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xTTS – Lesson(s) learned

rmoug.org

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- **Tool Owner** of TVD-Backup

- Experiences with Oracle since 2006 (8i – 21c)
  - Architecture, Installation & Configuration
  - High Availability Solutions (RAC, Data Guard, GoldenGate)
  - Migration Projects
  - Backup & Recovery (RMAN, Data Pump)
  - Cloud (Amazon, Oracle)
- **Oracle ACE**

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FOUNDED IN
1994

16 TRIVADIS WORKSPACES

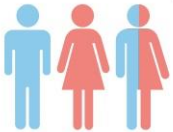
SWITZERLAND, GERMANY, AUSTRIA, DENMARK, ROMANIA

118 MILLION CHF
TURNOVER

300 SLA's
(SERVICE LEVEL AGREEMENTS)

4000
TRAINING PARTICIPANTS PER YEAR

800
CUSTOMERS



700
EMPLOYEES

5 MILLION CHF
BUDGET FOR SCIENCE AND DEVELOPMENT PER YEAR

EXPERIENCE FROM
1900 PROJECTS
PER YEAR

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Agenda

1. Introduction
2. Preparation Tasks
3. Metadata Export
4. Data File Transportation
5. Metadata Import
6. Post Tasks
7. Pitfalls

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Introduction

Initial Situation

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- Migration of **more than 100 databases from 11.2.0.4 to 19c**
  - Sizes of the databases between 10 GB and 25 TB
  - Stages: development, test, production
- **New hardware** (server, storage), but the **same endianness**
- Implementation of the **CDB architecture**
- **Downtime** of the production databases was limited to a **maximum of 2 hours**

Limitations

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- (National) character set between source and target have to be equal or compatible
  - To use compatible character sets (strict (binary) subset), special requirements have to be fulfilled
  - For national character set, no columns of the types NCHAR, NVARCHAR2, NCLOB cannot exist

```
ORA-39123: Data Pump transportable tablespace job aborted
ORA-29345: cannot plug a tablespace into a database using an incompatible character set
```

- Tablespaces in the target with the same have to be dropped/renamed
  - Or use REMAP_TABLESPACE during the import
- To transport columns of the type TIMESTAMP WITH LOCAL TIME ZONE (TSLTZ), the database time zone has to be equal
- Target database version (parameter COMPATIBLE) has to be equal or higher than the source version
- Objects owned by SYS cannot be transported

Check MOS notes 1166564.1 and 1454872.1 for more restrictions and details.

Workflow

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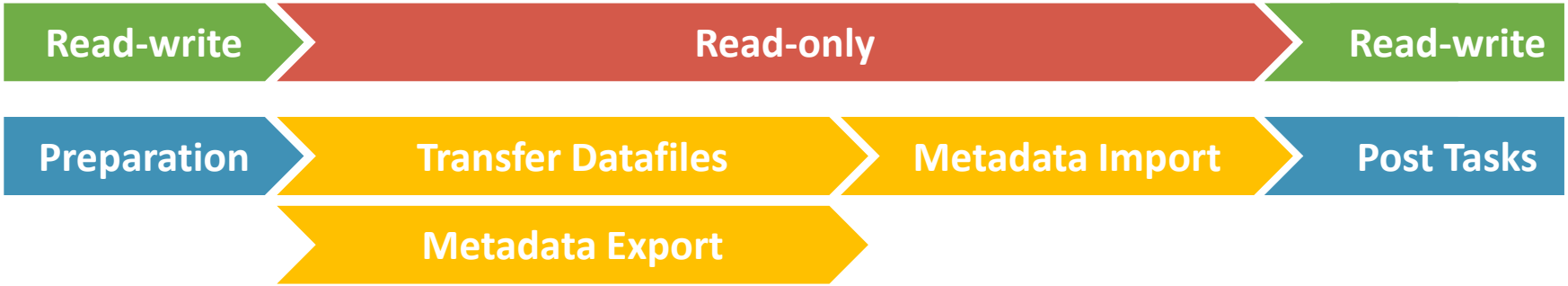

- Transport set check
- Create target DB
- Create objects and users
- Perform dry-run of the metadata export (19c)
- Restore level 0 backup on the target site

