Delphix

Oracle TDE with PDBs and try not go mad again

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OakTable

SYMPOSIUM 42

TDE can help me to:

A) protect my database from SQL ingestion in application server

B) protect my database from access with stolen credentials

C) protect my database from unauthorized admin access

D) protect my database from update outside of SQL engine

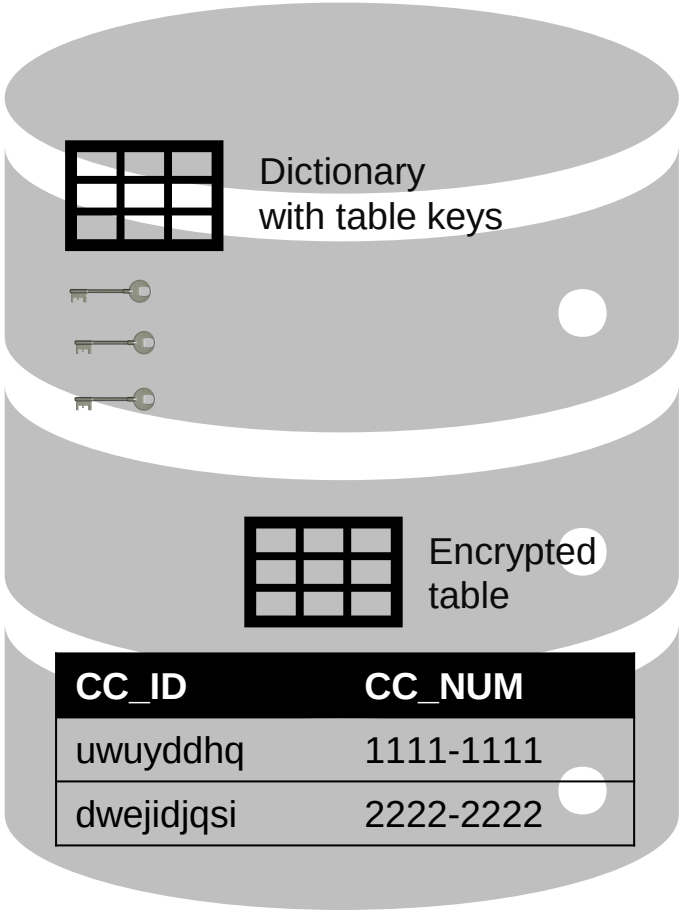
E) protect my database from stolen hard drive or tape with backup
(only if you don’t backup keystore with your datafiles)

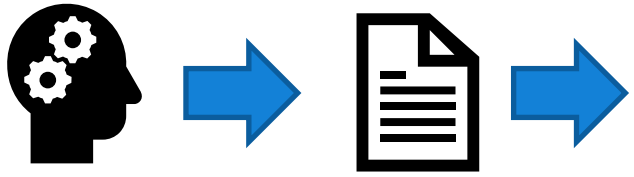
How TDE works

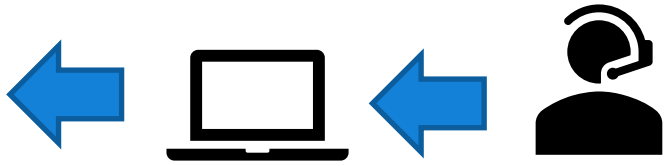
Master Key

Software wallet

Hardware module





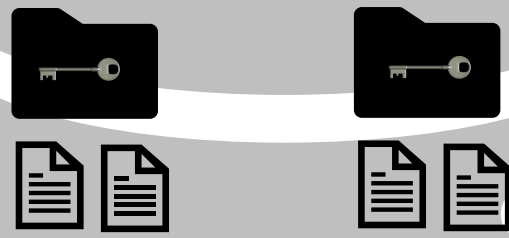


Master Key

Software wallet

Hardware module

Tablespace with key



Encrypted files

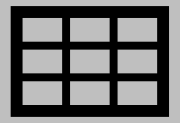
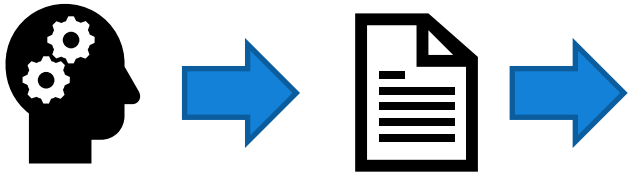
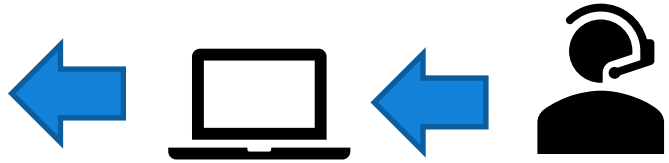


Table with sensitive data

CC_ID	CC_NUM
uwuyddhq	1111-1111
dwejidjqsi	2222-2222





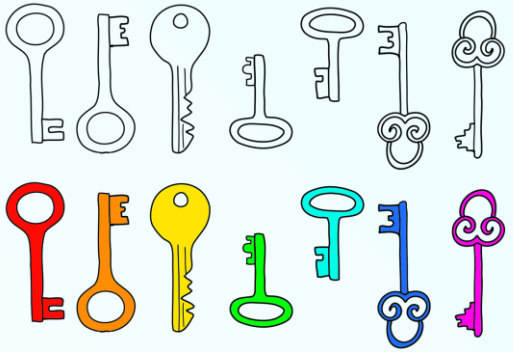
Checking encryption

```
create table pioro.test_enc_column (id number, cc varchar2(50) encrypt) tablespace users;
Table created.
insert into pioro.test_enc_column values (1, 'marcin');
1 row created.
commit;
Commit complete.

create table pioro.test_noenc (id number, cc varchar2(50) ) tablespace users;
Table created.
insert into pioro.test_noenc values (1, 'przepiorowski');
1 row created.
commit;
Commit complete.
shutdown immediate

[oracle@hobbiton ~]$ grep -i przepiorowski /u01/app/oracle/oradata/PIORO19/devdb/users01.dbf
Binary file /u01/app/oracle/oradata/PIORO19/devdb/users01.dbf matches


[oracle@hobbiton ~]$ grep -i marcin /u01/app/oracle/oradata/PIORO19/devdb/users01.dbf
[oracle@hobbiton ~]$
```

Table vs Tablespace encryption – review

Table	Tablespace
No range scan on indexes	Unique and range scans on indexes
Space overhead (1 to 52 bytes per row)	No space overhead
Potential impact on execution plan 728292.1.	No impact on execution plan
Always encrypted	Decrypted in SGA
Key per table	Key per tablespace

TDE Master Note – MOS 1228046.1
TDE 12c FAQ - MOS 2253348.1
Quick TDE Setup and FAQ - MOS 1251597.1



Wallets

Multitenant keystores (wallet) types:

- United – TDE master encryption key for CDB and all PDBs are in same keystore
- Isolated – TDE master encryption key for CDB and PDB's are in individual PDB's keystores

```
SQL> select con_id, wrl_parameter, status, wallet_type, keystore_mode from v$encryption_wallet;

  CON_ID WRL_PARAMETER                                      STATUS          WALLET_TYPE     KEYSTORE
-------- ---------------------------------------------------------- --------------- --------------- --------
       1 /u01/app/oracle/wallets/tde/pioro19/                       OPEN            PASSWORD        NONE
       2                                                            OPEN            PASSWORD        UNITED
       3                                                            OPEN            PASSWORD        UNITED
```

