunction with SAP NetWeaver. It does not focus on specific hardware generations of Exadata systems (such as X7, X8, or X8M) or on Oracle Cloud Infrastructure–specific topics (such as setting up a virtual cloud network or security rules).

This document discusses the relevant migration tools and methods as well as their advantages and disadvantages. RMAN-specific migration methods like RMAN Backup/Restore and RMAN Duplicate Database are discussed in detail and examples of most of the required steps are provided. Other migration methods might be described in detail in subsequent versions of this document, depending and prioritized on customer demands.

BASIC CONSIDERATIONS FOR DATABASE MIGRATIONS

When migrating databases, you must consider several things, some more obvious than others. For example:

- Vendor of the source and target database
- Versions and patch levels of the database software
- OS and architecture of the platforms involved
- Encryption
- Different types of storage for the database relevant files
- Size of the database

Migrating databases for SAP NetWeaver can be more complex, and the scope of tasks to perform for the migration can vary widely. For example, if you are migrating from an Exadata on-premises system or an on-premises Oracle Database Appliance to Exadata Cloud@Customer or Exadata Cloud Service, and the source database is already RAC-enabled and appropriate downtime is acceptable, the effort is usually less than migrating from another database and OS platform.

Following are the most important aspects to consider before choosing your migration methods or services:

- Whether the source environment consists of an Oracle Database on Linux x86_64 and is being migrated from a single instance, from on-premises Exadata, or from a customer-built Oracle Real Application Clusters (Oracle RAC) Database cluster to Exadata Cloud@Customer or Exadata Cloud Service
- Whether the source environment is using an Oracle Database on an OS platform *not* based on Linux x86_64 and requires a heterogenous platform migration
- Whether the source environment must be migrated from a database platform other than Oracle Database
- Downtime considerations and requirements for migration

- The robustness of the migration path
- Data encryption using Transparent Data Encryption (TDE)
- Oracle Database software versions
- Modifications to the SAP NetWeaver software, such as RFC connections, scheduled jobs, SAP Solution Manager changes, SAP Gateway changes, SAP Transaction DB13, or new SAP licenses.
- Changes in your existing operating concept
- New skills required for your technical staff
- Involvement of external service partners

You must consider what aspects are affected and relevant for *your* migration project.

DATABASE MIGRATION TOOLS, METHODS, AND SERVICES

Numerous methods and services exist for migrating a system based on SAP NetWeaver to Oracle Exadata Cloud@Customer or Exadata Cloud Service. This section describes those methods and services, and lists the pros and cons for each one.

Oracle Recovery Manager

Oracle Recovery Manager (RMAN) supports multiple migration techniques, all with different pros and cons.

Back Up, Restore, and Recover Database

With the Back Up, Restore, and Recover Database method, the source database is backed up and then restored and recovered on the target system.

Pros

- It's efficient and fast because it can be highly parallelized.
- It's easy to set up and run.
- Only a few post-migration tasks are required on the database side.
- With Oracle Database 19c and the appropriate SAP Bundle Patches, the database can be restored and TDE-encrypted in one step.

Cons

- The source and target database software (Oracle Homes) must be the same version and must have the same SAP Bundle Patches installed.
- The source and target database must be on the same OS and have the same endian type.
- Migration happens offline.
- Shared disk space is required to back up the database on the source system and to restore it on the target system.

Duplicate Database

The Duplicate Database method is similar to the Back Up, Restore, and Recover Database method. However, instead of backing up the database to disk and restoring it from disk, the database is copied directly from source to target through a SQL*Net (network) connection.

Pros

- Because of parallelism, this method can be efficient and fast if network bandwidth is high enough and latency is low.
- It's easy to set up and run.
- Only a few post-migration tasks are required on the database side.
- With Oracle Database 19c and the appropriate SAP Bundle Patches, the database can be restored and TDE-encrypted in one step.
- No shared disk space for backup is required.

Cons

- The source and target database software (Oracle Homes) must be the same version and must have the same SAP Bundle Patches installed.
- The source and target database must be on the same OS and have the same endian type.
- Migration happens offline. Although the database can be open during duplication, the SAP application should be offline for consistency.
- Speed is limited by the network.

Transportable Tablespaces

The Transportable Tablespaces (TTS) method lets you migrate the data files with application data between different OS platforms and endian types. The data files of the source database must be accessible on the target system (for example, on NFS) and can be converted and copied into Oracle Automatic Storage Management (Oracle ASM) in one step. Other than the methods in which data is exported from the source database and imported into a newly created target database, TTS is the only supported method for migrating heterogenous platforms without the need to export data or read and write it using the SQL layer.

This method is a combination of converting source data files into target data files and exporting and importing just metadata by using Oracle Data Pump (expdp and impdp).

Typically, only application-specific tablespaces are transported. The target database is created and prepared as a new database with just the SYSTEM and SYSAUX tablespaces by using SAP Software Provisioning Manager (SWPM). All the tablespaces except SYSTEM and SYSAUX are dropped (with the `including datafiles and contents` clause) after initial creation. Each required tablespace from the source is then migrated into Oracle ASM on the target system, and metadata about those tablespaces is imported using impdp.

Endian conversion can be done by using either RMAN CONVERT or the DBMS_FILE_TRANSFER package. The Oracle Database Migrating Non-CDBs to New Hardware with a Different Endian Operating System and for a New Release guide is a good resource on how to use TTS for migration.

Pros

- You don't need to export all the data from tables.
- You don't need to re-create indexes or statistics.
- Endian conversion can be parallelized on the data-file level.
- The source and target database software versions can be different as long as the "compatible" initialization parameter is set properly.

Cons

- There's no support for endian conversion and TDE-encryption in one step.
- Tablespaces must be self-contained (locally managed).
- A separate export and import of metadata by using Data Pump is required.
- A new database with just the SYSTEM and SYSAUX tablespaces is required, and the source tablespaces must be imported.
- Migration happens offline.
- The migration is complex and requires many manual steps.
- Migration time is mainly determined by the time it takes to export and import the metadata of the single database user SAPSR3. This operation can be very slow because metadata export and import cannot be parallelized, and all SAP data belongs to the single database user SAPSR3 with about 100,000 tables and more than 200,000 indexes. With SAP Business Warehouse, this process is even slower because there are typically several hundred thousands or millions of table and index partitions.

Transportable Database

This Transportable Database method supports conversions of whole databases between different OS platforms of the same endian type. Examples are migrations from Microsoft Windows to Linux x86_64 (little endian to little endian) or Solaris SPARC to IBM AIX (big endian to big endian). The conversion of IBM AIX to Linux x86_64 (big endian to little endian) is not supported.

Pros

- You don't need to export all the data from tables.
- You don't need to re-create indexes or statistics.
- Conversion can be parallelized.
- The source and target database software versions can be different as long as the "compatible" initialization parameter is set properly.
- Migration of the whole database (including the SYSTEM and SYSAUX tablespaces) is supported.

Cons

- Endian conversion is not supported.
- TDE-encryption can't be performed in one step.
- Migration happens offline.

- The migration is complex and requires many manual steps.

Oracle Data Pump

Oracle Data Pump is a toolset that supports multiple migration techniques, all with different pros and cons. The toolset consists of the command line tools impdp and expdp, and the DBMS_DATAPUMP and DBMS_METADATA PL/SQL packages.

Oracle Data Pump can help to move data in the following ways:

- **Data file copying**: This method is basically the Transportable Tablespace method explained in the preceding section. You copy (and convert, if necessary) data files by using RMAN and export and import tablespace metadata by using expdp and impdp.
- **Direct path**: Usually, direct path unloading and loading of data can greatly improve performance during migrations in which data file copying cannot be used. However, there are numerous situations in which direct path cannot be used. For more information, see Using Direct Path to Move Data.
- **External tables**: Moving data by using external tables does not have the limitations of direct path unless there are conflicting table attributes. For more information, see Using External Tables to Move Data.
- **Conventional path**: The conventional path is based on export and import through the SQL layer, which is also one of the migration methods with the biggest impact on performance.
- **Network link**: When you copy data over a network link (in this context, the same as a database link), the data is copied from the source database to the target database over the network. No export dump files need to be written. This method tries to read and write the data by using direct path; if that is not possible, it uses conventional path. For more information, see Using Network Link Import to Move Data.

Data Pump requires a pre-existing database on the target system. Data file copying requires only the SYSTEM and SYSAUX tablespaces to exist in that database. However, the other methods require all the tablespaces to be created as empty tablespaces before data is copied into them.

If you need endian conversion but do not need to export and import data, data file copying (Transportable Tablespace) is the most useful method. Consider the other methods if data needs to be migrated by exporting and importing and you do not want to use SAP R3Load.

Oracle Data Guard Standby Database

Oracle Data Guard provides a set of services that create, maintain, and manage standby databases. Standby databases are full copies of the primary database and can be used to reduce the downtime involved in migrating. Physical standby databases are supported for SAP migration; logical standby databases are not supported.

Following are the pros and cons of using Data Guard physical standby database for migration.

Pros

- Downtime is minimal.
- The setup is relatively simple.
- You can use this method if the source and target have the same endian type and OS platform.

Cons

- The same database version and patch level are required.
- If the source database is not TDE-enabled, encryption must be enabled as a separate step after migration.
- You cannot use this method for heterogenous migrations between source and target platforms with different endian types.

Oracle Zero Downtime Migration

Oracle Zero Downtime Migration is based on Oracle Data Guard technology and uses a physical standby database to perform online migration. Zero Downtime Migration requires a separate host that orchestrates the whole migration process: building the physical standby database, applying all redo logs from the source, and switching over and swapping roles. Because Zero Downtime Migration is based on physical standby database and supports only Linux x86_64 on the source and target host, only homogeneous migrations are possible. Zero Downtime Migration can transfer initial backup files by using Object Storage, NFS, or Zero Data Loss Recovery Appliance (ZDLRA).

Pros

- Oracle recommends this migration approach for moving databases to Oracle Cloud platforms.
- This method is the same as using Data Guard physical standby. See the previous section for the pros for that method.

Cons

- This method is the same as using Data Guard physical standby. See the previous section for the cons for that method.
- This method has not been successfully tested with SAP.

Migration Services for SAP Offered by Oracle Advanced Customer Services

Oracle offers database migrations as a service and supports customers at all relevant migration scenarios by choosing the approach that works best to meet individual customer requirements. Oracle Advanced Customer Services offers advanced and highly optimized migration methods such as Oracle to Oracle (O2O), Oracle to Oracle Online (Triple O), and Oracle GoldenGate.

SAP R3Load

SAP R3Load is one of the most common and well-known methods for SAP database migrations. The method has been optimized over the years and can be used in almost every database migration scenario. With SAP R3load, all SAP-related database tables and views are exported and imported into a prepared and empty target database.

Pros

- SAP R3Load can be used for homogeneous *and* heterogeneous migration scenarios (the OS and DB platform can be different).
- SAP R3Load can be highly parallelized on the export and import level.
- Large tables can be split into multiple export files in parallel and imported in parallel.

