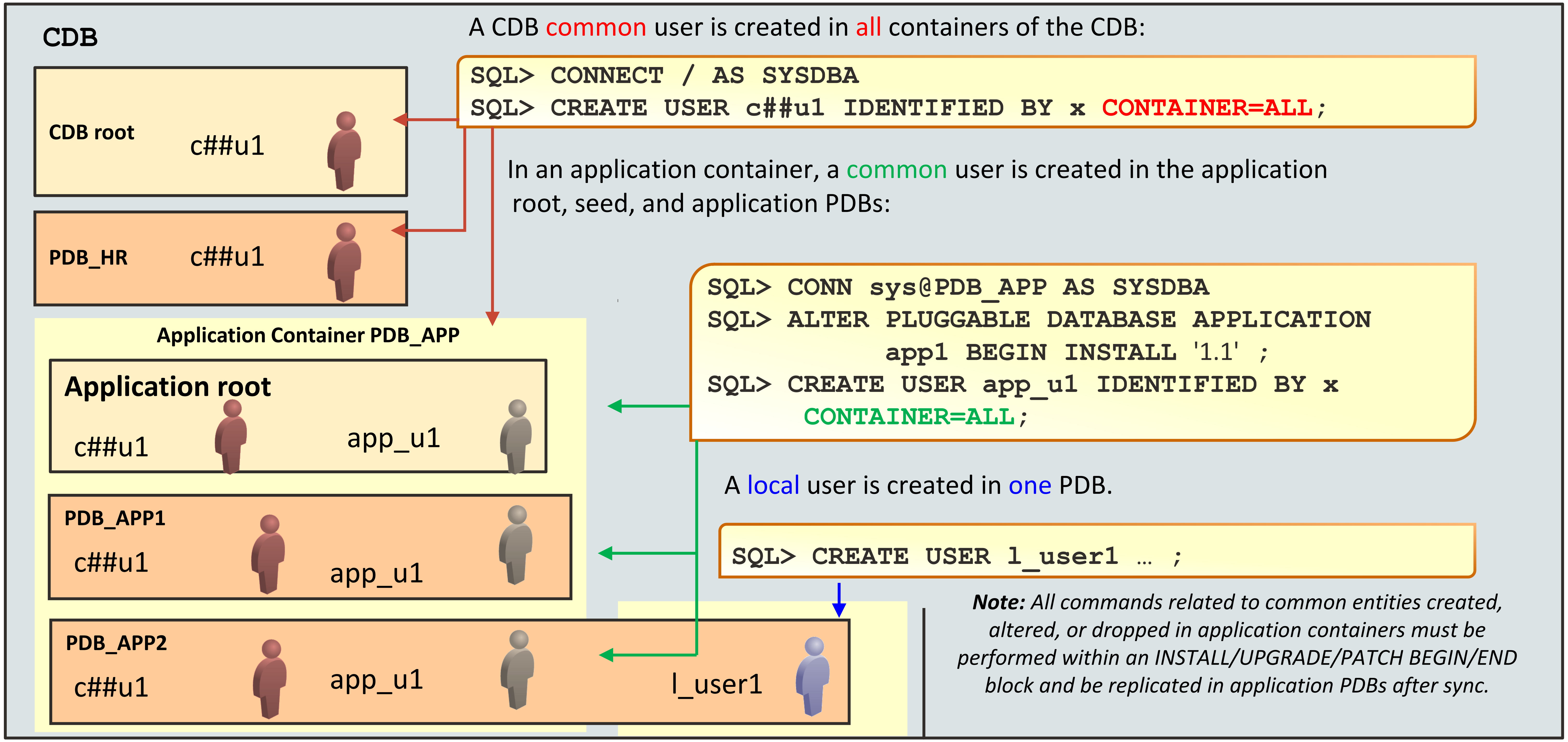
Security

Objectives

After completing this lesson, you should be able to:

- Manage common and local users, roles, privileges, and profiles in PDBs
- Manage common and local objects in application containers
- Enable common users to access data in PDBs
- Manage PDB lockdown profiles
- Audit users in CDB and PDBs
- Manage other types of policies in application containers
- Protect data with Database Vault policies in CDB and PDBs
- Encrypt data in PDBs
- Configure isolated PDB keystores
- Unplug and plug an encrypted PDB in a one-step operation
- Allow per-PDB wallets for certificates

Creating Common Users in the CDB and PDBs



A CDB common user is created in all containers of the CDB:

```
SQL> CONNECT / AS SYSDBA
SQL> CREATE USER c##u1 IDENTIFIED BY x CONTAINER=ALL;
```