Wallets

Locations:

- WALLET_ROOT (init.ora but also TDE_CONFIGURATION value)
- WALLET_LOCATION (sqlnet.ora)
- ENCRYPTION_WALLET_LOCATION (sqlnet.ora)
- $ORACLE_BASE/admin/db_unique_name/wallet
- $ORACLE_HOME/admin/db_unique_name/wallet

TNS_ADMIN can do a trick as well ☺

```
ls -l /u01/app/oracle/wallets/tde/pioro19/

-rw-------. 1 oracle oinstall 7855 Sep 12 16:53 ewallet_2022091220513916.p12
-rw-------. 1 oracle oinstall 8507 Sep 12 16:53 ewallet_2022091220533242.p12
-rw-------. 1 oracle oinstall 4171 Sep 13 11:23 ewallet_2022091315231259.p12
-rw-------. 1 oracle oinstall 5835 Sep 13 11:23 ewallet.p12
```

Wallets

The use of PKI (orapki) encryption with Transparent Data Encryption is deprecated.
Use the ADMINISTER KEY MANAGEMENT SQL statement.

```
[oracle@hobbiton ~]$ $ORACLE_HOME/bin/orapki wallet display -wallet
/u01/app/oracle/wallets/tde/pioro19/
Oracle PKI Tool Release 19.0.0.0.0 - Production
..
Enter wallet password:
..
Oracle Secret Store entries:
ORACLE.SECURITY.DB.ENCRYPTION.AVpZ8Ohu50/jv2uvQxp59rQAAAAAAAAAAAAAAAAAAAAAAAAAAAA
ORACLE.SECURITY.DB.ENCRYPTION.AYtos6a6Ck+kv45nlnFP4EsAAAAAAAAAAAAAAAAAAAAAAAAAAAA
ORACLE.SECURITY.DB.ENCRYPTION.MASTERKEY
ORACLE.SECURITY.DB.ENCRYPTION.MASTERKEY.E7B331B4F01249C8E055020C29B28AD3
ORACLE.SECURITY.ID.ENCRYPTION.

SQL> @keys
KEY_ID                                                TAG                                 CON_ID
----------------------------------------------------- ---------------------------------- ----------
AVpZ8Ohu50/jv2uvQxp59rQAAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master 2                                1
AYtos6a6Ck+kv45nlnFP4EsAAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master devdb                           3
```

Check if TDE was ever enabled

You can’t recreate a wallet if database was encrypted before

Check table **`x$kcbdbk`**

Clean database (no tablespace encryption enabled)

```
11g
BITAND(FLAGS,8) == 0

12c+
mkloc == 0
```

Database setup

Multitenant setup

```
mkdir -p /u01/app/oracle/wallets/tde/pioro19

sqlnet.ora
WALLET_LOCATION=
(SOURCE=
  (METHOD=FILE)
   (METHOD_DATA=
    (DIRECTORY=/u01/app/oracle/wallets/tde/${ORACLE_SID}/)))
```

Multitenant setup

```
SQL> select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet

    CON_ID WRL_PARAMETER                                STATUS                    WALLET_TYPE
---------- ---------------------------------------- ------------------------- ---------------
         1 /u01/app/oracle/wallets/tde/pioro19      NOT_AVAILABLE             UNKNOWN
         2                                          NOT_AVAILABLE             UNKNOWN
         3                                          NOT_AVAILABLE             UNKNOWN

SQL> select con_id, mkloc from x$kcbdbk

    CON_ID      MKLOC
---------- ----------
         1          0
         2          0
         3          0
```

Multitenant setup

```
administer key management create keystore /u01/app/oracle/wallets/tde/pioro19/' identified by xxx;

select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;

    CON_ID WRL_PARAMETER                                      STATUS             WALLET_TYPE
---------- ---------------------------------------------- ------------------ ------------
         1 /u01/app/oracle/wallets/tde/pioro19/           CLOSED             UNKNOWN
         2                                                CLOSED             UNKNOWN
         3                                                CLOSED             UNKNOWN

administer key management set keystore open identified by xxx;

select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;

    CON_ID WRL_PARAMETER                                      STATUS                WALLET_TYPE
---------- ---------------------------------------------- --------------------- ------------
         1 /u01/app/oracle/wallets/tde/pioro19/           OPEN_NO_MASTER_KEY    PASSWORD
         2                                                CLOSED                UNKNOWN
         3                                                CLOSED                UNKNOWN
```

Multitenant setup

```
administer key management set key using tag "first master key cdb" identified by delphix with backup
using 'backup before master cdb';

select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;

    CON_ID WRL_PARAMETER                                STATUS                         WALLET_TYPE
---------- ---------------------------------------- ------------------------------ -----------
         1 /u01/app/oracle/wallets/tde/pioro19/     OPEN                           PASSWORD
         2                                          CLOSED                         UNKNOWN
         3                                          CLOSED                         UNKNOWN

select con_id, mkloc from x$kcbdbk;

    CON_ID      MKLOC
---------- ----------
         1          1
         2          0
         3          0
```

Multitenant setup

```
administer key management set keystore open identified by delphix container = all;

select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;

    CON_ID WRL_PARAMETER                                 STATUS               WALLET_TYPE
---------- ---------------------------------------- -------------------- ----------------
         1 /u01/app/oracle/wallets/tde/pioro19/     OPEN                 PASSWORD
         2                                          CLOSED               UNKNOWN
         3                                          OPEN_NO_MASTER_KEY   PASSWORD

administer key management set key using tag "first master key all" identified by delphix with backup
using 'backup before master all' container=all;

select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;

    CON_ID WRL_PARAMETER                                 STATUS               WALLET_TYPE
---------- ---------------------------------------- -------------------- ----------------
         1 /u01/app/oracle/wallets/tde/pioro19/     OPEN                 PASSWORD
         2                                          CLOSED               UNKNOWN
         3                                          OPEN                 PASSWORD
```

Multitenant setup

```
alter session set container = devdb;


select con_id, wrl_parameter, status, wallet_type from v$encryption_wallet;


    CON_ID WRL_PARAMETER                          STATUS                         WALLET_TYPE
---------- ------------------------------------ ------------------------------ -----------
         3                                       OPEN                           PASSWORD


create tablespace ts_pii datafile '/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01.dbf' size 10M
encryption using 'AES256' default storage(encrypt);
```

RAC

12.1

- non-shared TDE wallets are supported but not recommended

19c

- Oracle does not support the use of individual TDE wallets for each Oracle RAC node. Instead, use shared wallets for TDE in the Oracle RAC environment.
    - Oracle ACFS
    - ASM , +DATA/$ORACLE_UNQNAME/WALLETS.

- Keystore operations (such as opening or closing the keystore, or rekeying the TDE master encryption key) can be issued on any one Oracle RAC instance. Internally, the Oracle database takes care of synchronizing the keystore context on each Oracle RAC node ?????