- Oracle direct path load interfaces are supported for fast data loading.
- Import into TDE-encrypted tablespaces is supported.
- Partitioned tables are supported.
- Reorganization of the entire database is provided, which typically results in space optimization and better performance.
- You can introduce new database features, such as table or index compression or tablespace encryption.

Cons

- Migration happens offline.
- A created target database with appropriately sized encrypted tablespaces is required.
- Only tables defined by SAP can be migrated.
- Triggers cannot be migrated using SAP R3Load.
- Database statistics must be collected after migration.

Summary of Migration Tools, Methods, and Services

Considering the pros and cons of each method, the currently recommended ways to migrate existing SAP databases to Exadata Cloud Service or Exadata Cloud@Customer are as follows:

For homogeneous migrations:

- Oracle Data Guard Standby Database using Physical Standby
- Oracle RMAN Restore or Duplicate commands
- Oracle Migration Services for SAP (GoldenGate, O2O, or Triple O)

For heterogeneous migrations:

- SAP R3Load
- Oracle Migration Services for SAP (GoldenGate, O2O, or Triple O)

The following sections focus on RMAN-based migration methods. Other methods might be described in upcoming updates of this document or are already covered in documents and notes available from Oracle or SAP.

PERFORMING DATABASE MIGRATION

This section describes how to use the Oracle RMAN Back Up, Restore, and Recover Database method and the Duplicate Database method to migrate existing SAP databases to Exadata Cloud Service or Exadata Cloud@Customer. Also refer to SAP Note 3018983, which contains complementary information, best practices, and example scripts.

Supported Character Sets

Only the following database character sets and national character sets are supported with SAP:

- For Unicode SAP databases:
    - UTF-8 as the database character set
    - UTF-8 as the national character set
- For non-Unicode SAP databases:
    - WE8DEC as the database character set
    - UTF-8 as the national character set

The migrated database must use the same database character set and national character set as the source database. Changing character sets during database migration to Exadata Cloud Service or Exadata Cloud@Customer is not supported.

Customers who need to migrate from non-Unicode to Unicode must perform an SAP Unicode migration, which is a separate migration project.

Premigration Considerations

Depending on your specific implementation of SAP NetWeaver, you might need to perform some tasks before you can begin the migration. For example:

- Any satellite systems that are connected to the SAP system might require changes.
- Database links from or to the database might also need to be migrated.
- Some SAP jobs might need to be set on-hold before migration, so that they do not run into errors when the system is first started up after migration.

Performing Database Migration using Oracle RMAN

Each database migration that relies solely on Oracle RMAN is performed in two major steps:

1. Install a new system, as described in the referenced documents for installing SAP NetWeaver based systems on Exadata Cloud Service or Exadata Cloud@Customer.
2. Replace the SAP database in the new installation with the database that you are migrating.

The advantage of this approach is that most SAP relevant software installations and configurations of the Exadata compute nodes are performed by SAP SWPM before the initial database is replaced by the one that is being migrated.

For all RMAN-based migrations, we recommend applying the same SAP Bundle Patch on the source system and the target system to avoid issues during restore or recovery, or conflicts that might arise because of minor incompatibilities.

The examples in the “Back Up, Restore, and Recover Method” and “Duplicate Database Method” sections assume that migration is performed from and to only one database instance and that any necessary modifications (for example, for RAC) are part of the post-migration work. Even if the source system and target system have the

same number of database compute nodes, migrations using RMAN might require several database-related post-migration steps. Those steps are discussed in "Post-Migration Tasks."

Prerequisites

Consider the following prerequisites before you begin the migration.

Oracle RDBMS Home Software Versions and Patches

If the source database is version 19c, we strongly recommend that you apply the latest SAP Bundle Patch on the source and target systems. If your source database is still unencrypted, the SAP Bundle Patch contains important patches to encrypt tablespaces as needed when the database is being restored. This requires a TDE encryption wallet set up on the source database.

If the source database is version 12.1, 12.2, or 18c, it cannot be encrypted when the database is being restored. Instead, the database is restored and recovered from the backup and then encrypted in a second step.

In either case, software versions and patches in both Oracle RDBMS Homes (source and target) must be the same.

TDE Setup

The best time to set up and implement TDE is *before* you migrate the database. This lets you back up the encrypted database on the source, restore and recover the database on the target, and keep existing encryption keys. In this case, the database is backed up on the source and restored on the target (possibly to a different location), and the encryption keys are transported from the encryption wallet on the source to a newly created encryption wallet on the target.

The next best option for databases already using version 19c is to set up a TDE encryption wallet on the source without encrypting any tablespaces. This allows TDE encryption of all tablespaces during database restore on the target.

If these options are not feasible, you can introduce TDE encryption only on the target by setting up a new encryption wallet with a new master key. The database is restored unencrypted and must be encrypted manually after recovery.

Back Up, Restore, and Recover Method

This section provides the major steps and several examples for using the RMAN Back Up, Restore, and Recover Database method for migration.

Prerequisites

This migration method is based on backing up the database on a source system and restoring it on a target system. So, you should choose a backup destination that the source and target can access or that you can detach from the source after backup and attach to the target before restore.

The easiest method is to mount a shared NFS file system on the source and target that is large enough to keep a full backup of the database. You could use an Exadata ASM Cluster File System exported to source or an external ZFS appliance.

Migration Steps

1. Create an online backup of the source database that includes the archive logs and controlfile.
2. Create an Oracle parameter file (`pfile`) that contains all the `init.ora` parameters of the source system.
3. If the source database is already encrypted with TDE, transport the contents of the encryption wallet to the target:
   A. Create a temporary encryption wallet on the file system.
   B. Merge the encryption keys from the source into the temporary encryption wallet.
   C. If required, copy the temporary encryption wallet to a file system location that can be accessed from the target system.
4. If the source database is not encrypted but TDE has been set up on it (it has an active encryption wallet and master key but no encrypted tablespaces), perform one of the following actions:
   - (Recommended) Set up a new encryption wallet with a master key on the target after you restore the controlfile from the backup**.**
   - Transport the encryption keys from the source to the target, as directed in step 3.
5. If the source database is not encrypted and has no TDE setup (no active encryption wallet), you must create an encryption wallet with encryption keys and an autologin wallet on the target system in a later step.
6. Copy the Oracle parameter file (`pfile`) to the target system and make the parameter adjustments (for example, `control_files`, `audit_file_dest`, and `log_archive_dest_1`) required to start the target database instance into the `nomount` state.
7. Set up TDE configuration.
   - If the database is 19c, set up the `tde_configuration` and `wallet_root` initialization parameters as part of the TDE configuration.
   - If the database is 12.1, 12.2, or 18c, set up the TDE configuration in `sqlnet.ora`.
8. Start the target database instance into the `nomount` state by using the prepared `pfile`.
9. Restore the original controlfile and bring the database into the `mount` state.
10. Create the required directory for the encryption wallet in ASM.
11. If the source database was already encrypted with TDE, perform these steps:
    A. Create an empty encryption wallet on ASM on the target system.
    B. Merge the encryption keys from the previously created encryption wallet into the new encryption wallet on ASM.
    C. Create an autologin wallet.
12. If the source database was not encrypted but was configured for TDE, perform one of the following actions:
    - (Recommended) Create an encryption wallet with a master key.
    - Transport the encryption keys from the source into a new encryption wallet on the target, as directed in step 11.

13. If the source database was not encrypted and had no TDE configuration, perform these steps:
    A. Create an empty encryption wallet on ASM on the target system.
    B. Create an autologin wallet.
14. Restore and recover your database.
    - If the source database was already encrypted, just restore and recover the database on the target.
    - If the source database was unencrypted but was on 19c with the latest SAP Bundle Patches and had TDE set up, use the `as encrypted` clause during database restore.
    - If the source database was on 12.1, 12.2, or 18c and was unencrypted, defer the encryption of the database until your database is successfully restored, recovered, and opened.
15. Open the database with the `resetlogs` option
16. If the source database was not encrypted and had no TDE configuration, perform these steps:
    A. Create and set a new master key and restart the database instance.
    B. If the source database was unencrypted and could not be restored and encrypted during step 14, the next step is to encrypt it. You can do this either online or offline. The offline approach can be optimized to complete encryption much faster than the online approach, but the online approach lets you access the database much earlier while encryption is in progress.
17. To perform an offline encryption, follow these steps:
    A. Encrypt the SYSTEM tablespace and all the UNDO tablespaces offline (in the `mount` state).
    B. Open the database and set all the tablespaces *except* the SYSTEM and UNDO tablespaces offline.
    C. Encrypt each data file of those tablespaces. You can parallelize this task by scheduling the required DDL commands as jobs using the `dbms_scheduler` package.
    D. When all the data files are encrypted, set all the tablespaces back online.
    E. Create an encrypted temporary tablespace to replace the unencrypted PSAPTEMP tablespace.
    F. Change the default temporary tablespace to the new encrypted temporary tablespace, drop the old PSAPTEMP tablespace, and rename the new encrypted temporary tablespace to PSAPTEMP.
18. To perform an online encryption, perform one of the following steps:
    - Open the unencrypted database and use Oracle online encryption to encrypt all the tablespaces.

      This operation works on the tablespace level and cannot be parallelized on the data file level (as it can in offline encryption). Online encryption can be done either serially (tablespace by tablespace) or in parallel (more than one tablespace at the same time), although each tablespace is encrypted by only one process. This means that the encryption of large tablespaces with many data files might take a long time. In addition, each unencrypted data file is encrypted into a new encrypted data file with a different name.

    - Open the unencrypted database, set up SAP BR*Tools, and use the `tablespace creation` and `tablespace reorganization` commands to create new encrypted tablespaces and to move your tables into the encrypted tablespaces.

Example 1: RMAN Back Up, Restore, and Recover from an encrypted Oracle 19c Source Database

This example illustrates the RMAN Back Up, Restore, and Recover migration method in detail by migrating an encrypted source database, ODA, from an on-premises Exadata to Exadata Cloud@Customer. It uses an NFS file system mounted at `/backup` as a shared media for backups.

You configure the RMAN backup targets (for example, on NFS) especially for the migration, and create an online backup of the source database that includes archive logs, the controlfile, and optionally, the spfile. You then revert the backup targets to the old location after creating the backup.

On the source system, perform the following steps:

1. Take note of your current backup targets.

```
[oracle@myhost1 dbs]$ rman target /

Recovery Manager: Release 19.0.0.0.0 - Production on Tue Jan 5 15:30:32 2021
Version 19.9.0.0.0

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connected to target database: ODA (DBID=3151516788)

RMAN> show all;

using target database control file instead of recovery catalog
RMAN configuration parameters for database with db_unique_name ODA are:
CONFIGURE RETENTION POLICY TO REDUNDANCY 1; # default
CONFIGURE BACKUP OPTIMIZATION OFF; # default
CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default
CONFIGURE CONTROLFILE AUTOBACKUP ON; # default
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE DEVICE TYPE DISK PARALLELISM 16 BACKUP TYPE TO BACKUPSET;
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT   '<orig_location>/%U';
CONFIGURE MAXSETSIZE TO UNLIMITED; # default
CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE
; # default
CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/oracle/ODA/19/dbs/snapcf_ODA.f'; # default
```

2. As the `root` user, run the following commands:

```
mkdir /backup/mig_oda
chown oracle:oinstall /backup/mig_oda
```

3. As the `oracle` user with the source database environment set, run the following commands:

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '/backup/mig_oda/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '/backup/mig_oda/%U' MAXPIECESIZE 128 G;
SET ENCRYPTION OFF;

BACKUP DATABASE CURRENT CONTFOLFILE SPFILE PLUS ARCHIVELOG;
```

4. Create an Oracle parameter file (`pfile`) that contains all the `init.ora` parameters of your source system.