- Set tablespaces read-only
- Transfer datafiles to the target site or recover final consistent incremental backup
- Export metadata

- Import metadata
- Set tablespaces read-write

- Gather statistics
- Correct OMF names
- Adjust default tablespace
- Recover standby (if required)

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Preparation Tasks

List of Tablespaces

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- Use the following query to get the list of user-defined Tablespaces

```
SQL> SELECT tablespace_name, block_size, extent_management, bigfile, encrypted
       FROM dba_tablespaces
      WHERE contents = 'PERMANENT'
            AND tablespace_name NOT IN (
                  SELECT default_tablespace FROM dba_users
                   WHERE username IN (
                            SELECT schema FROM dba_registry))
   ORDER BY tablespace_name;


TABLESPACE_NAME                BLOCK_SIZE EXTENT_MAN BIG ENC
------------------------------ ---------- ---------- --- ---
AUDIT_DATA                           8192 LOCAL      NO  NO
HIST_ARCHIVE                        16384 LOCAL      YES NO
HR_DATA                              8192 LOCAL      NO  YES
PERFSTAT_TS                          8192 LOCAL      NO  NO
USERS                                8192 LOCAL      NO  NO
```

Non-default blocksize

False postive

Transport Set Check

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- Check if the selected Tablespaces are **self-contained** – **no dependencies** to other Tablespaces

```
SQL> BEGIN
   DBMS_TTS.TRANSPORT_SET_CHECK(
      ts_list => 'AUDIT_DATA,HIST_ARCHIVE,HR_DATA,USERS',
      incl_constraints => TRUE,
      full_check => TRUE
   );
END;
/

SQL> SELECT * FROM transport_set_violations;

VIOLATIONS
--------------------------------------------------------------------------------
ORA-39907: Index HR.EMPLOYEES_IDX in tablespace HR_IDX points to table HR.EMPLOYEES in
tablespace HR_DATA.
ORA-39908: Index HR.EMPLOYEES_UNQ_CON in tablespace HR_CONS enforces primary constraints
of table HR.EMPLOYYEES in tablespace HR_DATA.
```

Two-way dependencies check

Index Tablespace not part of set

Use parameter TTS_CLOSURE_CHECK to perform or skip transport set check during the Data Pump export operation.

Check for UNUSED Columns

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- If tables with UNUSED columns exist in the database, drop these columns

```
SQL> ALTER TABLE my_tab DROP UNUSED COLUMNS;
```

- Otherwise, the following error is raised during the metadata import

```
ORA-39083: Object type TABLE:"APP"."MY_TAB" failed to create with error:
ORA-00904: "SYS_C00111_18092915:37:55$": invalid identifier
```

- Use the following query to find all tables with UNUSED columns

```
SQL> SELECT * FROM dba_unused_col_tabs ORDER BY owner, table_name
```

An unused column has no column ID and is renamed to SYS_C00002_21081310:09:11$.

Former column ID

Timestamp of the change

Create Target DB/PDB

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- It is recommended to use the **same character set between source and target**

```
SQL> SELECT property_name, property_value FROM database_properties
      WHERE property_name LIKE '%CHARACTERSET';

PROPERTY_NAME                  PROPERTY_VALUE
------------------------------ ------------------------------
NLS_CHARACTERSET               WE8MSWIN1252
NLS_NCHAR_CHARACTERSET         AL16UTF16
```

- In the case of a CDB, the PDB can use a **subset character set** of the CDB
  - Use AL32UTF8 as character set for the CDB
- PDBs with a different character set **cannot be created directly**
  - Instead an unplugged **PDB archive or a remote clone** is required
  - Create a **dummy CDB** with the correct character set
- Verify/install **required database components**

Create Objects

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- As preparation for the user creation and the transport, dependent objects have to be created

Directories DBA_DIRETORIES	**Global Temporary Tables** DBA_TABLES	**Network ACLs** DBA_NETWORK_ACLS
Profiles DBA_PROFILES	**Public Database Links** DBA_DB_LINKS	**Public Synonyms** DBA_SYNONYMS
Roles DBA_ROLES	**Scheduler Job Classes** DBA_SCHEDULER_JOB_CLASSES	**SQL Plan Baselines** DBA_SQL_PLAN_BASELINES
SQL Profiles DBA_SQL_PROFILES		

- Data Pump Export/Import can be used to transport these objects
  - Or use DBMS_METADATA.GET_DDL to create DDL statements (SYS is required)

```
SQL> SELECT DBMS_METADATA.GET_DDL('PROFILE', 'MY_PROFILE' FROM dual;
```

When DBMS_METADATA is used for database links, the passwords are obfuscated (Doc ID 1905221.1).