RAC

```
[oracle@hobbiton ~]$ sudo sysdig fd.name=/u01/app/oracle/wallets/tde/pioro19/ewallet.p12
987253 07:55:47.619539508 1 oracle (33689.33689) < openat
fd=16(<f>/u01/app/oracle/wallets/tde/pioro19/ewallet.p12) dirfd=-100(AT_FDCWD)
name=/u01/app/oracle/wallets/tde/pioro19/ewallet.p12 flags=1(O_RDONLY) mode=0 dev=FD00
```

Daily actions

Encrypting system objects

```
SQL> create table test_enc_column (id number, cc varchar2(50) encrypt) tablespace users;
create table test_enc_column (id number, cc varchar2(50) encrypt) tablespace users
                                         *
ERROR at line 1:
ORA-28336: cannot encrypt SYS owned objects
```

You can encrypt SYSTEM, SYSAUX, TEMP and UNDO tablespace but you can’t close wallet manually anymore.
MOS 2393734.1

Tablespace level encryption

```
create tablespace ts_pii_pdb datafile '/u01/app/oracle/oradata/PIORO19/devdb/ts_pii.dbf' size 100M
encryption using 'AES256' encrypt;
```

ALTER SYSTEM SET ENCRYPT_NEW_TABLESPACES = value;

- CLOUD_ONLY transparently encrypts the tablespace in the Cloud using the AES128 algorithm CLOUD_ONLY is the default.
- ALWAYS automatically encrypts the tablespace using the AES128 algorithm if you omit the ENCRYPTION clause of CREATE TABLESPACE
- DDL encrypts the tablespace using the specified setting of the ENCRYPTION

Tablespace level encryption

```
alter system set encrypt_new_tablespaces = always;
System altered.

create tablespace ts_enc2 datafile '/u01/app/oracle/oradata/PIORO19/devdb/ts_enc2_01.dbf' size 10M;
Tablespace created.

SQL> select TABLESPACE_NAME, ENCRYPTED from dba_tablespaces;

TABLESPACE_NAME                ENC
------------------------------ ---
SYSTEM                         NO
SYSAUX                         NO
UNDOTBS1                       NO
TEMP                           NO
USERS                          NO
TS_ENC                         YES
TS_ENC2                        YES
```

System tablespace encryption

```
SQL> shutdown
Pluggable Database closed.
SQL> show pdbs

    CON_ID CON_NAME                          OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         4    DEVDB                                MOUNTED
SQL> ALTER TABLESPACE SYSTEM ENCRYPTION OFFLINE ENCRYPT;

Tablespace altered.

Elapsed: 00:00:00.01
SQL> ALTER TABLESPACE SYSAUX ENCRYPTION OFFLINE ENCRYPT;

Tablespace altered.

Elapsed: 00:00:03.34
SQL> ALTER TABLESPACE UNDOTBS1 ENCRYPTION OFFLINE ENCRYPT;

Tablespace altered.
```

System tablespace encryption

```
SQL> select tablespace_name, encrypted from dba_tablespaces;

TABLESPACE_NAME                ENC
------------------------------ ---
SYSTEM                         YES
SYSAUX                         YES
UNDOTBS1                       YES
TEMP                           NO
USERS                          NO
TS_PII_PDB                     YES
```

```
[oracle@hobbiton trace]$ grep -i SLON /u01/app/oracle/oradata/PIORO19/devdb/system01.dbf
Binary file /u01/app/oracle/oradata/PIORO19/devdb/system01.dbf matches
```

Restart

```
SQL> startup mount
Database mounted.

SQL> administer key management set keystore open force keystore identified by delphix container=all;
keystore altered.

SQL> show pdbs
    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       MOUNTED
         3 DEVDB                          MOUNTED
         4 SYSENC2                        MOUNTED

SQL> alter session set container = sysenc2;
Session altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
                                                 CLOSED          UNKNOWN
```

Restart

```
SQL> alter database open;
Database altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
/u01/app/oracle/wallets/tde/pioro19/             OPEN            PASSWORD
                                                 CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
```

```
2022-09-16T13:06:34.156315-04:00
DEVDB(3):Error 28365 during pluggable database DEVDB opening in read write
2022-09-16T13:06:34.156457-04:00
DEVDB(3):Errors in file /u01/app/oracle/diag/rdbms/pioro19/pioro19/trace/pioro19_p000_30796.trc:
ORA-28365: wallet is not open
DEVDB(3):Pluggable database DEVDB pseudo close cleaning up
```

Restart

```
SQL> administer key management set keystore open force keystore identified by delphix container=all;
keystore altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS           WALLET_TYPE
------------------------------------------------ ---------------- ---------------
/u01/app/oracle/wallets/tde/pioro19/             OPEN             PASSWORD
                                                 CLOSED           UNKNOWN
                                                 CLOSED           UNKNOWN
                                                 CLOSED           UNKNOWN
```

Restart

```
SQL> administer key management set keystore close identified by delphix container=all;
keystore altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
/u01/app/oracle/wallets/tde/pioro19/             CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
```

Restart

```
SQL> administer key management set keystore open force keystore identified by delphix container=all;
keystore altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
/u01/app/oracle/wallets/tde/pioro19/             OPEN            PASSWORD
                                                 OPEN            PASSWORD
                                                 CLOSED          UNKNOWN
                                                 CLOSED          UNKNOWN
```

Restart

```
SQL> alter session set container = sysenc2;
Session altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
                                                 CLOSED          UNKNOWN

SQL> administer key management set keystore open force keystore identified by delphix;
keystore altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS          WALLET_TYPE
------------------------------------------------ --------------- ---------------
                                                 OPEN            PASSWORD

SQL> alter pluggable database sysenc2 open ;
Pluggable database altered.
```

Autologin wallet

Creating a Auto login for wallet

```
administer key management create auto_login keystore from keystore '/path' identified by delphix;
```

```
administer key management create local auto_login keystore from keystore '/path' identified by delphix;
```

Wallet backup

- Backup your wallet
- Backup your wallet always and probably include with database backup
- Backing up using administer command is not enough – you need to backup a physical file to other location
- Did I say to backup your wallet ??????

REKEY master key

```
alter system flush buffer_cache; alter system checkpoint;
[oracle@oracle18 ~]$ dd if=/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01.dbf of=block.dmp_enc bs=8k
count=1 skip=131

administer key management set key using tag "rekey pdb" identified by delphix with backup using
"backup";
keystore altered.
alter system flush buffer_cache; alter system checkpoint;

[oracle@oracle18 ~]$ dd if=/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01.dbf of=block.dmp_enc_rekey
bs=8k count=1 skip=131
[oracle@oracle18 ~]$ md5sum block.dmp_enc
ab35da0dbe93a006424d94566c906db2  block.dmp_enc
[oracle@oracle18 ~]$ md5sum block.dmp_enc_rekey
ab35da0dbe93a006424d94566c906db2  block.dmp_enc_rekey
```