```
SQL> create pfile='/backup/mig_oda/init_oda.ora' from spfile;
```

5. Restore the original backup locations.

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '<orig_location>/%U' MAXPIECESIZE 128 G;
```

6. Prepare to copy the encryption keys from the encryption wallet of the source database.

   A. Create a temporary encryption wallet on the file system.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE '/tmp/' identified by "<password>";

keystore altered.
```

   B. Merge the encryption keys from the encryption wallet on the source into the temporary encryption wallet.

```
SQL> ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '+DATAC1/ODA/orawallet/tde/'
IDENTIFIED BY "<password>" INTO EXISTING KEYSTORE '/tmp/' IDENTIFIED BY "<password>"
WITH BACKUP;

keystore altered.
```

On the target system, perform the following steps:

1. Make necessary adjustments for the target environment in the parameter file by adjusting file system and ASM disk group locations (for example, `audit_file_dest` and `db_recovery_file_dest`) and by adding the initialization parameters for TDE. Then, copy the parameter file to the `dbs` directory under the Oracle RDBMS Home on your target system. The parameter file needs to be only on one cluster node because it is required only during the migration of the database.

```
tde_configuration = 'KEYSTORE_CONFIGURATION=FILE'
wallet_root = '+DATAC2/ODA/orawallet'
```

2. Create the required wallet locations on ASM.

```
[oracle@node1 ~]$ asmcmd
ASMCMD> cd +DATAC2
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

3. Start the target database instance with the prepared parameter file into the `nomount` state.

```
SQL> startup nomount pfile='?/dbs/init_oda.ora';
ORACLE instance started.

Total System Global Area 6.8719E+10 bytes
Fixed Size                  26611816 bytes
Variable Size            3.3018E+10 bytes
Database Buffers         3.5568E+10 bytes
Redo Buffers              107601920 bytes
```

4. Create an encryption wallet on ASM, merge the encryption keys from the temporary encryption wallet, and shut down the database instance.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE identified by "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '/tmp/' IDENTIFIED BY "<password>" INTO
EXISTING KEYSTORE '+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>" WITH BACKUP;

keystore altered.

SQL> shutdown immediate;
Database closed.
Database dismounted.
ORACLE instance shut down.
```

5. Once more, start the target database instance with the prepared parameter file into the `nomount` state.

```
SQL> startup nomount pfile='?/dbs/init_oda.ora';
ORACLE instance started.

Total System Global Area 6.8719E+10 bytes
Fixed Size                  26611816 bytes
Variable Size            3.3018E+10 bytes
Database Buffers         3.5568E+10 bytes
Redo Buffers              107601920 bytes
```

6. Open the new encryption wallet and create an autologin wallet so that it opens automatically when the database instance is started.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE
'+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>";

keystore altered.
```

7. Once more, shut down and then start the target database instance with the prepared parameter file into the `nomount` state.

```
SQL> shutdown immediate;
Database closed.
Database dismounted.
ORACLE instance shut down.

SQL> startup nomount pfile='?/dbs/init_oda.ora';
ORACLE instance started.

Total System Global Area 6.8719E+10 bytes
Fixed Size                  26611816 bytes
Variable Size            3.3018E+10 bytes
Database Buffers         3.5568E+10 bytes
Redo Buffers              107601920 bytes
```

8. Verify that the wallet opens and that the master key is present.

```
SQL> select * from v$encryption_wallet;

WRL_TYPE
--------------------
WRL_PARAMETER
------------------------------------------------------------------------------
STATUS                         WALLET_TYPE          WALLET_OR KEYSTORE FULLY_BAC
------------------------------ -------------------- --------- -------- ---------
    CON_ID
----------
ASM
+DATAC1/ODA/orawallet/tde/
OPEN                           AUTOLOGIN            SINGLE    NONE     NO
         0


SQL> select max(key_id) from v$encryption_keys;

MAX(KEY_ID)
--------------------------------------------------------------------------------
Ae/pik4KoU/ov/VbX9QoMEkAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

9. Restore the controlfile from backup.

```
RMAN> restore controlfile from '/backup/mig_oda/c-3151516788-20201009-00';

Starting restore at 09-OCT-20
using target database controlfile instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=2109 device type=DISK

channel ORA_DISK_1: restoring control file
channel ORA_DISK_1: restore complete, elapsed time: 00:00:03
output file name=+DATAC1/ODA/cntrloda.dbf
output file name=+RECOC1/ODA/cntrloda.dbf
Finished restore at 09-OCT-20
```

10. Mount the database.

```
RMAN> alter database mount;
```

11. Create the list of the `set newname` commands to be used in the next step. For example:

```
set linesize 1000
set serveroutput on
spool setnewname.sql

declare
  src_pat varchar2(50):='+DATAC1';
  tgt_pat varchar2(50):='+DATAC2';
  old_name varchar2(2000);
  new_name varchar2(2000);
begin
  src_pat:='^'||src_pat;
  for c1 in (select name from v$datafile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for datafile '||old_name||' to '||new_name||';');
  end loop;
```

```
  for c1 in (select name from v$tempfile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for tempfile '||old_name||' to '||new_name||';');
  end loop;
end;
/
spool off
```

12. If necessary, adjust the locations and names of all database-related files by using the `set newname` command during restore.

```
RMAN> catalog start with '/backup/mig_oda/';
run {
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/system.295.1042756999' to
'+DATAC2/ODA/DATAFILE/system.295.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/sysaux.296.1042756999' to
'+DATAC2/ODA/DATAFILE/sysaux.296.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo001.297.1042757001' to
'+DATAC2/ODA/DATAFILE/psapundo001.297.1042757001';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.300.1042757673' to
'+DATAC2/ODA/DATAFILE/psapsr3.300.1042757673';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.301.1042757675' to
'+DATAC2/ODA/DATAFILE/psapsr3.301.1042757675';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.302.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.302.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.303.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.303.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.304.1042757679' to
'+DATAC2/ODA/DATAFILE/psapsr3.304.1042757679';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.305.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3.305.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.306.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3750.306.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.307.1042757683' to
'+DATAC2/ODA/DATAFILE/psapsr3750.307.1042757683';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.308.1042757685' to
'+DATAC2/ODA/DATAFILE/psapsr3750.308.1042757685';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.309.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.309.1042757687';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.310.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.310.1042757687';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3usr.311.1042757689' to
'+DATAC2/ODA/DATAFILE/psapsr3usr.311.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo002.312.1042757689' to
'+DATAC2/ODA/DATAFILE/psapundo002.312.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/big.341.1049019829' to
'+DATAC2/ODA/DATAFILE/big.341.1049019829';

set NEWNAME FOR TEMPFILE '+DATAC1/ODA/TEMPFILE/psaptemp.298.1042757001' to
'+DATAC2/ODA/TEMPFILE/psaptemp.298.1042757001';

restore database;
switch datafile all;
switch tempfile all;
}
```

13. Recover and open the database.

```
RMAN> recover database;

RMAN> alter database open resetlogs;
```

Example 2: RMAN Back Up, Restore, and Recover from an unencrypted Oracle 19c Source Database with existing TDE Configuration

This example illustrates the RMAN Back Up, Restore, and Recover migration method in detail by migrating an unencrypted source database, ODA, that has TDE configuration (an encryption wallet) from an on-premises Exadata to Exadata Cloud@Customer. It uses an NFS file system mounted at `/backup` as a shared media for backups. The database is encrypted while it is being restored.

You configure the RMAN backup targets (for example, on NFS) especially for the migration, and create an online backup of the source database that includes archive logs, the controlfile, and optionally, the spfile. Then you revert the backup targets to the old location after creating the backup.

On the source system, perform the following steps:

1. Create the required wallet location on ASM.

```
[oracle@node1 ~]$ asmcmd
ASMCMD> cd +DATAC1
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

   Note: If you are not using ASM on the source, you need to create the directory structure for the wallet on a file system.

2. Make necessary adjustments in the server parameter file on the source by adding the initialization parameters for TDE.

```
tde_configuration = 'KEYSTORE_CONFIGURATION=FILE'
wallet_root = '+DATAC1/ODA/orawallet'
```

3. Restart the database instances to make the changes take effect

4. Create the encryption wallet and autologin wallet.

```
SQL> select key_id,KEY_USE from v$encryption_keys;

no rows selected

SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE
'+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
```

```
SQL> alter system set "_db_discard_lost_masterkey"=TRUE;

System altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'MASTERKEY' FORCE KEYSTORE IDENTIFIED
BY "<password>" WITH BACKUP;

keystore altered.
```

The TDE configuration on the source is complete.

5. Take note of the current backup targets.

```
[oracle@myhost1 dbs]$ rman target /

Recovery Manager: Release 19.0.0.0.0 - Production on Tue Jan 5 15:30:32 2021
Version 19.9.0.0.0

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connected to target database: ODA (DBID=3151516788)

RMAN> show all;

using target database control file instead of recovery catalog
RMAN configuration parameters for database with db_unique_name ODA are:
CONFIGURE RETENTION POLICY TO REDUNDANCY 1; # default
CONFIGURE BACKUP OPTIMIZATION OFF; # default
CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default
CONFIGURE CONTROLFILE AUTOBACKUP ON; # default
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE DEVICE TYPE DISK PARALLELISM 16 BACKUP TYPE TO BACKUPSET;
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT   '<orig_location>/%U';
CONFIGURE MAXSETSIZE TO UNLIMITED; # default
CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE
; # default
CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/oracle/ODA/19/dbs/snapcf_ODA.f'; # default
```

6. As the `root` user, run the following commands:

```
mkdir /backup/mig_oda
chown oracle:oinstall /backup/mig_oda
```

7. As the `oracle` user with the source database environment set, run the following commands:

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '/backup/mig_oda/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '/backup/mig_oda/%U' MAXPIECESIZE 128 G;
SET ENCRYPTION OFF;

BACKUP DATABASE CURRENT CONTFOLFILE SPFILE PLUS ARCHIVELOG;
```

8. Create an Oracle parameter file (`pfile`) that contains all the `init.ora` parameters of the source system.