Create User 1/2

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- Create all required users in the target database
  - Otherwise, ORA-29342 is raised during the metadata import

```
ORA-39123: Data Pump transportable tablespace job aborted
ORA-29342: user HR does not exist in the database
```

- A temporarily remapping of the default tablespace is required

```
$> impdp … DUMPFILE = users.dmp REMAP_TABLESPACE = HR_DATA:DUMMY_TS,…
```

- Data Pump does not import grants on SYS objects
  - MOS Note: Data Pump: GRANTs On SYS Owned Objects Are Not Transferred With Data Pump And Are Missing In The Target Database (Doc ID 1911151.1)
  - To avoid errors during the compilation of PL/SQL objects and views, grant the missing grants manually

Easiest way to transport the users is to use Data Pump.

Create User 2/2

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- Query to generate GRANT commands for all grants on SYS objects

```
SQL> SELECT 'GRANT ' || privilege || ' "SYS"."' || table_name ||
            '" TO "' || grantee || '";' AS "GRANT_COMMAND"
       FROM dba_tab_privs
      WHERE owner = 'SYS'
            AND grantee IN (SELECT username
                              FROM dba_users
                             WHERE oracle_maintained = 'N');

GRANT_COMMAND
--------------------------------------------------------------------------------
GRANT SELECT "SYS"."V_$SESSION" TO "APP_USER";
```

New column in Oracle 12c

Starting with Oracle 12c, use the column ORACLE_MAINTAINED of DBA_USERS to exclude system users like SYS, SYSTEM, DBSNMP, etc.

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Metadata Export

Test Mode for Transportable Tablespaces

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- **Estimation of the required time** for the metadata export was not possible before 19c without setting the **tablespaces** to **read-only**

```
Data Pump transportable tablespace job aborted
ORA-39185: The transportable tablespace failure list is

ORA-29335: tablespace 'HR_DATA' is not read only
```

- Starting with 19c, a **test mode as part of the closure check** was added

```
$> expdp … TRANSPORTABLE_TABLESPACES = HR_DATA,USERS TTS_CLOSURE_CHECK = TEST_MODE
```

- Generated dump file **cannot be used for the metadata import**

```
Dump file set is unusable. TEST_MODE requested.
```

Parallelize Metadata Operations

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- Before 21c, only one Data Pump worker was supported

```
ORA-39002: invalid operation
ORA-39047: Jobs of type TRANSPORTABLE cannot use multiple execution streams.
```

- In 21c, all defined Data Pump workers (**PARALLEL** parameter) are exporting/importing metadata
- Each worker processes **one type of metadata** at the same time

```
20-APR-21 08:28:27.212: W-1 Startup on instance 1 took 1 seconds
20-APR-21 08:28:29.079: W-2 Startup on instance 1 took 1 seconds
...
20-APR-21 08:29:02.686: W-1 Processing object type TRANSPORTABLE_EXPORT/TABLE
20-APR-21 08:29:04.601: W-2 Processing object type TRANSPORTABLE_EXPORT/CONSTRAINT/CONSTRAINT
20-APR-21 08:29:04.671: W-2      Completed 50 CONSTRAINT objects in 0 seconds
20-APR-21 08:29:11.621: W-2 Processing object type TRANSPORTABLE_EXPORT/POST_INSTANCE/PROCACT_INSTANCE
20-APR-21 08:29:11.650: W-2      Completed 15 PROCACT_INSTANCE objects in 0 seconds
20-APR-21 08:29:12.304: W-2 Processing object type TRANSPORTABLE_EXPORT/POST_INSTANCE/PROCDEPOBJ
20-APR-21 08:29:12.334: W-2      Completed 10 PROCDEPOBJ objects in 0 seconds
20-APR-21 08:29:47.203: W-1      Completed 57 TABLE objects in 0 seconds
```

Set Tablespaces read-only

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- Before the metadata export can be executed, all involved tablespace have to be switched to read-only

```
SQL> ALTER TABLESPACE HR_DATA READ ONLY;
```

- This command will hang indefinitely, if active transactions exist
  - Internal wait event is *unbound tx*
- Check if pending in-doubt transactions exist and terminate them

```
SQL> SELECT * FROM dba_2pc_pending;
```

If possible, deactivate the listener and restart the database (in restricted mode) before starting the whole operation.