Tablespace encryption key

```
SQL> select NAME, ENCRYPTEDTS, MASTERKEYID, STATUS, et.CON_ID from v$encrypted_tablespaces et,
v$tablespace t where et.ts# = t.ts#;

NAME                           ENC MASTERKEYID                    STATUS.              CON_ID
------------------------------ --- -------------------------------- -------------- ----------
SYSTEM                         YES 4AE87763092B4F45BFE2C5BB635733F4  NORMAL                  4
SYSAUX                         YES 4AE87763092B4F45BFE2C5BB635733F4  NORMAL                  4
UNDOTBS1                       YES 4AE87763092B4F45BFE2C5BB635733F4  NORMAL                  4
TS_PII_PDB                     YES 4AE87763092B4F45BFE2C5BB635733F4  NORMAL                  4
```

```
SQL> select key_id, tag, con_id from v$encryption_keys;

KEY_ID                                                    TAG                    CON_ID
--------------------------------------------------------- ------------------- ----------
AUrod2MJK09Fv+LFu2NXM/QAAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master devdb 2             4
```

Tablespace encryption key

MOS Doc ID 1228046.1

```
4AE87763092B4F45BFE2C5BB635733F4

01 4AE87763092B4F45BFE2C5BB635733F4

SQL> select utl_raw.cast_to_varchar2(utl_encode.base64_encode('014AE87763092B4F45BFE2C5BB635733F4'))
from dual;

AUrod2MJK09Fv+LFu2NXM/Q=


AUrod2MJK09Fv+LFu2NXM/QAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Wallet operations during rekey

```
sudo sysdig fd.name=/u01/app/oracle/wallets/tde/pioro19/ewallet.p12

209682 07:59:04.674268440 0 oracle_33689_pi (33689.33689) < openat
fd=16(<f>/u01/app/oracle/wallets/tde/pioro19/ewallet.p12) dirfd=-100(AT_FDCWD)
name=/u01/app/oracle/wallets/tde/pioro19/ewallet.p12 flags=1(O_RDONLY) mode=0 dev=FD00
209687 07:59:04.674331466 0 oracle_33689_pi (33689.33689) > read
fd=16(<f>/u01/app/oracle/wallets/tde/pioro19/ewallet.p12) size=65536
209688 07:59:04.674337218 0 oracle_33689_pi (33689.33689) < read res=9371
data=0.$....0.$]..*.H........$N..$J0.$F0.$B..*.H........$30.$/...0.$(..*.H......0W..*


218584 07:59:04.767724841 2 oracle_33689_pi (33689.33689) < openat
fd=16(<f>/u01/app/oracle/wallets/tde/pioro19/ewallet.p12) dirfd=-100(AT_FDCWD)
name=/u01/app/oracle/wallets/tde/pioro19/ewallet.p12 flags=263(O_TRUNC|O_CREAT|O_RDWR) mode=0666
dev=FD00
218589 07:59:04.767766495 2 oracle_33689_pi (33689.33689) > write
fd=16(<f>/u01/app/oracle/wallets/tde/pioro19/ewallet.p12) size=8192
218590 07:59:04.767825947 2 oracle_33689_pi (33689.33689) < write res=8192
data=0.$....0.$]..*.H........$N..$J0.$F0.$B..*.H........$30.$/...0.$(..*.H......0W..*
```

REKEY tablespace online

```
alter session set container = pdb1;
Session altered.

select key_version, status from V$ENCRYPTED_TABLESPACES;
KEY_VERSION STATUS
----------- ----------
          0 NORMAL

alter tablespace ts_pii encryption using 'AES192' rekey file_name_convert = ('ts_pii01.dbf',
'ts_pii01_new.dbf');

Tablespace altered.

select key_version, status from V$ENCRYPTED_TABLESPACES;

KEY_VERSION STATUS
----------- ----------
          1 NORMAL
```

REKEY tablespace online

```
select name from v$datafile;

NAME
--------------------------------------------------------------------------------
/u01/app/oracle/oradata/PIORO19/devdb/system01.dbf
/u01/app/oracle/oradata/PIORO19/devdb/sysaux01.dbf
/u01/app/oracle/oradata/PIORO19/devdb/undotbs01.dbf
/u01/app/oracle/oradata/PIORO19/devdb/users01.dbf
/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01_new.dbf


[oracle@oracle18 ~]$ dd if=/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01_new.dbf
of=block.dmp_enc_rekey_new bs=8k count=1 skip=131

[oracle@oracle18 ~]$ md5sum block.dmp_enc
ab35da0dbe93a006424d94566c906db2  block.dmp_enc

[oracle@oracle18 ~]$ md5sum block.dmp_enc_rekey_new
c4f4537701ea28a7f48fc3fab8950c86  block.dmp_enc_rekey_new
```

Changing the Wallet password

Changing the Password-Protected wallet Password

```
administer key management alter keystore password [force keystore]
identified by old_password set new_password
with backup;
```

Plug / Unplug / Clone

Unplug/plug PDB

```
alter pluggable database pdb1 close;
Pluggable database altered.


alter pluggable database  pdb1 UNPLUG INTO '/tmp/pdb1.pdb';
alter pluggable database  pdb1 UNPLUG INTO '/tmp/pdb1.pdb'
*
ERROR at line 1:
ORA-46680: master keys of the container database must be exported
```

Unplug/plug PDB

```
administer key management export encryption keys with secret "delphix" to '/tmp/pdb1.p12' identified by
xxx;
administer key management export encryption keys with secret "delphix" to '/tmp/pdb1.p12' identified by
xxx
*
ERROR at line 1:
ORA-46658: keystore not open in the container

alter pluggable database pdb1 open read write;
Pluggable database altered.


alter session set container = pdb1;
Session altered.

administer key management export encryption keys with secret "password" to '/tmp/pdb1.key' force
keystore identified by xxx;
keystore altered.
```

Unplug/plug PDB

```
alter session set container = cdb$root;
Session altered.


alter pluggable database  pdb1 UNPLUG INTO '/tmp/pdb1.pdb';
Pluggable database altered.
```

Unplug/plug PDB

```
create pluggable database pdb1 using '/tmp/pdb1_new.pdb'
FILE_NAME_CONVERT=('/tmp/','/u01/app/oracle/oradata/CLT18MT/PDB1/');
Pluggable database created.


alter pluggable database pdb1 open read write;
Warning: PDB altered with errors.


select message, status from PDB_PLUG_IN_VIOLATIONS  where name  = 'PDB1';

MESSAGE                                          STATUS
-----------------------------------------------  ---------
PDB needs to import keys from source.            PENDING


alter session set container=pdb1;
Session altered.

administer key management import encryption keys with secret "password" from '/tmp/pdb1.key' force
keystore identified by delphixclone with backup;
keystore altered.
```

Unplug/plug PDB

```
alter session set container=cdb$root;
Session altered.


alter pluggable database pdb1 close;
Pluggable database altered.


alter pluggable database pdb1 open read write;
Pluggable database altered.
```

Unplug/plug PDB

```
alter session set container=pdb1;
Session altered.


select count(*) from  pioro.test_ts_enc;
select count(*) from  pioro.test_ts_enc
                           *
ERROR at line 1:
ORA-28365: wallet is not open


administer key management set keystore open identified by xxxclone;
keystore altered.


select count(*) from  pioro.test_ts_enc;


  COUNT(*)
----------
      9999
```

Unplug/plug PDB

```
alter pluggable database  pdb1 unplug into '/tmp/pdb1.xml' encrypt using myhiddenpassword;
Pluggable database altered.
```

```
create pluggable database pdb1 using '/tmp/pdb1.xml' nocopy tempfile reuse decrypt using
myhiddenpassword keystore identified by xxxclone;
Pluggable database created.
```

```
alter pluggable database  pdb1 unplug into '/tmp/pdb1.pdb' encrypt using myhiddenpassword;
Pluggable database altered.
```

```
create pluggable database pdb1 using '/tmp/pdb1.pdb'
file_name_convert=('/tmp/','/u01/app/oracle/oradata/CLT18MT/PDB1/') decrypt using myhiddenpassword
keystore identified by xxxclone;
Pluggable database created.
```

No Keys ?!?