```
SQL> create pfile='/backup/mig_oda/init_oda.ora' from spfile;
```

9. Restore original backup locations.

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '<orig_location>/%U' MAXPIECESIZE 128 G;
```

On the target system, perform the following steps:

1. Make necessary adjustments for the target environment in the parameter file by adjusting file system and ASM disk group locations (for example, `audit_file_dest` and `db_recovery_file_dest`) and by adding the initialization parameters for TDE. Then, copy the parameter file to the `dbs` directory under the Oracle RDBMS Home on your target system. The parameter file needs to be only on one cluster node because it is required only during the migration of the database.

```
tde_configuration = 'KEYSTORE_CONFIGURATION=FILE'
wallet_root = '+DATAC2/ODA/orawallet'
```

2. Create the required wallet locations on ASM.

```
[oracle@node1 ~]$ asmcmd
ASMCMD> cd +DATAC2
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

3. Start the target database instance with the prepared parameter file into the `nomount` state.

```
SQL> startup nomount pfile='?/dbs/init_oda.ora';
ORACLE instance started.

Total System Global Area 6.8719E+10 bytes
Fixed Size                  26611816 bytes
Variable Size            3.3018E+10 bytes
Database Buffers         3.5568E+10 bytes
Redo Buffers              107601920 bytes
```

4. Restore the control file from backup.

```
RMAN> restore controlfile from '/backup/mig_oda/c-3151516788-20201009-00';

Starting restore at 09-OCT-20
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=2109 device type=DISK

channel ORA_DISK_1: restoring control file
channel ORA_DISK_1: restore complete, elapsed time: 00:00:03
output file name=+DATAC1/ODA/cntrloda.dbf
output file name=+RECOC1/ODA/cntrloda.dbf
Finished restore at 09-OCT-20
```

5. Mount the database.

```
RMAN> alter database mount;
```

6. Create the list of the `set newname` commands to be used in the next step. For example:

```
set linesize 1000
set serveroutput on
spool setnewname.sql

declare
  src_pat varchar2(50):='+DATAC1';
  tgt_pat varchar2(50):='+DATAC2';
  old_name varchar2(2000);
  new_name varchar2(2000);
begin
  src_pat:='^'||src_pat;
  for c1 in (select name from v$datafile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for datafile '||old_name||' to '||new_name||';');
  end loop;
  for c1 in (select name from v$tempfile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for tempfile '||old_name||' to '||new_name||';');
  end loop;
end;
/
spool off
```

7. If necessary, adjust the locations and names of all database-related files by using the `set newname` command during restore with the `as encrypted` clause.

```
RMAN> catalog start with '/backup/mig_oda/';
run {
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/system.295.1042756999' to
'+DATAC2/ODA/DATAFILE/system.295.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/sysaux.296.1042756999' to
'+DATAC2/ODA/DATAFILE/sysaux.296.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo001.297.1042757001' to
'+DATAC2/ODA/DATAFILE/psapundo001.297.1042757001';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.300.1042757673' to
'+DATAC2/ODA/DATAFILE/psapsr3.300.1042757673';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.301.1042757675' to
'+DATAC2/ODA/DATAFILE/psapsr3.301.1042757675';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.302.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.302.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.303.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.303.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.304.1042757679' to
'+DATAC2/ODA/DATAFILE/psapsr3.304.1042757679';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.305.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3.305.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.306.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3750.306.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.307.1042757683' to
'+DATAC2/ODA/DATAFILE/psapsr3750.307.1042757683';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.308.1042757685' to
'+DATAC2/ODA/DATAFILE/psapsr3750.308.1042757685';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.309.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.309.1042757687';
```

```
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.310.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.310.1042757687';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3usr.311.1042757689' to
'+DATAC2/ODA/DATAFILE/psapsr3usr.311.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo002.312.1042757689' to
'+DATAC2/ODA/DATAFILE/psapundo002.312.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/big.341.1049019829' to
'+DATAC2/ODA/DATAFILE/big.341.1049019829';

set NEWNAME FOR TEMPFILE '+DATAC1/ODA/TEMPFILE/psaptemp.298.1042757001' to
'+DATAC2/ODA/TEMPFILE/psaptemp.298.1042757001';

restore database as encrypted;
switch datafile all;
switch tempfile all;
}
```

8. Recover and open the database.

```
RMAN> recover database;

RMAN> alter database open resetlogs;
```

All the tablespaces should be reported as encrypted.

```
SQL> select TS#,ENCRYPTIONALG,ENCRYPTEDTS,STATUS from v$encrypted_tablespaces;

       TS# ENCRYPT ENC STATUS
---------- ------- --- ----------
         0 AES128  YES NORMAL
         1 AES128  YES NORMAL
         2 AES128  YES NORMAL
         4 AES128  YES NORMAL
         5 AES128  YES NORMAL
         6 AES128  YES NORMAL
         7 AES128  YES NORMAL
         8 AES128  YES NORMAL
         9 AES128  YES NORMAL
```

Example 3: RMAN Back Up, Restore, and Recover from an unencrypted Oracle 19c Source Database with no TDE Configuration

This example illustrates the RMAN Back Up, Restore, and Recover migration method in detail by migrating an unencrypted source database, ODA, without any TDE configuration from an on-premises Exadata to Exadata Cloud@Customer. It uses an NFS filesystem mounted at `/backup` as a shared media for backups. At the end of this example, two Oracle-native encryption methods are shown: offline and online.

You configure the RMAN backup targets (for example, on NFS) especially for the migration, and create an online backup of the source database that includes archive logs, the controlfile, and optionally, the spfile. You then revert the backup targets to the old location after creating the backup.

On the source system, perform the following steps:

1. Take note of the current backup targets.

```
[oracle@myhost1 dbs]$ rman target /

Recovery Manager: Release 19.0.0.0.0 - Production on Tue Jan 5 15:30:32 2021
Version 19.9.0.0.0

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connected to target database: ODA (DBID=3151516788)

RMAN> show all;

using target database control file instead of recovery catalog
RMAN configuration parameters for database with db_unique_name ODA are:
CONFIGURE RETENTION POLICY TO REDUNDANCY 1; # default
CONFIGURE BACKUP OPTIMIZATION OFF; # default
CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default
CONFIGURE CONTROLFILE AUTOBACKUP ON; # default
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE DEVICE TYPE DISK PARALLELISM 16 BACKUP TYPE TO BACKUPSET;
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT   '<orig_location>/%U';
CONFIGURE MAXSETSIZE TO UNLIMITED; # default
CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE
; # default
CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/oracle/ODA/19/dbs/snapcf_ODA.f'; # default
```

2. As the `root` user, run the following commands:

```
mkdir /backup/mig_oda
chown oracle:oinstall /backup/mig_oda
```

3. As the `oracle` user with the source database environment set, run the following commands:

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '/backup/mig_oda/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '/backup/mig_oda/%U' MAXPIECESIZE 128 G;
SET ENCRYPTION OFF;

BACKUP DATABASE CURRENT CONTFOLFILE SPFILE PLUS ARCHIVELOG;
```

4. Create an Oracle parameter file (`pfile`) that contains all the `init.ora` parameters of your source system.

```
SQL> create pfile='/backup/mig_oda/init_oda.ora' from spfile;
```

5. Restore the original backup locations.

```
[oracle@ dbs]$ rman target /

CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '<orig_location>/%F';
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '<orig_location>/%U' MAXPIECESIZE 128 G;
```

On the target system, perform the following steps:

1. Make necessary adjustments for the target environment in the parameter file by adjusting file system and ASM disk group locations (for example, `audit_file_dest` and `db_recovery_file_dest`) and by adding the initialization parameters for TDE. Then, copy the parameter file to the `dbs` directory under the Oracle RDBMS Home on your target system. The parameter file needs to be only on one cluster node because it is required only during the migration of the database.

```
tde_configuration = 'KEYSTORE_CONFIGURATION=FILE'
wallet_root = '+DATAC2/ODA/orawallet'
```

2. Create the required wallet locations on ASM.

```
[oracle@node1 ~]$ asmcmd
ASMCMD> cd +DATAC2
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

3. Start the target database instance with the prepared parameter file into the `nomount` state.

```
SQL> startup nomount pfile='?/dbs/init_oda.ora';
ORACLE instance started.

Total System Global Area 6.8719E+10 bytes
Fixed Size                  26611816 bytes
Variable Size            3.3018E+10 bytes
Database Buffers         3.5568E+10 bytes
Redo Buffers              107601920 bytes
```

4. Restore the controlfile from backup.

```
RMAN> restore controlfile from '/backup/mig_oda/c-3151516788-20201009-00';

Starting restore at 09-OCT-20
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=2109 device type=DISK

channel ORA_DISK_1: restoring control file
channel ORA_DISK_1: restore complete, elapsed time: 00:00:03
output file name=+DATAC1/ODA/cntrloda.dbf
output file name=+RECOC1/ODA/cntrloda.dbf
Finished restore at 09-OCT-20
```

5. Mount the database.

```
RMAN> alter database mount;
```

6. Create the list of the `set newname` commands to be used in the next step. For example:

```
set linesize 1000
set serveroutput on
spool setnewname.sql

declare
  src_pat varchar2(50):='+DATAC1';
  tgt_pat varchar2(50):='+DATAC2';
  old_name varchar2(2000);
  new_name varchar2(2000);
begin
```

```
  src_pat:='^'||src_pat;
  for c1 in (select name from v$datafile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for datafile '||old_name||' to '||new_name||';');
  end loop;
  for c1 in (select name from v$tempfile) loop
    old_name := ''''||c1.name||'''';
    new_name := ''''||REGEXP_REPLACE(c1.name,src_pat,tgt_pat)||'''';
    dbms_output.put_line('set newname for tempfile '||old_name||' to '||new_name||';');
  end loop;
end;
/
spool off
```

7. If necessary, adjust the locations and names of all database-related files by using the `set newname` command during restore.

```
RMAN> catalog start with '/backup/mig_oda/';
run {
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/system.295.1042756999' to
'+DATAC2/ODA/DATAFILE/system.295.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/sysaux.296.1042756999' to
'+DATAC2/ODA/DATAFILE/sysaux.296.1042756999';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo001.297.1042757001' to
'+DATAC2/ODA/DATAFILE/psapundo001.297.1042757001';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.300.1042757673' to
'+DATAC2/ODA/DATAFILE/psapsr3.300.1042757673';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.301.1042757675' to
'+DATAC2/ODA/DATAFILE/psapsr3.301.1042757675';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.302.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.302.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.303.1042757677' to
'+DATAC2/ODA/DATAFILE/psapsr3.303.1042757677';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.304.1042757679' to
'+DATAC2/ODA/DATAFILE/psapsr3.304.1042757679';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3.305.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3.305.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.306.1042757681' to
'+DATAC2/ODA/DATAFILE/psapsr3750.306.1042757681';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.307.1042757683' to
'+DATAC2/ODA/DATAFILE/psapsr3750.307.1042757683';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.308.1042757685' to
'+DATAC2/ODA/DATAFILE/psapsr3750.308.1042757685';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.309.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.309.1042757687';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3750.310.1042757687' to
'+DATAC2/ODA/DATAFILE/psapsr3750.310.1042757687';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapsr3usr.311.1042757689' to
'+DATAC2/ODA/DATAFILE/psapsr3usr.311.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/psapundo002.312.1042757689' to
'+DATAC2/ODA/DATAFILE/psapundo002.312.1042757689';
set NEWNAME FOR DATAFILE '+DATAC1/ODA/DATAFILE/big.341.1049019829' to
'+DATAC2/ODA/DATAFILE/big.341.1049019829';

set NEWNAME FOR TEMPFILE '+DATAC1/ODA/TEMPFILE/psaptemp.298.1042757001' to
'+DATAC2/ODA/TEMPFILE/psaptemp.298.1042757001';

restore database;
```

```
switch datafile all;
switch tempfile all;
}
```

8. Recover and open the database.