Metadata Export

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- Starting with Oracle 10g Data Pump (expdp) is used to export the metadata of the transportable tablespaces
  - Role DATAPUMP_EXP_FULL_DATABASE is required

```
$> expdp … TRANSPORT_TABLESPACES = TS1,TS2
```

- Exclude of statistics with EXCLUDE = STATISTICS does not work in this mode (Doc ID 1517267.1)

```
$> expdp … EXCLUDE = TABLE_STATISTICS,INDEX_STATISTICS,USER_PREF_STATISTICS
```

- For older databases the legacy Export Utility (exp) has to be used

```
$> exp … TRANSPORT_TABLESPACE = Y TABLESPACES = TS1,TS2
```

Exclude statistics to speed up the metadata export.

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Data File Transportation

DBMS_FILE_TRANSFER 1/2

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- Can be used to **transfer datafiles** between source and target using **database links**
  - ASM → ASM, ASM → Filesystem, Filesystem → ASM, Filesystem → Filesystem
- Introduced with Oracle 10g
- **Converts the endianness automatically** during the transfer
- **DIRECTORY objects** are used to locate the datafiles

```
SQL> CREATE DIRECTORY source_dir AS '+DATA/DB/DATAFILE';   -- Source
SQL> CREATE DIRECTORY target_dir AS '/u01/oradata/NEWDB';  -- Target
```

- **No support for OMF**
  - In the case of ASM an alias is created with the defined name

Use online datafile move to rename the transported datafiles to OMFs.

DBMS_FILE_TRANSFER 2/2

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- Support for push (PUT_FILE) and pull (GET_FILE) transfers

```
SQL> BEGIN
   DBMS_FILE_TRANSFER.PUT_FILE (
      source_directory_object => 'SOURCE_DIR', source_file_name => 'hr_data_001.dbf',
      destination_directory_object => 'TARGET_DIR', destination_file_name => 'hr_data_001.dbf',
      destination_database => 'TARGETDB_LINK.trivadistraining.com'
   );
END;
/

SQL> BEGIN
   DBMS_FILE_TRANSFER.GET_FILE (
      source_directory_object => 'SOURCE_DIR', source_file_name => 'hr_data_001.dbf',
      source_database => 'SOURCEDB_LINK.trivadistraining.com'
      destination_directory_object => 'TARGET_DIR', destination_file_name => 'hr_data_001.dbf'
   );
END;
/
```

Maximum supported file size is 2 TB. Monitor V$SESSION_LONGOPS to see the remaining time.

Foreign Tablespace/Datafile Restore

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- Starting with 12c, tablespaces and datafiles can be restored with backup sets of a foreign database
  - Multiple backupsets can be combined in one operation
- Endianness can be changed during the restore (FROM PLATFORM)
- Use TO NEW clause to generate new OMF or define your own location and names by using the FORMAT clause

```
RMAN> RUN {
   RESTORE FROM PLATFORM 'Linux x86 64-bit' FOREIGN TABLESPACE "USERS","HR_DATA"
   TO NEW | FORMAT '/u01/oradata/%d/%N_%f.dbf'
   FROM BACKUPSET '/backup/tts_inc0_users.bak', '/backup/tts_inc0_hr_data.bak';
}

RMAN> RUN {
   RESTORE FROM PLATFORM 'Linux x86 64-bit' ALL FOREIGN DATAFILES
   TO NEW | FORMAT '/u01/oradata/%d/%N_%f.dbf'
   FROM BACKUPSET '/backup/tts_inc0_users.bak', '/backup/tts_inc0_hr_data.bak';
}
```

All datafiles in the backup set(s)

FROM PLATFORM clause is mandatory when the backup is from databases below 12c – even when the platform is the same.