```
SQL> alter session set container = devdb;

SQL> @wallet
WRL_PARAMETER.                                      STATUS           WALLET_TYPE
--------------------------------------------------- ---------------- ---------------
                                                    OPEN             PASSWORD


SQL> create tablespace ts_pii_pdb datafile '/u01/app/oracle/oradata/PIORO19/devdb/ts_pii.dbf' size 10M
encryption using 'AES256' default storage(encrypt);

SQL> create table test (name varchar2(10)) tablespace ts_pii_pdb;
Table created.

SQL> insert into test values ('Marcin');
1 row created.

SQL> commit;
Commit complete.
```

No Keys ?!?

```
SQL> @keys
KEY_ID                                                           TAG                  CON_ID
---------------------------------------------------------------- ------------------ ----------
Ac3KWSggv0/hv9ZDtD+qmpEAAAAAAAAAAAAAAAAAAAAAAAAAAAA  initial CDB key             1
AbEgNxflw09Sv4RWTMA2oM4AAAAAAAAAAAAAAAAAAAAAAAAAAAA  initial devdb key           3

SQL> show pdbs
    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         3 DEVDB                          READ WRITE NO

SQL> alter session set container = devdb;
Session altered.

SQL> ADMINISTER KEY MANAGEMENT EXPORT ENCRYPTION KEYS WITH SECRET "delphix" TO '/tmp/devdb.p12' FORCE
KEYSTORE IDENTIFIED BY delphix;
keystore altered.

SQL> shutdown
Pluggable Database closed.
```

No Keys ?!?

```
SQL> alter pluggable database devdb unplug into '/tmp/devdb.xml';
Pluggable database altered.

SQL> drop pluggable database devdb;
Pluggable database dropped.

SQL> create pluggable database devdb using '/tmp/devdb.xml' nocopy;
Pluggable database created.

SQL> show pdbs
    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         4 DEVDB                          MOUNTED

SQL> alter session set container = devdb;
Session altered.
```

No Keys ?!?

```
SQL> startup
Warning: PDB altered with errors.
Pluggable Database opened.

SQL> @keys
no rows selected

SQL> @wallet
WRL_PARAMETER                                    STATUS           WALLET_TYPE
------------------------------------------------ ---------------- ---------------
                                                 CLOSED           UNKNOWN

SQL> administer key management set keystore open force keystore identified by delphix;
keystore altered.

SQL> @wallet
WRL_PARAMETER                                    STATUS           WALLET_TYPE
------------------------------------------------ ---------------- ---------------
                                                 OPEN             PASSWORD
```

No Keys ?!?

```
SQL> @keys
no rows selected

SQL> select con_id, name, cause, message, status from PDB_PLUG_IN_VIOLATIONS where name = 'DEVDB';
    CON_ID    NAME         CAUSE.               MESSAGE.                                    STATUS
         4    DEVDB.       Wallet Key Needed.   PDB needs to import keys from source.    PENDING

SQL> administer key management import encryption keys with secret "delphix" from '/tmp/devdb.p12' FORCE
KEYSTORE IDENTIFIED BY delphix with backup;
keystore altered.

SQL> shutdown
Pluggable Database closed.
SQL> startup
Pluggable Database opened.

SQL> select con_id, name, cause, message, status from PDB_PLUG_IN_VIOLATIONS where name = 'DEVDB’;
 CON_ID       NAME.        CAUSE.               MESSAGE.                                    STATUS
       4      DEVDB.       Wallet Key Needed.   PDB needs to import keys from source.    RESOLVED
```

No Keys ?!?

```
SQL> @wallet
WRL_PARAMETER                                      STATUS          WALLET_TYPE
-------------------------------------------------- --------------- ---------------

                                                   OPEN            PASSWORD


SQL> @keys
no rows selected

SQL> select * from test;
NAME
----------
Marcin
```

No Keys ?!?

```
SQL> alter session set container = cdb$root;
Session altered.

SQL> @keys
KEY_ID                                                           TAG                  CON_ID
---------------------------------------------------------------- ------------------ ----------
Ac3KWSggv0/hv9ZDtD+qmpEAAAAAAAAAAAAAAAAAAAAAAAAAAAA  initial CDB key             1
AbEgNxflw09Sv4RWTMA2oM4AAAAAAAAAAAAAAAAAAAAAAAAAAAA  initial devdb key           3

SQL> show pdbs

    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         4 DEVDB                          READ WRITE NO
```

No Keys ?!?

https://docs.oracle.com/en/database/oracle/oracle-database/19/asoag/managing-keystores-encryption-keys-in-united-mode.html#GUID-34325A34-02A1-445E-BE5A-993CA5EDB926

“After you create the cloned PDB, encrypted data is still accessible by the clone using the master encryption key of the original PDB. After a PDB is cloned, there may be user data in the encrypted tablespaces. This encrypted data is still accessible because the master encryption key of the source PDB is copied over to the destination PDB. Because the clone is a copy of the source PDB but will eventually follow its own course and have its own data and security policies, you should rekey the master encrytion key of the cloned PDB.”

Also here Doc ID 2764277.1

Clone PDB

```
create pluggable database pdb2 from pdb1 file_name_convert=('PDB1','PDB2');
create pluggable database pdb2 from pdb1 file_name_convert=('PDB1','PDB2')
*
ERROR at line 1:
ORA-46697: Keystore password required.


create pluggable database pdb2 from pdb1 file_name_convert=('PDB1','PDB2') keystore identified by xxx;

Pluggable database created.
```

Clone PDB

```
@show_keys
    CON_ID KEY_ID                                                    TAG
---------- ------------------------------------------------------- --------------------------------
         3 AZAsw6mosk/pv7DQnWwc2XMAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey 1212
         1 AZZzCkrae08Zv1Th20jqQ3MAAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey 1212
         3 AWYbVyB7b08Iv2cLfpFuetcAAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey 1554


alter session set container = pdb2;
Session altered.

select * from pioro.test_ts_enc where rownum < 10;
select * from pioro.test_ts_enc where rownum < 10
                    *
ERROR at line 1:
ORA-28365: wallet is not open
```

Clone PDB

```
administer key management set keystore open force keystore identified by delphix;
keystore altered.


administer key management set key using tag "rekey new pdb" identified by delphix with backup using
"backup_0511_before_newpdb" container = all;

keystore altered.