```
RMAN> recover database;

RMAN> alter database open resetlogs;
```

9. Create an encryption wallet and autologin wallet.

```
SQL> select key_id,KEY_USE from v$encryption_keys;

no rows selected

SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE
'+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>";

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.

SQL> alter system set "_db_discard_lost_masterkey"=TRUE;

System altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'MASTERKEY' FORCE KEYSTORE IDENTIFIED
BY "<password>" WITH BACKUP;

keystore altered.
```

10. For offline encryption of the whole database, encrypt the SYSTEM and UNDO tablespaces in the `mount` state, open the database, set all the remaining permanent tablespaces offline, and start an encryption job for each data file. If you want to perform online encryption, skip to the next step.

    Note: The following example script uses all available Oracle job queue processes to encrypt data files as fast as possible in parallel and might consume a large amount of CPU resources. If other systems are running on the same host, we recommend configuring the Oracle job queue processes to a value that does not allocate more CPU resources than is reasonable.

```
shutdown immediate;
startup mount;

ALTER TABLESPACE SYSTEM ENCRYPTION OFFLINE ENCRYPT;
ALTER TABLESPACE PSAPUNDO001 ENCRYPTION OFFLINE ENCRYPT;
ALTER TABLESPACE PSAPUNDO002 ENCRYPTION OFFLINE ENCRYPT;
ALTER DATABASE OPEN;

declare
  cmd1 varchar2(32767);
  cmd2 varchar2(32767);
  job_cmd varchar2(32767);
```

```
  jobname varchar2(32767);
  prefix varchar2(512);
begin
  for t1 in (SELECT tablespace_name from dba_tablespaces where contents<>'TEMPORARY'
and contents<>'UNDO' and tablespace_name<>'SYSTEM') loop
    cmd1:='ALTER TABLESPACE '|| t1.tablespace_name ||' OFFLINE';
    begin
      execute immediate cmd1;
      exception
        when others then null;
    end;

    for f1 in (select file_name from dba_data_files where tablespace_name =
t1.tablespace_name) loop
      cmd2:='ALTER DATABASE DATAFILE '||''''||''''||f1.file_name||''''||''''||'
ENCRYPT';

      job_cmd:='BEGIN EXECUTE IMMEDIATE '''||cmd2||'''; END;';

      prefix:=substr(t1.tablespace_name||'ENC',1,18);
      jobname:=dbms_scheduler.generate_job_name(prefix);
      dbms_scheduler.create_job(job_name => jobname,job_type =>
'PLSQL_BLOCK',job_action => job_cmd,enabled => FALSE);
      dbms_scheduler.run_job(job_name => jobname,use_current_session => FALSE);
---      dbms_output.put_line(job_cmd);
    end loop;
  end loop;
end;
/
```

You can monitor the process by using the OS utility `top`, which shows numerous job queue processes consuming CPU time for encryption; by using `V$ENCRYPTED_TABLESPACES`; or by checking the status of the generated jobs in `DBA_SCHEDULER_JOBS`. For example:

```
Output of top:
376750 oracle    20   0   26.4g  99580  89440 S  26.8  0.1   0:02.93 ora_j007_MFG001
376512 oracle    20   0   26.7g  99684  89536 S  25.8  0.1   0:03.01 ora_j004_MFG001
376488 oracle    20   0   26.7g 106832  95292 S  24.8  0.1   0:03.12 ora_j000_MFG001
378349 oracle    20   0   26.7g  99120  89060 R  24.8  0.1   0:02.78 ora_j008_MFG001
378357 oracle    20   0   26.7g  99588  89432 R  24.5  0.1   0:02.46 ora_j00b_MFG001
376499 oracle    20   0   26.4g  98892  88844 R  22.5  0.1   0:02.85 ora_j003_MFG001
376495 oracle    20   0   26.7g  99832  89664 S  21.9  0.1   0:02.93 ora_j002_MFG001
376490 oracle    20   0   26.7g  99612  89472 S  21.2  0.1   0:02.58 ora_j001_MFG001
378360 oracle    20   0   26.4g 102676  92488 S  20.3  0.1   0:02.53 ora_j00c_MFG001
378353 oracle    20   0   26.7g  99784  89632 S  19.9  0.1   0:02.27 ora_j009_MFG001
376642 oracle    20   0   26.7g  99244  89164 S  19.6  0.1   0:02.82 ora_j006_MFG001
376558 oracle    20   0   26.4g  99284  89132 S  18.0  0.1   0:02.46 ora_j005_MFG001

Out of of V$ENCRYPTED_TABLESPACES:

SQL> select TS#,STATUS,ENCRYPTIONALG from V$ENCRYPTED_TABLESPACES;

       TS# STATUS     ENCRYPT
---------- ---------- -------
         0 NORMAL     AES128
         1 NORMAL     AES128
         2 NORMAL     AES128
         4 ENCRYPTING AES128
```

```
         5 ENCRYPTING AES128
         6 NORMAL     AES128
         7 NORMAL     AES128
         8 NORMAL     AES128
```

Regularly check the status of the encryption process. When all the data files are encrypted, set all the tablespaces back online. For example:

```
declare
  cmd1 varchar2(32767);
begin
  for t1 in (SELECT tablespace_name from dba_tablespaces where contents='PERMANENT' and
tablespace_name<>'SYSTEM') loop
    cmd1:='ALTER TABLESPACE '|| t1.tablespace_name ||' ONLINE';
    begin
      execute immediate cmd1;
      exception
        when others then null;
    end;
  end loop;
end;
/
```

11. For online encryption of the whole database, run the following PL/SQL script. Modify it to match your needs before running it.

    Note: The following example script uses all available Oracle job queue processes to encrypt tablespaces as fast as possible in parallel. Depending on the number of tablespaces, it might consume a large amount of CPU resources. We recommend configuring the Oracle job queue processes to a value that won't allocate more CPU resources than is reasonable.

```
declare
  old_file varchar2(500);
  new_file varchar2(500);
  cmd varchar2(32767);
  job_cmd varchar2(32767);
  jobname varchar2(32767);
  file_nr number;
  suffix varchar2(16):='_enc';
  prefix varchar2(512);
begin
  for t1 in (select tablespace_name from dba_tablespaces where contents<>'TEMPORARY')
loop
    file_nr := 1;
    cmd := 'ALTER TABLESPACE '||t1.tablespace_name||' ENCRYPTION ONLINE ENCRYPT
FILE_NAME_CONVERT=(';
    for f1 in (select file_name from dba_data_files where tablespace_name =
t1.tablespace_name) loop
      if file_nr>1 then
        cmd:=cmd||',';
      end if;
      old_file := f1.file_name;
      if instr(old_file,'.')>1 then
        new_file := substr(old_file,1,instr(old_file,'.')-
1)||lpad(to_char(file_nr),3,'0')||suffix||'.dbf';
      else
        new_file := old_file||lpad(to_char(file_nr),3,'0')||suffix||'.dbf';
      end if;
```

```
      file_nr:=file_nr+1;

cmd:=cmd||''''||''''||old_file||''''||''''||',''||''''||''''||new_file||''''||'''';
    end loop;
    cmd:=cmd||')';

    job_cmd:='BEGIN EXECUTE IMMEDIATE '''||cmd||'''; END;';

    prefix:=substr(t1.tablespace_name||'ENC',1,18);
    jobname:=dbms_scheduler.generate_job_name(prefix);
    dbms_scheduler.create_job(job_name => jobname,job_type => 'PLSQL_BLOCK',job_action
=> job_cmd,enabled => FALSE);
    dbms_scheduler.run_job(job_name => jobname,use_current_session => FALSE);
  end loop;
end;
/
```

12. Create an encrypted temporary tablespace to replace your unencrypted PSAPTEMP tablespace.

```
CREATE TEMPORARY TABLESPACE PSAPTEMP_ENC TEMPFILE '+DATAC2' SIZE 32767M ENCRYPTION
ENCRYPT;
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE PSAPTEMP_ENC;
DROP TABLESPACE PSAPTEMP;
ALTER TABLESPACE PSAPTEMP_ENC RENAME TO PSAPTEMP;
```

Duplicate Database Method

This section provides the major steps and several examples for using the RMAN Duplicate Database method for migration.

Prerequisites

RMAN Duplicate Database does not require a shared file system for backup and restore. Instead, it uses a SQL*Net connection to copy the mounted or opened source database to the target. If the copy was taken from a source database in the `open` state, the target database is automatically recovered and opened at the end of the process.

Because this method uses SQL*Net, we strongly recommend configuring dedicated SQL*Net connections and Oracle listeners solely for the duplication process. Doing so avoids conflicts with existing Oracle listeners controlled by Oracle Grid Infrastructure, and the listeners can be removed quickly after duplication. Also, SQL*Net and listeners are configured to work in two directions (source-to-target and target-to-source) because RMAN can either push or pull the source database. This depends on where it is started, the source or target system.

The RMAN `as encrypted` clause is supported only with Oracle Database 19c and the latest SAP Bundle Patch. If your source database is not already encrypted with TDE, then encryption is a post-duplication task for Oracle Database 12.1, 12.2, and 18c.

Migration Steps

1. Create a password file on the target under `$ORACLE_HOME/dbs`.
2. Prepare an Oracle initialization parameter file to start the target database instance into the `nomount` state.
   - If the database is 19c, set up the `tde_configuration` and `wallet_root` initialization parameters as part of the TDE configuration.
   - If the database is 12.1, 12.2, or 18c, set up your TDE configuration in `sqlnet.ora`.
   - Set up initialization parameters (for example, `db_file_name_convert` or `log_file_name_convert`) for name conversions if necessary or, alternatively, use the `set newname` option during duplication.
3. Configure SQL*Net and Oracle listeners on the source and target, and verify that the connections work in both directions.
4. If the source database is already encrypted with TDE, transport the contents of the encryption wallet to the target:
   A. Create a temporary encryption wallet on the file system.
   B. Merge the encryption keys from the source into the temporary encryption wallet.
   C. If required, copy the temporary encryption wallet to a file system location that can be accessed from the target system.
5. If the source database is not encrypted but TDE has been set up on it (it has an active encryption wallet and master key but no encrypted tablespaces), perform one of the following actions:
   - (Recommended) Set up a new encryption wallet with a master key on the target after you restore the controlfile from the backup.
   - Migrate the encryption keys from the source to the target, as directed in step 4.
6. If the source database is not encrypted and has no TDE set up (no active encryption wallet), you must create an encryption wallet with encryption keys and an autologin wallet on the target system in a later step.
7. Place your prepared Oracle parameter file (`pfile`) on the target system and start the target database instance into the `nomount` state.
8. Create the required directory for the encryption wallet in ASM.
9. If the source database was encrypted with TDE, perform these steps:
   A. Create an empty encryption wallet on ASM on the target system.
   B. Merge the encryption keys from the previously created temporary encryption wallet into your new encryption wallet on ASM and open it.
   C. Create an autologin wallet.

10. If the source database was not encrypted but was configured for TDE, perform one of the following actions:
    - Create an encryption wallet with a master key after duplication of the database and encrypt your database manually.
    - If you want to run RMAN duplicate database with the `as encrypted` clause transport the encryption keys from the source into a new encryption wallet on the target, as directed in step 9. Shut down the database instance and start it again into the `nomount` state. Verify that the encryption wallet opens automatically and that the encryption keys are present.
11. If the source database was not encrypted and had no TDE configuration, perform these steps:
    - Create an encryption wallet with a master key after duplication of the database and encrypt your database manually.
12. Run duplication of the source database.
13. If you decided to run RMAN duplicate database without `as encrypted` clause create a new encryption wallet with a new master key and encrypt your database manually by performing the following steps:
    A. Create an empty encryption wallet on ASM on the target system.
    B. Create and set a master key in the new encryption wallet.
    C. Create an autologin wallet.
    D. Encrypt your database manually

Example 1: RMAN Duplicate from an encrypted Oracle 19c Source Database

This example illustrates the RMAN Duplicate migration method in detail by migrating an encrypted source database, ODA, from an on-premises Exadata to Exadata Cloud@Customer.

On the source system, perform the following steps:

1. Create a temporary encryption wallet on the file system.