Foreign Datafile Recovery

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- After the restore of a foreign tablespace/datafile, the datafiles can be recovered with incremental backups
- Each foreign datafile has to be recovered
  - No support for wildcards
  - Combine all datafile locations in one command

```
RMAN> RUN {
   RECOVER FROM PLATFORM 'Linux x86 64-bit'
   FOREIGN DATAFILECOPY '/u01/oradata/%d/users_001.dbf',
                        '/u01/oradata/%d/hr_data_001.dbf'
   FROM BACKUPSET '/backup/tts_inc0_users.bak', '/backup/tts_inc0_hr_data.bak';
}
```

- Unfortunately, there is currently no way to track foreign datafiles from the database
  - In Oracle 21c, view V$FOREIGN_DATAFILE_COPY was added, but it is empty (Bug?)

Incremental Backups

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- **Incremental backups** are used to **minimize the downtime** of the datafile transport
- **Level 0** and subsequential **level 1 hot backups** are created on the source and restored on the target
- After setting the tablespaces read-only, a **final consistent level 1** is created and restored
  - This reduces the downtime dramatically
- Oracle provides a Perl script to automate this (Doc. ID 2471245.1)

```
$> perl xttdriver.pl --backup
$> perl xttdriver.pl --restore
```

- **Image copies** are used for the **level 0 backup**
  - A stage location is required to temporarily store the copies and backups

Use a shared filesystem (for example NFS) to share the copies and backups between source and target system.

Data Guard

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- If you want to have a **in-sync standby database** after importing the metadata, **restore the datafiles also on the standby site**
  - Imported datafiles are not automatically copied to the standby site
- DBMS_FILE_TRANSFER cannot connect to a standby database
  - As a workaround, use a dummy database on the target server
- As alternative, recreate the standby database or restore the new tablespaces
  - RECOVER STANDBY DATABASE command was added in 18c

```
-- Whole standby database
RMAN> RECOVER STANDBY DATABASE FROM SERVICE 'primary_tns_alias';

-- Tablespaces
RMAN> RESTORE TABLESPACE "USERS" FROM SERVICE 'primary_tns_alias';
```

Redo apply has to be stopped, before the recovery can be started.

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Metadata Import

Metadata Import

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- Provide the list of transported datafiles using TRANSPORT_DATAFILES parameter
  - Wildcards (*,?) for file names are supported starting with Oracle 12c Release 2
  - Remapping of Schemas is also possible durint the import

```
$> impdp … TRANSPORT_DATFILES = '/u01/oradata/DB/hr_data_001.dbf','…' \
           REMAP_SCHEMAS = HR:HR_NEW EXCLUDE = TRIGGER
```

- When the dump was created with the legacy Export Utility, use imp to import it

```
$> imp … DATFILES = '/u01/oradata/DB/hr_data_001.dbf','…' \
         TABLESPACES = HR_DATA,… TRANSPORT_TABLESPACE = Y \
         FROMUSER = HR TOUSER = HR_NEW
```

- Import all other non-transported objects using normal import mode
- Minimize the risk of ORA-600 by excluding triggers

Starting with 19c, tablespaces can be shared again between databases. Use parameter TRANSPORTABLE = KEEP_READ_ONLY to activate the pre-12.2 behavior.

Set Tablespaces read-write

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- Set the transported tablespaces in the target database to read-write

```
SQL> ALTER TABLESPACE HR_DATA READ WRITE;
```

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Post Tasks

Gather Statistics

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- If statistics were skipped during export or import, it is time to gather them
- Beside object statistics, update data dictionary and fixed object statistics as well

```
SQL> EXEC DBMS_STATS.SET_GLOBAL_PREFS('DEGREE', 8);
SQL> EXEC DBMS_STATS.SET_GLOBAL_PREFS('CONCURRENT','AUTOMATIC');

SQL> BEGIN
   DBMS_STATS.GATHER_DICTIONARY_STATS();
   DBMS_STATS.GATHER_FIXED_OBJECTS_STATS();
   DBMS_STATS.GATHER_DATABASE_STATS(
      options => 'GATHER',
      estimate_percent => DBMS_STATS.AUTO_SAMPLE_SIZE,
      method_opt => 'FOR ALL COLUMNS SIZE SKEWONLY',
      granularity => 'ALL',
      cascade => TRUE,
      degree => 8,
      no_invalidate => DBMS_STATS.AUTO_INVALIDATE
   );
END;
/
```

Gather statistics for the important schemas using GATHER_SCHEMA_STATS first.