@show_keys

    CON_ID KEY_ID                                                    TAG
---------- ------------------------------------------------------- --------------------------------
         6 AZROuKlafk96v73nWf2gGtoAAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey new pdb
         3 Ad9MKwByoU9yv1bOAnw2NhkAAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey new pdb
         1 AeVcqaBYnU9+v+z9zwgarIEAAAAAAAAAAAAAAAAAAAAAAAAAAAAA rekey new pdb
```

Clone PDB – 19c

```
SQL> select ts#, ENCRYPTEDKEY, MASTERKEYID, CON_ID from v$encrypted_tablespaces order by ts#;
   TS# ENCRYPTEDKEY                                                 MASTERKEYID                       CON_ID
------ ---------------------------------------------------------- -------------------------------- ----------
     0 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         3
     1 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         3
     2 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         3
     6 739737B12D4EC2A19F1E30D5C4B2D931BD2D9AA5810754E41D3ABA30A629D6D6 4AE87763092B4F45BFE2C5BB635733F4         3

SQL> select ts#, ENCRYPTEDKEY, MASTERKEYID, CON_ID from v$encrypted_tablespaces order by ts#;
   TS# ENCRYPTEDKEY                                                 MASTERKEYID                       CON_ID
------ ---------------------------------------------------------- -------------------------------- ----------
     0 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         5
     1 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         5
     2 2B5EFD42D32C24190A401BE3CD2FBC32DDA2647F0CB1BA8683E4165E1A935025 4AE87763092B4F45BFE2C5BB635733F4         5
     6 2BEEFE9F5E9A9B0182382CFD9EB46E85F3D3A2B9F0FF8CA3970C5B9E94F95061 4AE87763092B4F45BFE2C5BB635733F4         5
```

Clone PDB 19c

“By default, during a PDB clone or relocate operation, the data encryption keys are rekeyed, which implies a re-encryption of all encrypted tablespaces. This rekey operation can increase the time it takes to clone or relocate a large PDB. With the optional `NO REKEY` clause, the data encryption keys are not renewed, and encrypted tablespaces are not re-encrypted.”

https://docs.oracle.com/en/database/oracle/oracle-database/19/asoag/managing-keystores-encryption-keys-in-united-mode.html#GUID-34325A34-02A1-445E-BE5A-993CA5EDB926

```
SQL> create pluggable database sysenc3 from devdb FILE_NAME_CONVERT=('devdb','sysenc3') keystore
identified by delphix no rekey;

Pluggable database created.
```

Clone PDB 19c

```
dd if=/u01/app/oracle/oradata/PIORO19/devdb/ts_pii.dbf of=block_devdb.dmp bs=8k count=8 skip=128

dd if=/u01/app/oracle/oradata/PIORO19/sysenc/ts_pii.dbf of=block_synenc_rk.dmp bs=8k count=8 skip=128

dd if=/u01/app/oracle/oradata/PIORO19/sysenc3/ts_pii.dbf of=block_synenc3.dmp bs=8k count=8 skip=128

[oracle@hobbiton ~]$ md5sum block_devdb.dmp
ed179bcbdaeb2df7e5deec7ccce31f9f  block_devdb.dmp

[oracle@hobbiton ~]$ md5sum block_synenc_rk.dmp
4e650dac8572b65a78b6466bbf30ac01  block_synenc_rk.dmp

[oracle@hobbiton ~]$ md5sum block_synenc3.dmp
ed179bcbdaeb2df7e5deec7ccce31f9f  block_synenc3.dmp
```

Non-prod environments

Copy to non-prod

Is it Possible to Remove/Disable TDE?

NO

Doc ID 2488898.1 - Last update: 21-Jan-2019 !!!

Deleting the TDE wallet will not disable TDE. Once TDE wallet is configured, the wallet should never be deleted or recreated.

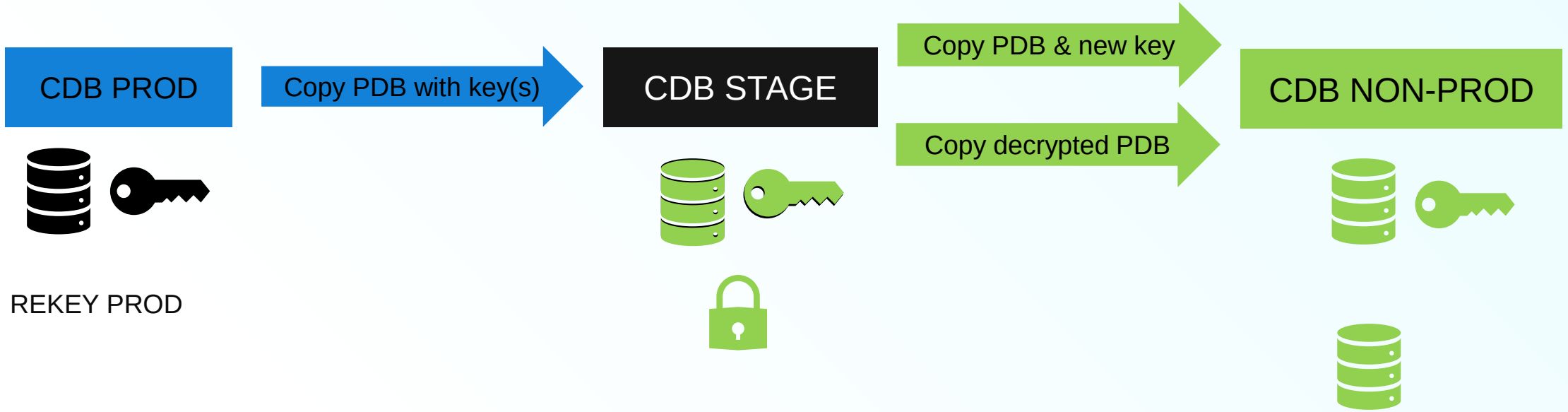
…

Even if there are no encrypted objects in the database, the TDE wallet has to be present in the wallet location. It does not cause any harm.

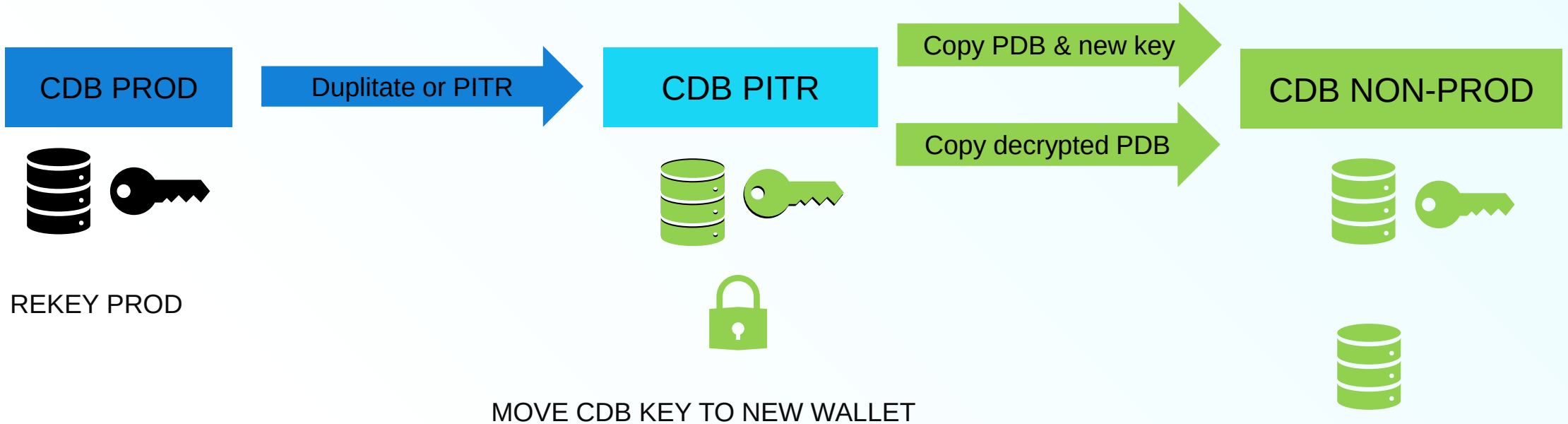
…

Recreating the wallet using any parameters is not supported. Oracle Support/Development team will not help in resolving any issues arising due to such operations.

How to move data to non-prod



How to move data to non-prod



Decrypt data