```
ADMINISTER KEY MANAGEMENT CREATE KEYSTORE '/tmp/' identified by "<password>";
```

2. Merge the encryption keys from the source into the temporary encryption wallet.

```
ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '+DATAC1/ODA/orawallet/tde/' INTO EXISTING
KEYSTORE '/tmp/' IDENTIFIED BY "<password>" WITH BACKUP;
```

3. If required, copy the temporary encryption wallet to a file system location that can be accessed from the target system.

```
[oracle@myhost1 ~]$ scp /tmp/ewallet.p12 myhost2:/tmp
```

4. Configure SQL*Net and Oracle Listener on the source and target and verify that the connections work in both directions.
    A. Create a `listener.ora` file on the source and start it.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERORG =
 (SID_LIST =
  (SID_DESC =
```

```
    (SID_NAME = ODA)
    (ORACLE_HOME = /oracle/ODA/19)
   )
  )
LISTENERORG =
  (DESCRIPTION_LIST =
   (DESCRIPTION =
    (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
   )
  )

[oracle@myhost1 ~]$ lsnrctl start LISTENERORG

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:47:44

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Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost1)(PORT=1600)))
STATUS of the LISTENER
------------------------
Alias                     LISTENERORG
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:47:44
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File
/oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

B. Configure a `tnsnames.ora` file.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
```

```
    (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

On the target system, perform the following steps:

1. Create an Oracle password file under `$ORACLE_HOME/dbs`.

```
[oracle@myhost2 dbs]$ orapwd file=orapwODA password=__Oracle123 force=y
```

2. Prepare an Oracle initialization parameter file to start the target database instance into the `nomount` state.

```
[oracle@myhost2 dbs]$ cat initODA.ora
_kolfuseslf=TRUE
_disable_directory_link_check=TRUE
db_name='ODA'
memory_max_target=10G
memory_target=8G
tde_configuration='KEYSTORE_CONFIGURATION=FILE'
wallet_root='+DATAC1/ODA/orawallet'
control_files='+DATAC1/ODA/cntrlODA.dbf'
cluster_database='FALSE'
```

3. Configure SQL*Net and Oracle Listener on the source and target and verify that the connections work in both directions.

   A. Create a `listener.ora` file on the target and start it.

```
[oracle@myhost2 dbs]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERDUP =
 (SID_LIST =
  (SID_DESC =
   (SID_NAME = ODA)
   (ORACLE_HOME = /oracle/ODA/19)
  )
 )
LISTENERDUP =
 (DESCRIPTION_LIST =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
 )

[oracle@myhost2 dbs]$ lsnrctl start LISTENERDUP

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:50:43

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Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost2)(PORT=1600)))
```

```
STATUS of the LISTENER
------------------------
Alias                     LISTENERDUP
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:50:43
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File
/oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

B. Configure a `tnsnames.ora` file.

```
[oracle@myhost2 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

4. Create the required directory for the encryption wallet in ASM.

```
[oracle@myhost2 ~]$ asmcmd
ASMCMD> cd +DATAC1
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

5. Start the target instance into the `nomount` state by using the prepared parameter file.

```
SQL> startup nomount pfile='?/dbs/initODA.ora"
ORACLE instance started.
```

6. Create an empty encryption wallet on ASM on the target system.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE IDENTIFIED BY "<password>";

keystore altered.
```

7. Merge the encryption keys from the previously created temporary encryption wallet into the new encryption wallet on ASM, and open it.

```
SQL> ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '/tmp/' IDENTIFIED BY "<password>" INTO
EXISTING KEYSTORE '+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>" WITH BACKUP;

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
```

8. Restart the target instance into the `nomount` state by using the prepared parameter file.
9. Open the encryption wallet and create an autologin wallet.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE IDENTIFIED BY
"<password>";

keystore altered.
```

10. Restart the target instance into the `nomount` state by using the prepared parameter file and verify that the encryption wallet opens automatically.

```
SQL> select WRL_TYPE,STATUS,WALLET_TYPE,WALLET_ORDER,KEYSTORE_MODE from
v$encryption_wallet;

WRL_TYPE             STATUS                         WALLET_TYPE          WALLET_OR
KEYSTORE
-------------------- ------------------------------ -------------------- --------- ----
----
FILE                 OPEN                           AUTOLOGIN            SINGLE    NONE
```

On the source system, run duplication of the source database.

```
connect target sys/"__Oracle123"@ORGODA
connect auxiliary sys/"__Oracle123"@DUPODA

run {
ALLOCATE CHANNEL t1 DEVICE TYPE disk;
ALLOCATE CHANNEL t2 DEVICE TYPE disk;
ALLOCATE CHANNEL t3 DEVICE TYPE disk;
ALLOCATE CHANNEL t4 DEVICE TYPE disk;
ALLOCATE CHANNEL t5 DEVICE TYPE disk;
ALLOCATE CHANNEL t6 DEVICE TYPE disk;
ALLOCATE CHANNEL t7 DEVICE TYPE disk;
ALLOCATE CHANNEL t8 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a1 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a2 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a3 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a4 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a5 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a6 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a7 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a8 DEVICE TYPE disk;
duplicate target database to ODA from active database using backupset nofilenamecheck;
}
```

Example 2: RMAN Duplicate from an unencrypted Oracle 19c Source Database with existing TDE Configuration

This example illustrates the RMAN Duplicate migration method in detail by migrating an unencrypted source database, ODA, from an on-premises Exadata to Exadata Cloud@Customer. The source database has an existing TDE configuration (encryption wallet).

On the source system, perform the following steps:

1. Create a temporary encryption wallet on the file system.

```
ADMINISTER KEY MANAGEMENT CREATE KEYSTORE '/tmp/' identified by "<password>";
```

2. Merge the encryption keys from the source into the temporary encryption wallet.

```
ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '+DATAC1/ODA/orawallet/tde/' INTO EXISTING
KEYSTORE '/tmp/' IDENTIFIED BY "<password>" WITH BACKUP;
```

3. If required, copy the temporary encryption wallet to a file system location that can be accessed from the target system.

```
[oracle@myhost1 ~]$ scp /tmp/ewallet.p12 myhost2:/tmp
```

4. Configure SQL*Net and Oracle Listener on the source and target, and verify that the connections work in both directions.

   A. Create a `listener.ora` file on the source and start it.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERORG =
 (SID_LIST =
  (SID_DESC =
   (SID_NAME = ODA)
   (ORACLE_HOME = /oracle/ODA/19)
  )
 )
LISTENERORG =
 (DESCRIPTION_LIST =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
 )

[oracle@myhost1 ~]$ lsnrctl start LISTENERORG

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:47:44

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Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost1)(PORT=1600)))
STATUS of the LISTENER
------------------------
```

```
Alias                     LISTENERORG
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:47:44
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File
/oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

B. Configure a `tnsnames.ora` file.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

On the target system, perform the following steps:

1. Create an Oracle password file under `$ORACLE_HOME/dbs`.

```
[oracle@myhost2 dbs]$ orapwd file=orapwODA password=__Oracle123 force=y
```

2. Prepare an Oracle initialization parameter file to start the target database instance into the `nomount` state.

```
[oracle@myhost2 dbs]$ cat initODA.ora
_kolfuseslf=TRUE
_disable_directory_link_check=TRUE
db_name='ODA'
memory_max_target=10G
memory_target=8G
tde_configuration='KEYSTORE_CONFIGURATION=FILE'
wallet_root='+DATAC1/ODA/orawallet'
control_files='+DATAC1/ODA/cntrlODA.dbf'
cluster_database='FALSE'
```

3. Configure SQL*Net and Oracle Listener on the source and target, and verify that the connections work in both directions.

   A. Create a `listener.ora` file on the target and start it.

```
[oracle@myhost2 dbs]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERDUP =
 (SID_LIST =
  (SID_DESC =
   (SID_NAME = ODA)
   (ORACLE_HOME = /oracle/ODA/19)
  )
 )
LISTENERDUP =
 (DESCRIPTION_LIST =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
 )

[oracle@myhost2 dbs]$ lsnrctl start LISTENERDUP

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:50:43

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Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost2)(PORT=1600)))
STATUS of the LISTENER
------------------------
Alias                     LISTENERDUP
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:50:43
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File
/oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

B. Configure a `tnsnames.ora` file.

```
[oracle@myhost2 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

4. Create the required directory for the encryption wallet in ASM.

```
[oracle@myhost2 ~]$ asmcmd
ASMCMD> cd +DATAC1
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

5. Start the target instance into the `nomount` state by using the prepared parameter file.

```
SQL> startup nomount pfile='?/dbs/initODA.ora"
ORACLE instance started.
```

6. Create an empty encryption wallet on ASM on the target system.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE IDENTIFIED BY "<password>";

keystore altered.
```

7. Merge the encryption keys from the previously created temporary encryption wallet into the new encryption wallet on ASM, and open it.

```
SQL> ADMINISTER KEY MANAGEMENT MERGE KEYSTORE '/tmp/' IDENTIFIED BY "<password>" INTO
EXISTING KEYSTORE '+DATAC1/ODA/orawallet/tde/' IDENTIFIED BY "<password>" WITH BACKUP;

keystore altered.

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
```

8. Restart the target instance into `nomount` state by using the prepared parameter file.

9. Open the encryption wallet and create an autologin wallet.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE IDENTIFIED BY
"<password>";

keystore altered.
```

10. Restart the target instance into the `nomount` state by using the prepared parameter file and verify that the encryption wallet opens automatically.