Restore Default Tablespaces

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- Restore the original default tablespaces of the transported user

```
SQL> ALTER USER "HR" DEFAULT TABLESPACE "HR_DATA";
```

- Genarate the required commands on the source database

```
SQL> SELECT 'ALTER USER "' || username || '" DEFAULT TABLESPACE "' ||
            default_tablespace || '";'
       FROM dba_users
      WHERE username IN ('HR', '…');
```

- Update the database default tablespace, if required

```
SQL> ALTER DATABASE DEFAULT TABLESPACE "USERS";
```

Correct OMF Names

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- Only required when OMFs are used, and the **file locations and names are not correct** because of the used transfer mode
- Starting with 12c **online datafile move** can be used to move/rename the datafiles online
  - Omit TO clause to create new OMF datafiles

```
-- Datafile number
SQL> ALTER DATABASE MOVE DATAFILE n;

-- Datafile path
SQL> ALTER DATABASE MOVE DATAFILE '+DATA/DB/hr_data_001.dbf';
```

Online datafile move is slower than an offline move using RMAN.

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Pitfalls

Tables with TSLTZ Columns

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- Columns of the type TIMESTAMP WITH LOCAL TIME ZONE (TSLTZ) can only be transported, when source and target use the same database time zone
  - These tables are automatically skipped in 12c and higher

```
W-1 Processing object type TRANSPORTABLE_EXPORT/TABLE
ORA-39360: Table "TTS_DEMO"."TSLTZ_TAB1" was skipped due to transportable
import and TSLTZ issues resulting from time zone mismatch.
```

- Change the database time zone to the value of the source database
  - This is only possible when not already tables with TSLTZ columns exist

```
SQL> ALTER DATABASE SET TIME_ZONE = '+05:00';
```

- If not possible, use normal Data Pump Export/Import to transport the data

Create the table before the recompilation of PL/SQL objects and views.

Global Temporary Tables

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- Global Temporary Tables (GTT) are not transported
  - These tables do not belong to a tablespace
- Data Pump export and import have to be used to transport them to the target database

```
$> expdp … INCLUDE=TABLE:"IN (SELECT table_name FROM dba_tables WHERE temporary
= 'Y')"
```

- Or create them manually either as preparation or post task

```
SQL> SELECT DBMS_METADATA.GET_DDL('TABLE','<Name>','<Schema>') FROM dual;
```

Create the table before the recompilation of PL/SQL objects and views.

Tables with XMLTYPE Columns

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- Transportation of tables with XMLTYPE columns is supported with 12.2.0.1 and higher
- In previous versions, following error is raised during the metadata import

```
ORA-39139: Data Pump does not support XMLType objects in version
"<SCHEMA_NAME>"."<TABLE_NAME>" will be skipped.
```

- Table exclude is required for the TTS operation

```
$> expdp … EXCLUDE=TABLE:"IN (SELECT table_name FROM dba_tab_columns WHERE
data_type = 'XMLTYPE')"
```

- Normal Data Pump export/import is required to transport them
- MOS note Is it supported to do a Transport Tablespace (TTS) Import with Data Pump on a tablespace with binary XML objects ? (Doc ID 1908140.1) describes this issue

Perform the exclude during the export to speed up the metadata export.

Further Information

Oracle Database 21c – Transporting Data
https://docs.oracle.com/en/database/oracle/oracle-database/21/admin/transporting-data.html#GUID-1901E9C3-8FCE-4D4E-AB65-34D703474E52

Master Note for Transportable Tablespaces (TTS) -- Common Questions and Issues (Doc ID 1166564.1)
https://support.oracle.com/epmos/faces/DocumentDisplay?id=1166564.1

My Oracle Support
https://support.oracle.com

Questions and answers..

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