```
alter tablespace TS_PII offline normal;
Tablespace altered.

alter tablespace TS_PII encryption offline decrypt
*
ERROR at line 1:
ORA-28435: cannot decrypt data file
/u01/app/oracle/oradata/PIORO19/devdb/ts_pii01.dbf which is not encrypted with
the database key
```

ORA-28435: Cannot Decrypt Data File %s Which Is Not Encrypted With The Database Key (From ALTER DATABASE DATAFILE ... DECRYPT) (Doc ID 2406173.1)

This is expected behavior …

Use:

```
alter table … move tablespace ts_non_encrypted;
```

Decrypt data

```
...
LOGFILE
GROUP 1 '/prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_1_gc1cbf1b_.log' SIZE 52428800,
GROUP 2 '/prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_2_gc1cbf4q_.log' SIZE 52428800,
GROUP 3 '/prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_3_gc1cbf57_.log' SIZE 52428800

2019-04-30T12:14:54.876814+01:00
Clearing online redo logfile 1 complete
Clearing online redo logfile 2 complete
Clearing online redo logfile 3 complete
Online log /prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_1_gc1cbf1b_.log: Thread 1 Group 1 was
previously cleared
Online log /prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_2_gc1cbf4q_.log: Thread 1 Group 2 was
previously cleared
Online log /prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_3_gc1cbf57_.log: Thread 1 Group 3 was
previously cleared
Online log /prodb/delphix/VTEST/datafile/VTEST/onlinelog/o1_mf_4_gdjcjnr1_.log: Thread 1 Group 4 was
previously cleared
Online log /prodb/delphix/VTEST/datafile/VTEST/onlinelog/o1_mf_5_gdjcjnso_.log: Thread 1 Group 5 was
previously cleared

Completed: alter database open resetlogs
2019-04-30T12:14:59.915339+01:00
```

Decrypt data

```
2019-04-30T12:15:01.117125+01:00
Shutting down instance (abort) (OS id: 2460)
…

2019-04-30T12:15:23.271945+01:00
ALTER DATABASE OPEN

2019-04-30T12:15:23.756549+01:00
Beginning crash recovery of 1 threads
 parallel recovery started with 7 processes

2019-04-30T12:15:23.938460+01:00
Recovery of Online Redo Log: Thread 1 Group 2 Seq 2 Reading mem 0
  Mem# 0: /prodb/delphix/VTEST/datafile/PROD/onlinelog/o1_mf_2_gc1cbf4q_.log
2019-04-30T12:15:23.938755+01:00
Completed redo application of 0.05MB
2019-04-30T12:15:23.979012+01:00
Slave encountered ORA-28365 exception during crash recovery
Slave exiting with ORA-28365 exception
2019-04-30T12:15:23.979455+01:00
Errors in file /product/oracle/12c/ora/diag/rdbms/VTEST/VTEST/trace/VTEST_p003_2601.trc:
ORA-28365: wallet is not open
```

Decrypt data

- Make sure there is no sign of encryption in:
  - redo logs (switch or recreate them)
  - undo tablespace (recreate ?)
  - archive log ?
- If you are cloning using snapshot / crash consistency tools – make sure you checkpoint your database

Move key between production / non-production

- No easy method in 12.1, 12.2 and 18c:
  - Doc ID 2216279.1 - How to delete old master keys from 12c TDE keystore (wallet).
  - Requires a open database but also requires to restart a database during a process

Move key – 19c

```
SQL> @keys
KEY_ID                                                   TAG                                 CON_ID
-------------------------------------------------------- ------------------------------ ----------
AVpZ8Ohu50/jv2uvQxp59rQAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master 2                             1
AchUP2/wAk+Uv0TcPpNFkTYAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master                              1
AfF2Wgxh0E+Vv8cG9hM7uacAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master                              1
AUVjlyq+0E9kv9REfPVEhsIAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master                              1

SQL> ADMINISTER KEY MANAGEMENT MOVE KEYS TO NEW KEYSTORE '/home/oracle/newkeys2' IDENTIFIED BY nowy
FROM FORCE KEYSTORE IDENTIFIED BY delphix WITH IDENTIFIER IN
'AchUP2/wAk+Uv0TcPpNFkTYAAAAAAAAAAAAAAAAAAAAAAAAAAA','AfF2Wgxh0E+Vv8cG9hM7uacAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAA','AUVjlyq+0E9kv9REfPVEhsIAAAAAAAAAAAAAAAAAAAAAAAAAAA' with backup;
keystore altered.