```
SQL> select WRL_TYPE,STATUS,WALLET_TYPE,WALLET_ORDER,KEYSTORE_MODE from
v$encryption_wallet;

WRL_TYPE             STATUS                         WALLET_TYPE          WALLET_OR
KEYSTORE
-------------------- ------------------------------ -------------------- --------- ----
----
FILE                 OPEN                           AUTOLOGIN            SINGLE    NONE
```

On the source system, run duplication of the source database.

```
connect target sys/"__Oracle123"@ORGODA
connect auxiliary sys/"__Oracle123"@DUPODA

run {
ALLOCATE CHANNEL t1 DEVICE TYPE disk;
ALLOCATE CHANNEL t2 DEVICE TYPE disk;
ALLOCATE CHANNEL t3 DEVICE TYPE disk;
ALLOCATE CHANNEL t4 DEVICE TYPE disk;
ALLOCATE CHANNEL t5 DEVICE TYPE disk;
ALLOCATE CHANNEL t6 DEVICE TYPE disk;
ALLOCATE CHANNEL t7 DEVICE TYPE disk;
ALLOCATE CHANNEL t8 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a1 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a2 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a3 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a4 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a5 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a6 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a7 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a8 DEVICE TYPE disk;
duplicate target database to ODA from active database using backupset as encrypted
nofilenamecheck;
}
```

Example 3: RMAN Duplicate from an unencrypted Oracle 19c Source Database with no TDE Configuration

This example illustrates the RMAN Duplicate migration method in detail by migrating an unencrypted source database, ODA, from an on-premises Exadata to Exadata Cloud@Customer. The source database has no existing TDE configuration (encryption wallet). TDE encryption is implemented on the target after duplication.

On the source system, configure SQL*Net and Oracle Listener on the source and target and verify that the connections work in both directions:

1. Create a `listener.ora` file on the source and start it.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERORG =
 (SID_LIST =
  (SID_DESC =
   (SID_NAME = ODA)
   (ORACLE_HOME = /oracle/ODA/19)
  )
 )
LISTENERORG =
 (DESCRIPTION_LIST =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
 )

[oracle@myhost1 ~]$ lsnrctl start LISTENERORG

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:47:44

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Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost1)(PORT=1600)))
STATUS of the LISTENER
------------------------
Alias                     LISTENERORG
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:47:44
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File         /oracle/base/diag/tnslsnr/migtest1/listenerorg/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost1)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

2. Configure a `tnsnames.ora` file.

```
[oracle@myhost1 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
```

```
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

On the target system, perform the following steps:

1. Create an Oracle password file under `$ORACLE_HOME/dbs`.

```
[oracle@myhost2 dbs]$ orapwd file=orapwODA password=__Oracle123 force=y
```

2. Prepare an Oracle initialization parameter file to start the target database instance into the `nomount` state.

```
[oracle@myhost2 dbs]$ cat initODA.ora
_kolfuseslf=TRUE
_disable_directory_link_check=TRUE
db_name='ODA'
memory_max_target=10G
memory_target=8G
tde_configuration='KEYSTORE_CONFIGURATION=FILE'
wallet_root='+DATAC1/ODA/orawallet'
control_files='+DATAC1/ODA/cntrlODA.dbf'
cluster_database='FALSE'
```

3. Configure SQL*Net and Oracle Listener on the source and target and verify that the connections work in both directions.

   A. Create a `listener.ora` file on the target and start it.

```
[oracle@myhost2 dbs]$ cat $ORACLE_HOME/network/admin/listener.ora
SID_LIST_LISTENERDUP =
 (SID_LIST =
  (SID_DESC =
   (SID_NAME = ODA)
   (ORACLE_HOME = /oracle/ODA/19)
  )
 )
LISTENERDUP =
 (DESCRIPTION_LIST =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
 )

[oracle@myhost2 dbs]$ lsnrctl start LISTENERDUP

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-JAN-2021 19:50:43

Copyright (c) 1991, 2020, Oracle.  All rights reserved.

Starting /oracle/ODA/19/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
```

```
System parameter file is /oracle/ODA/19/network/admin/listener.ora
Log messages written to /oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=myhost2)(PORT=1600)))
STATUS of the LISTENER
------------------------
Alias                     LISTENERDUP
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-JAN-2021 19:50:43
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /oracle/ODA/19/network/admin/listener.ora
Listener Log File
/oracle/base/diag/tnslsnr/migtest2/listenerdup/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=myhost2)(PORT=1600)))
Services Summary...
Service "ODA" has 1 instance(s).
  Instance "ODA", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

B. Configure a `tnsnames.ora` file.

```
[oracle@myhost2 ~]$ cat $ORACLE_HOME/network/admin/tnsnames.ora
ORGODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost1)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
DUPODA =
 (DESCRIPTION =
  (ADDRESS_LIST =
   (ADDRESS = (PROTOCOL = TCP)(HOST = myhost2)(PORT = 1600))
  )
  (CONNECT_DATA =
   (SERVICE_NAME = ODA)
  )
 )
```

4. Start the target instance into the `nomount` state by using the prepared parameter file.

```
SQL> startup nomount pfile='?/dbs/initODA.ora"
ORACLE instance started.
```

On the source system, run duplication of the source database.

```
connect target sys/"__Oracle123"@ORGODA
connect auxiliary sys/"__Oracle123"@DUPODA

run {
ALLOCATE CHANNEL t1 DEVICE TYPE disk;
ALLOCATE CHANNEL t2 DEVICE TYPE disk;
ALLOCATE CHANNEL t3 DEVICE TYPE disk;
```

```
ALLOCATE CHANNEL t4 DEVICE TYPE disk;
ALLOCATE CHANNEL t5 DEVICE TYPE disk;
ALLOCATE CHANNEL t6 DEVICE TYPE disk;
ALLOCATE CHANNEL t7 DEVICE TYPE disk;
ALLOCATE CHANNEL t8 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a1 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a2 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a3 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a4 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a5 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a6 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a7 DEVICE TYPE disk;
ALLOCATE AUXILIARY CHANNEL a8 DEVICE TYPE disk;
duplicate target database to ODA from active database using backupset nofilenamecheck;
}
```

On the target system, perform the following steps:

1. Create the required directory for the encryption wallet in ASM.

```
[oracle@myhost2 ~]$ asmcmd
ASMCMD> cd +DATAC1
ASMCMD> mkdir ODA
ASMCMD> cd ODA
ASMCMD> mkdir orawallet
ASMCMD> mkdir orawallet/tde
```

2. Restart the target database into the `open` state.
3. Create an empty encryption wallet on ASM on the target system.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE IDENTIFIED BY "<password>";

keystore altered.
```

4. Open the encryption wallet and set a new master key.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
SQL> alter system set "_db_discard_lost_masterkey"=TRUE;

System altered.
SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'MASTERKEY' FORCE KEYSTORE IDENTIFIED
BY "<password>" WITH BACKUP;

keystore altered.
```

5. Restart the target database into the `open` state.
6. Open the encryption wallet and create an autologin wallet.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY "<password>";

keystore altered.
SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM KEYSTORE IDENTIFIED BY
"<password>";

keystore altered.
```

7. Restart the target instance into the `open` state by using the prepared parameter file and verify that the encryption wallet opens automatically.

```
SQL> select WRL_TYPE,STATUS,WALLET_TYPE,WALLET_ORDER,KEYSTORE_MODE from
v$encryption_wallet;

WRL_TYPE             STATUS                         WALLET_TYPE          WALLET_OR
KEYSTORE
-------------------- ------------------------------ -------------------- --------- ----
----
FILE                 OPEN                           AUTOLOGIN            SINGLE    NONE
```

8. Shut down the database again.

9. For offline encryption of the whole database, encrypt the SYSTEM and UNDO tablespaces in the `mount` state, open the database, set all the remaining permanent tablespaces offline and start an encryption job for each data file. If you want to perform online encryption, skip to the next step.

```
shutdown immediate;
startup mount;

ALTER TABLESPACE SYSTEM ENCRYPTION OFFLINE ENCRYPT;
ALTER TABLESPACE PSAPUNDO001 ENCRYPTION OFFLINE ENCRYPT;
ALTER TABLESPACE PSAPUNDO002 ENCRYPTION OFFLINE ENCRYPT;
ALTER DATABASE OPEN;

declare
  cmd1 varchar2(32767);
  cmd2 varchar2(32767);
  job_cmd varchar2(32767);
  jobname varchar2(32767);
  prefix varchar2(512);
begin
  for t1 in (SELECT tablespace_name from dba_tablespaces where contents<>'TEMPORARY'
and contents<>'UNDO' and tablespace_name<>'SYSTEM') loop
    cmd1:='ALTER TABLESPACE '|| t1.tablespace_name ||' OFFLINE';
    begin
      execute immediate cmd1;
      exception
        when others then null;
    end;

    for f1 in (select file_name from dba_data_files where tablespace_name =
t1.tablespace_name) loop
      cmd2:='ALTER DATABASE DATAFILE '||''''||''''||f1.file_name||''''||''''||'
ENCRYPT';

      job_cmd:='BEGIN EXECUTE IMMEDIATE '''||cmd2||'''; END;';

      prefix:=substr(t1.tablespace_name||'ENC',1,18);
      jobname:=dbms_scheduler.generate_job_name(prefix);
      dbms_scheduler.create_job(job_name => jobname,job_type =>
'PLSQL_BLOCK',job_action => job_cmd,enabled => FALSE);
      dbms_scheduler.run_job(job_name => jobname,use_current_session => FALSE);
---      dbms_output.put_line(job_cmd);
    end loop;
  end loop;
end;
/
```

You can monitor the process by using the OS utility `top`, which shows numerous job queue processes consuming CPU time for encryption; by using `V$ENCRYPTED_TABLESPACES`; or by checking the status of the generated jobs in `DBA_SCHEDULER_JOBS`. For example:

```
Output of top:
376750 oracle    20   0   26.4g  99580  89440 S  26.8  0.1   0:02.93 ora_j007_MFG001
376512 oracle    20   0   26.7g  99684  89536 S  25.8  0.1   0:03.01 ora_j004_MFG001
376488 oracle    20   0   26.7g 106832  95292 S  24.8  0.1   0:03.12 ora_j000_MFG001
378349 oracle    20   0   26.7g  99120  89060 R  24.8  0.1   0:02.78 ora_j008_MFG001
378357 oracle    20   0   26.7g  99588  89432 R  24.5  0.1   0:02.46 ora_j00b_MFG001
376499 oracle    20   0   26.4g  98892  88844 R  22.5  0.1   0:02.85 ora_j003_MFG001
376495 oracle    20   0   26.7g  99832  89664 S  21.9  0.1   0:02.93 ora_j002_MFG001
376490 oracle    20   0   26.7g  99612  89472 S  21.2  0.1   0:02.58 ora_j001_MFG001
378360 oracle    20   0   26.4g 102676  92488 S  20.3  0.1   0:02.53 ora_j00c_MFG001
378353 oracle    20   0   26.7g  99784  89632 S  19.9  0.1   0:02.27 ora_j009_MFG001
376642 oracle    20   0   26.7g  99244  89164 S  19.6  0.1   0:02.82 ora_j006_MFG001
376558 oracle    20   0   26.4g  99284  89132 S  18.0  0.1   0:02.46 ora_j005_MFG001

Out of of V$ENCRYPTED_TABLESPACES:

SQL> select TS#,STATUS,ENCRYPTIONALG from V$ENCRYPTED_TABLESPACES;

       TS# STATUS     ENCRYPT
---------- ---------- -------
         0 NORMAL     AES128
         1 NORMAL     AES128
         2 NORMAL     AES128
         4 ENCRYPTING AES128
         5 ENCRYPTING AES128
         6 NORMAL     AES128
         7 NORMAL     AES128
         8 NORMAL     AES128
```