SQL> @keys
KEY_ID                                                   TAG                                 CON_ID
-------------------------------------------------------- ------------------------------ ----------
AVpZ8Ohu50/jv2uvQxp59rQAAAAAAAAAAAAAAAAAAAAAAAAAAA  new master 2                             1
```

Move key – 19c

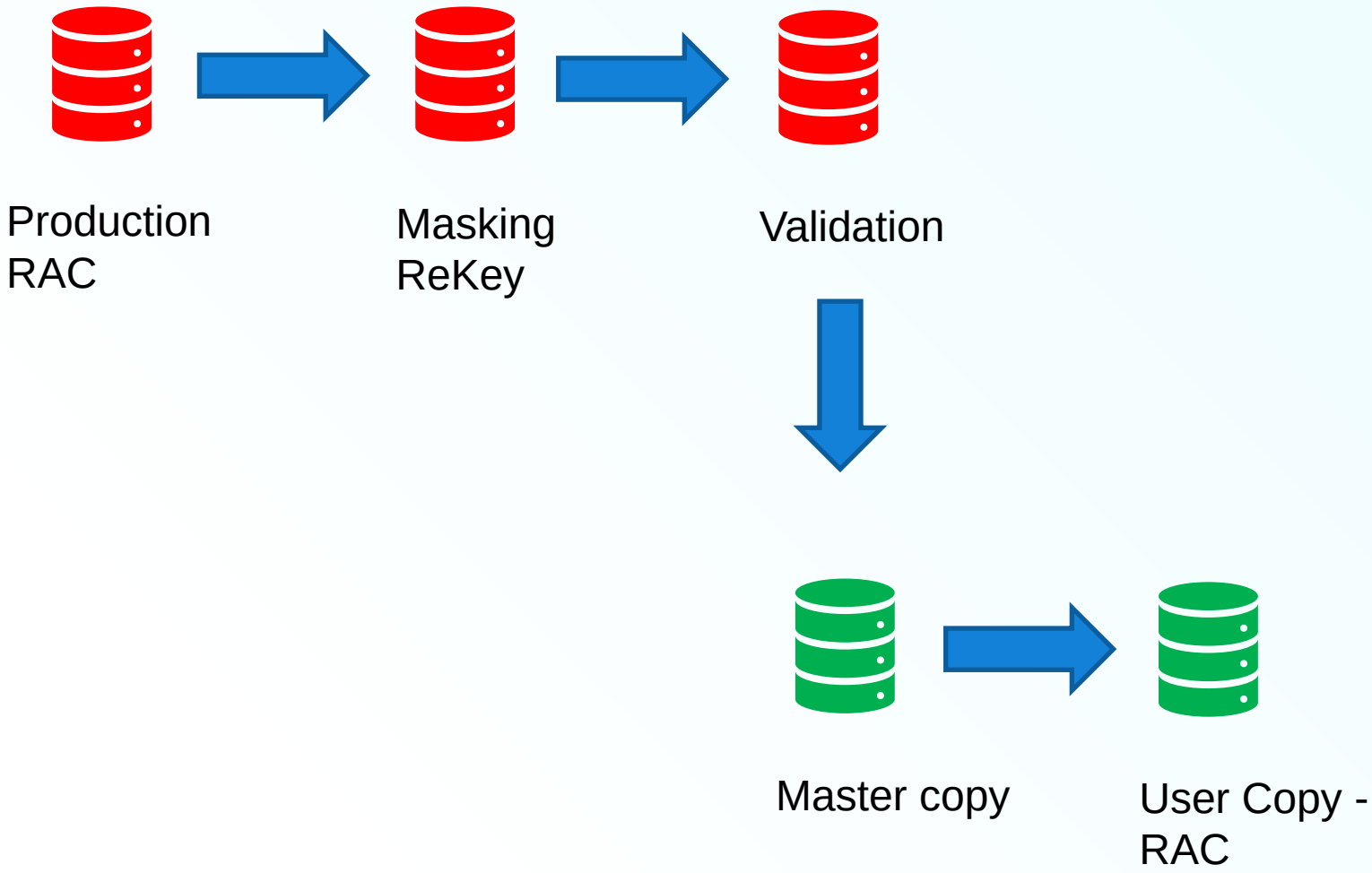
```
SQL> @keys
KEY_ID                                                    TAG                                 CON_ID
--------------------------------------------------------- ------------------------------ ----------
AZ/qG+GDmE/Tv7mpI8btokQAAAAAAAAAAAAAAAAAAAAAAAAAAA  rekey pdb                                      5
Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAA  sysenc2-nonprod                                5

SQL> select ts#, MASTERKEYID, CON_ID from v$encrypted_tablespaces order by ts# ;
       TS# MASTERKEYID                                CON_ID
---------- ------------------------------ ---------
         6 DF679DFC14BF4FD8BFDF02E37D9FC684 -

SQL> alter session set container = cdb$root;
Session altered.

SQL> ADMINISTER KEY MANAGEMENT MOVE KEYS TO NEW KEYSTORE '/home/oracle/newkeys2' IDENTIFIED BY nowy
FROM FORCE KEYSTORE IDENTIFIED BY test WITH IDENTIFIER IN
'AZ/qG+GDmE/Tv7mpI8btokQAAAAAAAAAAAAAAAAAAAAAAAAAAA' with backup;
*
ERROR at line 1:
ORA-46688: cannot move a master key
```

Ad9nnfwUv0/Yv98C432fxoQ

Move key between production / non-production

- No easy method in 12.1, 12.2, 18c and 19c:
  - Doc ID 2216279.1 - How to delete old master keys from 12c TDE keystore (wallet).
  - Requires a open database but also requires to restart a database during a process

Real config


Production
RAC
Masking
ReKey
Validation
Master copy
User Copy -
RAC

Solution based on recovery / unplug / plug / export / import

```
select con_id, status from v$encryption_wallet;

CON_ID     STATUS
-------    --------------------
           OPEN_NO_MASTER_KEY
```

```
select * from XXX.TEST;
select * from XXX.TEST;

ERROR at line 1:
ORA-28374: typed master key not found in wallet
```

```
select id from table;
ID
--
10

update table set id = 20;
ORA-28374: typed master key not found in wallet
```

```
alter pluggable database ”test" open read write
ERROR at line 1:
ORA-30013: undo tablespace '\''BIGTBS'\'' is
currently in use’
```

Set same key

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEY using tag 'sysenc2-nonprod' FORCE KEYSTORE identified by
test with backup;
keystore altered.

SQL> @keys
KEY_ID                                                   TAG                 ACTIVATION_TIME
-------------------------------------------------------- ------------------  ---------------------------
AZ/qG+GDmE/Tv7mpI8btokQAAAAAAAAAAAAAAAAAAAAAAAAAAAA  rekey pdb          18-SEP-22 09.57.57.445127 AM
Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAAAA  sysenc2-nonprod

SQL> administer key management use key 'Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAAAA' force
keystore identified by test with backup;
Keystore altered.

SQL> @keys
KEY_ID                                                   TAG                 ACTIVATION_TIME
-------------------------------------------------------- ------------------  ---------------------------
AZ/qG+GDmE/Tv7mpI8btokQAAAAAAAAAAAAAAAAAAAAAAAAAAAA  rekey pdb          18-SEP-22 09.57.57.445127 AM
Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAAAA  sysenc2-nonprod    18-SEP-22 02.32.39.984053 PM
```

Set same key

```
SQL> shutdown
Pluggable Database closed.

SQL> alter session set container = cdb$root;
Session altered.

SQL> drop pluggable database sysenc2 including datafiles;
Pluggable database dropped.

SQL> create pluggable database sysenc2 using '/tmp/sysenc2_fc.pdb' decrypt using delphix keystore
identified by test FILE_NAME_CONVERT=('/tmp','/u01/app/oracle/oradata/TGT19/sysenc2');
Pluggable database created.
```

Set same key

```
SQL> alter session set container = sysenc2;
Session altered.

SQL> administer key management set keystore open force keystore identified by test;
keystore altered.

SQL> startup
Pluggable Database opened.

SQL> @keys
no rows selected

SQL> administer key management use key 'Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAAA' force
keystore identified by test with backup;
keystore altered.

SQL> @keys
KEY_ID                                                   TAG                    CON_ID
-------------------------------------------------------- -------------------- ----------
Ad9nnfwUv0/Yv98C432fxoQAAAAAAAAAAAAAAAAAAAAAAAAAAA  sysenc2-nonprod                 3
```

I am using TDE because:

A) database is in the regulated industry, and I have to

B) I want to feel safe

C) I want to increase a risk of my own ransomeware attack by losing my keystore or password to a keystore

Key take aways

- Upgrade to 19c
- Build a strategy to copy your production database to non-prod
- Make sure your protection needs are fulfilled by TDE

Q&A

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