When all the data files are encrypted, set all the tablespaces back online. For example:

```
declare
  cmd1 varchar2(32767);
begin
  for t1 in (SELECT tablespace_name from dba_tablespaces where contents='PERMANENT' and
tablespace_name<>'SYSTEM') loop
    cmd1:='ALTER TABLESPACE '|| t1.tablespace_name ||' ONLINE';
    begin
      execute immediate cmd1;
      exception
        when others then null;
    end;
  end loop;
end;
/
```

10. For online encryption of the whole database, run the following PL/SQL script. Modify it to match your needs before running it.

```
declare
  old_file varchar2(500);
  new_file varchar2(500);
  cmd varchar2(32767);
  job_cmd varchar2(32767);
```

```
  jobname varchar2(32767);
  file_nr number;
  suffix varchar2(16):='_enc';
  prefix varchar2(512);
begin
  for t1 in (select tablespace_name from dba_tablespaces where contents<>'TEMPORARY')
loop
    file_nr := 1;
    cmd := 'ALTER TABLESPACE '||t1.tablespace_name||' ENCRYPTION ONLINE ENCRYPT
FILE_NAME_CONVERT=(';
    for f1 in (select file_name from dba_data_files where tablespace_name =
t1.tablespace_name) loop
      if file_nr>1 then
        cmd:=cmd||',';
      end if;
      old_file := f1.file_name;
      if instr(old_file,'.')>1 then
        new_file := substr(old_file,1,instr(old_file,'.')-
1)||lpad(to_char(file_nr),3,'0')||suffix||'.dbf';
      else
        new_file := old_file||lpad(to_char(file_nr),3,'0')||suffix||'.dbf';
      end if;
      file_nr:=file_nr+1;

cmd:=cmd||''''||''''||old_file||''''||''''||'','||''''||''''||new_file||''''||'''';
    end loop;
    cmd:=cmd||')';

    job_cmd:='BEGIN EXECUTE IMMEDIATE '''||cmd||'''; END;';

    prefix:=substr(t1.tablespace_name||'ENC',1,18);
    jobname:=dbms_scheduler.generate_job_name(prefix);
    dbms_scheduler.create_job(job_name => jobname,job_type => 'PLSQL_BLOCK',job_action
=> job_cmd,enabled => FALSE);
    dbms_scheduler.run_job(job_name => jobname,use_current_session => FALSE);
  end loop;
end;
/
```

11. Create an encrypted temporary tablespace to replace your unencrypted PSAPTEMP tablespace.

```
CREATE TEMPORARY TABLESPACE PSAPTEMP_ENC TEMPFILE '+DATAC2' SIZE 32767M ENCRYPTION
ENCRYPT;
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE PSAPTEMP_ENC;
DROP TABLESPACE PSAPTEMP;
ALTER TABLESPACE PSAPTEMP_ENC RENAME TO PSAPTEMP;
```

Post-Migration Tasks

After migration of the database to the target system there are usually numerous post-migration tasks that need to be performed on the Oracle Database side as well as on the SAP application side.

Database-Related Post-Migration Tasks

Common Oracle Database related post-migration tasks for example are:

Adjust Oracle Initialization Parameters

Follow the relevant SAP Notes for your target system and set Oracle initialization parameters appropriately. The server parameter file (`spfile`) should be kept on ASM to be shared across the database instances.

Adjust Oracle RAC–specific parameters. For example, if your target system has two database compute nodes:

```
ODA001.instance_number=1
ODA002.instance_number=2
ODA001.thread=1
ODA002.thread=2
ODA001.undo_tablespace='PSAPUNDO1'
ODA002.undo_tablespace='PSAPUNDO2'
*.remote_listener='<your_scan_name>:1521'
```

If you are using Oracle Database 19c, ensure that parameters for TDE are set properly for each database instance.

```
*.tde_configuration = 'KEYSTORE_CONFIGURATION=FILE'
*.wallet_root = '+DATAC1/ODA/orawallet'
```

For Oracle Database 12.1, 12.2, or 18c, TDE is configured in `sqlnet.ora` instead of the `spfile`. For example:

```
ENCRYPTION_WALLET_LOCATION=
 (SOURCE=
  (METHOD=FILE)
   (METHOD_DATA=
    (DIRECTORY=+DATAC1/ODA/orawallet)))
```

The following additional initialization parameters might also need adjustment:

```
log_archive_dest
db_create_file_dest
db_create_online_log_dest_1
db_create_online_log_dest_2
compatible
db_recovery_file_dest
db_recovery_file_dest_size
```

Adjust Online Redo Logs and UNDO Tablespaces

Start your first instance and add online redo log groups and UNDO tablespaces as needed.

Manage the Password File

Check whether your version of Oracle Database supports shared password files on ASM. If so, we recommend using a shared password file across the database instances. Otherwise, or if you do not want the password file to be shared, place it under `$ORACLE_HOME/dbs`. In this case, ensure that the proper password file is copied to all other Oracle RDBMS Homes on all database compute nodes.

Configure the Database with Oracle Clusterware

As mentioned earlier, this document assumes that an initial installation with SWPM is performed and that the initial database is then replaced by the one being migrated. This process configures the new temporary database with Oracle Clusterware. SAP Application Servers installed using SWPM also have their own dedicated database service.

If you could not follow this approach, you can perform all the required steps manually by using the `srvctl` utility. Register the database and the database instances with Oracle Clusterware and create a database service for each application server that connects to the system. Configure the database services to run only on one database instance at a time to ensure that each SAP Application Server connects only to one database instance at the same time. Configure the database services to fail over to other database instances as needed (but always to just one).

SAP-Related Post-Migration Tasks

Common SAP NetWeaver® related post-migration tasks for example are:

Application Server Profiles

Application server profiles are created during application server installation using SWPM. If you install new application servers after migration, SWPM automatically creates the proper profiles. SWPM also creates a Linux command line script that you must run on the target system to create a database service dedicated to the application server being installed.

If you keep your current application servers, you need to modify the application server instance profiles so that each application server connects to its dedicated database server via the scan listener. Also, you must create the database services.

For example, if you want to use EZCONNECT for a dialog instance named D01 and a database service named ODA_D01:

```
SAP instance profile parameters:

SAPSYSTEMNAME=ODA
INSTANCE_NAME=D01
dbs/ora/tnsname=//<scan-listener>/ODA_D01
```

If you want to use `sqlnet.ora` with a TNS name to connect:

```
Sqlnet.ora:
ODA_D01= (DESCRIPTION =
   (ADDRESS=(PROTOCOL=TCP)
            (HOST=<scan-listener>)
            (PORT=1521)
   )
   (CONNECT_DATA =
       (SERVICE_NAME = ODA_D01)
       (GLOBAL_NAME = ODA)
       (FAILOVER_MODE =
            (TYPE = SELECT)
            (METHOD = BASIC)
      )
   )
)
```

```
SAP instance profile parameters:

SAPSYSTEMNAME=ODA
INSTANCE_NAME=D01
```

```
dbs/ora/tnsname=ODA_D01
```

Other SAP Post-Migration Tasks

Following are some other potential SAP-related post-migration tasks:

- Adjust SAP RFC connections
- Reschedule SAP jobs
- Make any necessary SAP Solution Manager changes
- Install new SAP licenses
- Configure remote backups using DB13

REFERENCES

SAP

Most of the SAP links require SAP login credentials for access.

SAP Documentation

- SAP Product Availability Matrix (PAM)
- SAP Software Logistics Toolset (SL Tools)
- SAP Download Manager
- SAP Software Download Center (SWDC)
- SAP NetWeaver Guide Finder
- SAP Community Network: Oracle Community
- SAP Help Portal: TCP/IP Ports of All SAP Products

SAP Notes

- 2956661 - SAP NetWeaver on Oracle Database Exadata Cloud@Customer
- 2614080 - SAP on Linux with Oracle Database Exadata Cloud@Customer: Enhanced Monitoring
- 2470718 - Oracle Database Parameter 12.2 / 18c / 19c
- 1888485 - Database Parameter for 12.1.0.2
- 2378252 - Oracle Database Initialization Parameters for SAP NetWeaver Systems
- 2520061 - SAP on Oracle Cloud Infrastructure: Support prerequisites
- 611361 - Hostnames of SAP ABAP Platform servers
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- 1914631 - Central Technical Note for Oracle Database 12c Release 1 (12.1)
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- 2660020 - Central Technical Note for Oracle Database 18c
- 2799900 - Central Technical Note for Oracle Database 19c

- 1868094 - Overview: Oracle Security SAP Notes
- 1496927 - Protection of SAP instances through Oracle Clusterware
- 2591575 - Using Oracle Transparent Data Encryption (TDE) with SAP NetWeaver
- 2799991 - TDE Encryption Conversions for Tablespaces and Databases
- 1598594 - BR*Tools configuration for Oracle installation using user "oracle"
- 113747 - Owners and authorizations of BR*Tools
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- 2618837 - Oracle Exadata Cloud@Customer: Patches for 12.2.0.1
- 2618881 - Oracle Exadata Cloud@Customer: Patches for 12.1.0.2
- 2884306 - Managing SAPDATA_HOME and ORACLE_BASE on Oracle Engineered Systems
- 2992680 - Managing shared and multiple Oracle Homes on Oracle Engineered Systems
- 2660062 - Oracle Exadata Cloud Service: Patches for Oracle 18c
- 2799970 - Patches for 19c: Oracle Exadata Cloud@Customer
- 2422996 - Oracle: OPatch Versions 12.2.0.1.8, 11.2.0.3.18 and Newer
- 3018983 - Additional information to the Oracle technical brief "Migrating SAP NetWeaver based Systems to Oracle Exadata Cloud Solutions"

Oracle

- Oracle Database Exadata Cloud@Customer Gen 2
- Oracle Cloud Hosting and Delivery Policies
- Oracle Database
- Oracle Linux
- Oracle-SAP Solutions site

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Author: Markus Breunig
Contributing Authors: Torsten Grambs, Jan Klokkers