In an application container, a common user is created in the application root, seed, and application PDBs:

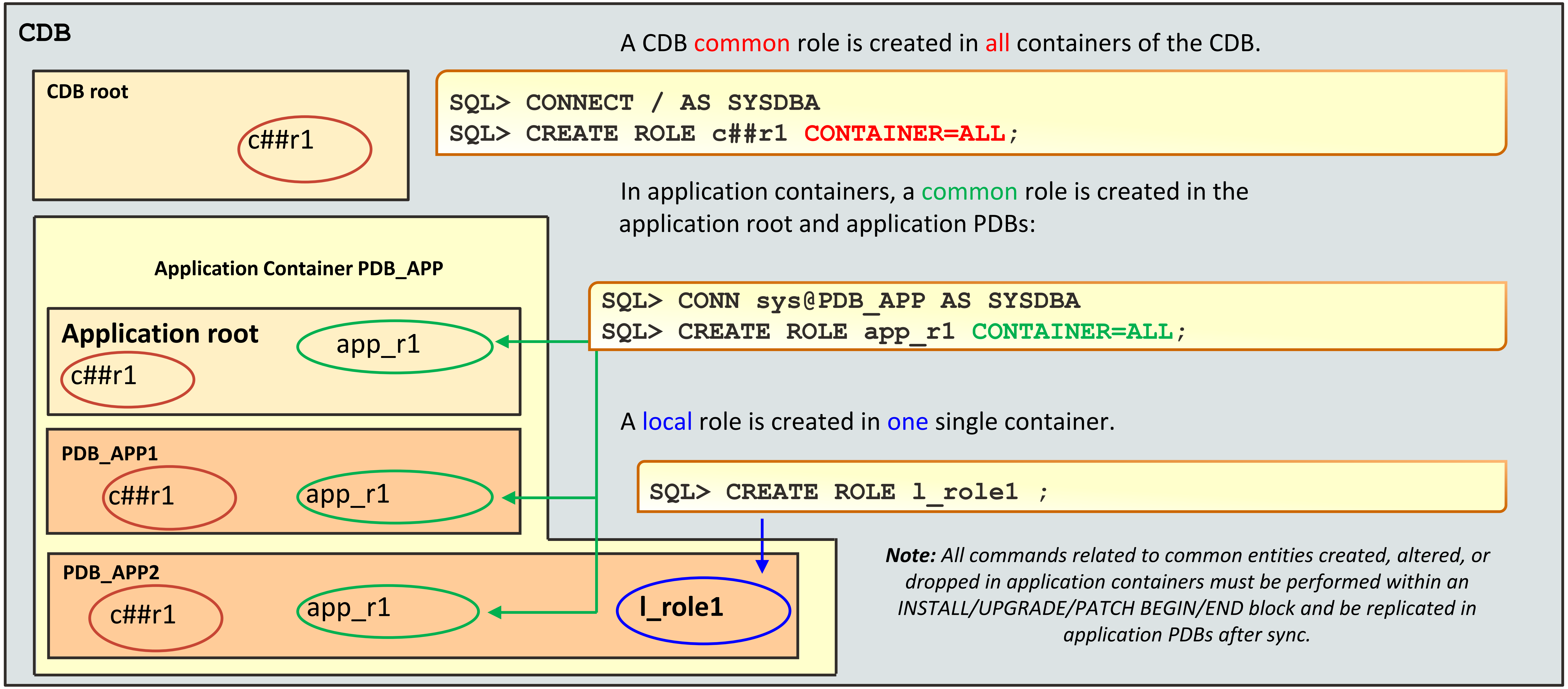
```
SQL> CONN sys@PDB_APP AS SYSDBA
SQL> ALTER PLUGGABLE DATABASE APPLICATION
           app1 BEGIN INSTALL '1.1' ;
SQL> CREATE USER app_u1 IDENTIFIED BY x
      CONTAINER=ALL;
```

A local user is created in one PDB.

```
SQL> CREATE USER l_user1 … ;
```

Note: *All commands related to common entities created, altered, or dropped in application containers must be performed within an INSTALL/UPGRADE/PATCH BEGIN/END block and be replicated in application PDBs after sync.*

Creating Common Roles in the CDB and PDBs



A CDB common role is created in all containers of the CDB.

```
SQL> CONNECT / AS SYSDBA
SQL> CREATE ROLE c##r1 CONTAINER=ALL;
```

In application containers, a common role is created in the application root and application PDBs:

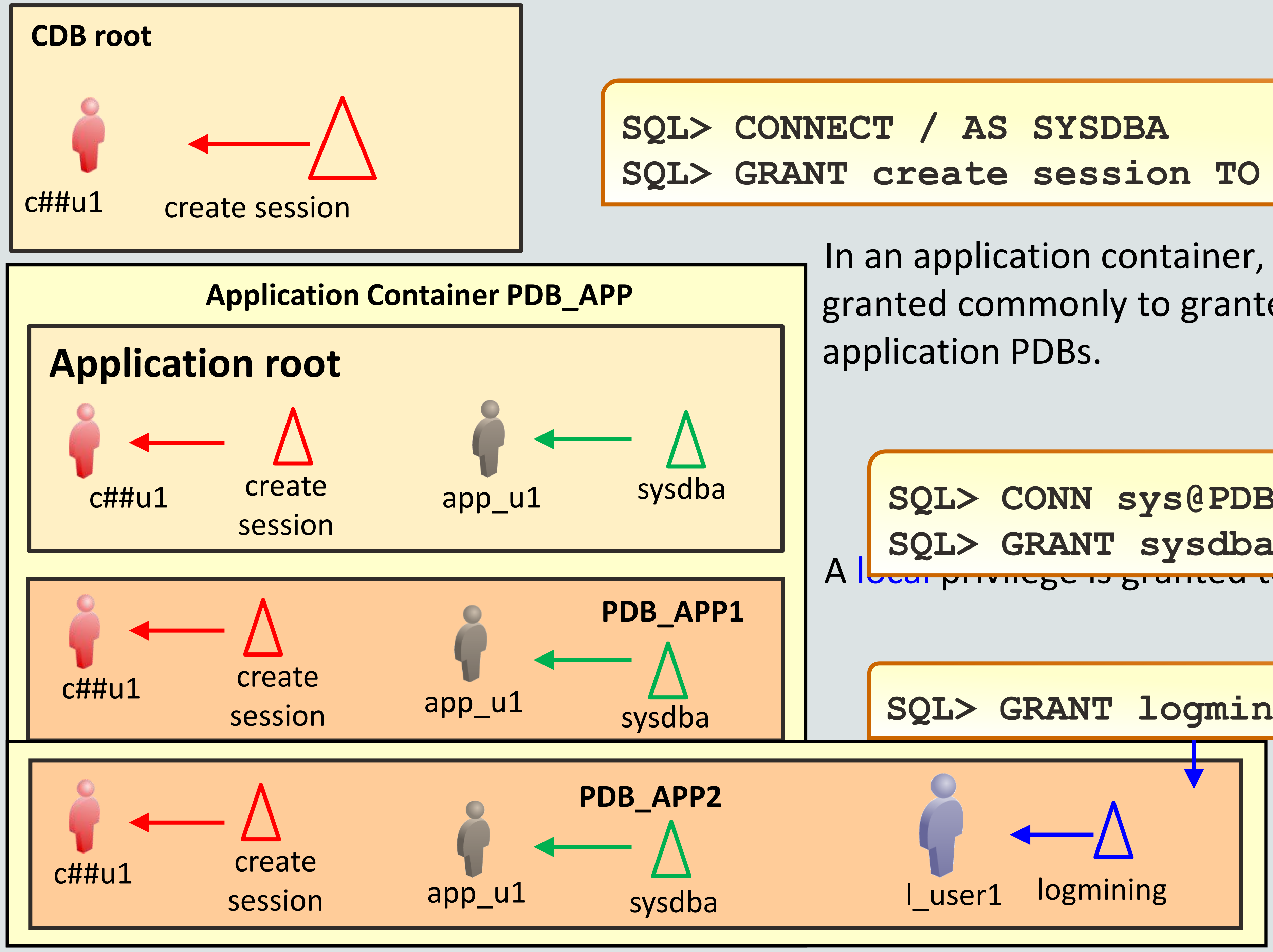
```
SQL> CONN sys@PDB_APP AS SYSDBA
SQL> CREATE ROLE app_r1 CONTAINER=ALL;
```

A local role is created in one single container.

```
SQL> CREATE ROLE l_role1 ;
```

Note: *All commands related to common entities created, altered, or dropped in application containers must be performed within an INSTALL/UPGRADE/PATCH BEGIN/END block and be replicated in application PDBs after sync.*

Granting Privileges Commonly in the CDB and PDBs



In a CDB, a common privilege is granted to a grantee in all containers of the CDB.

```
SQL> CONNECT / AS SYSDBA
SQL> GRANT create session TO c##u1  CONTAINER=ALL;
```

In an application container, a common privilege is a privilege granted commonly to grantees in the application root and application PDBs.

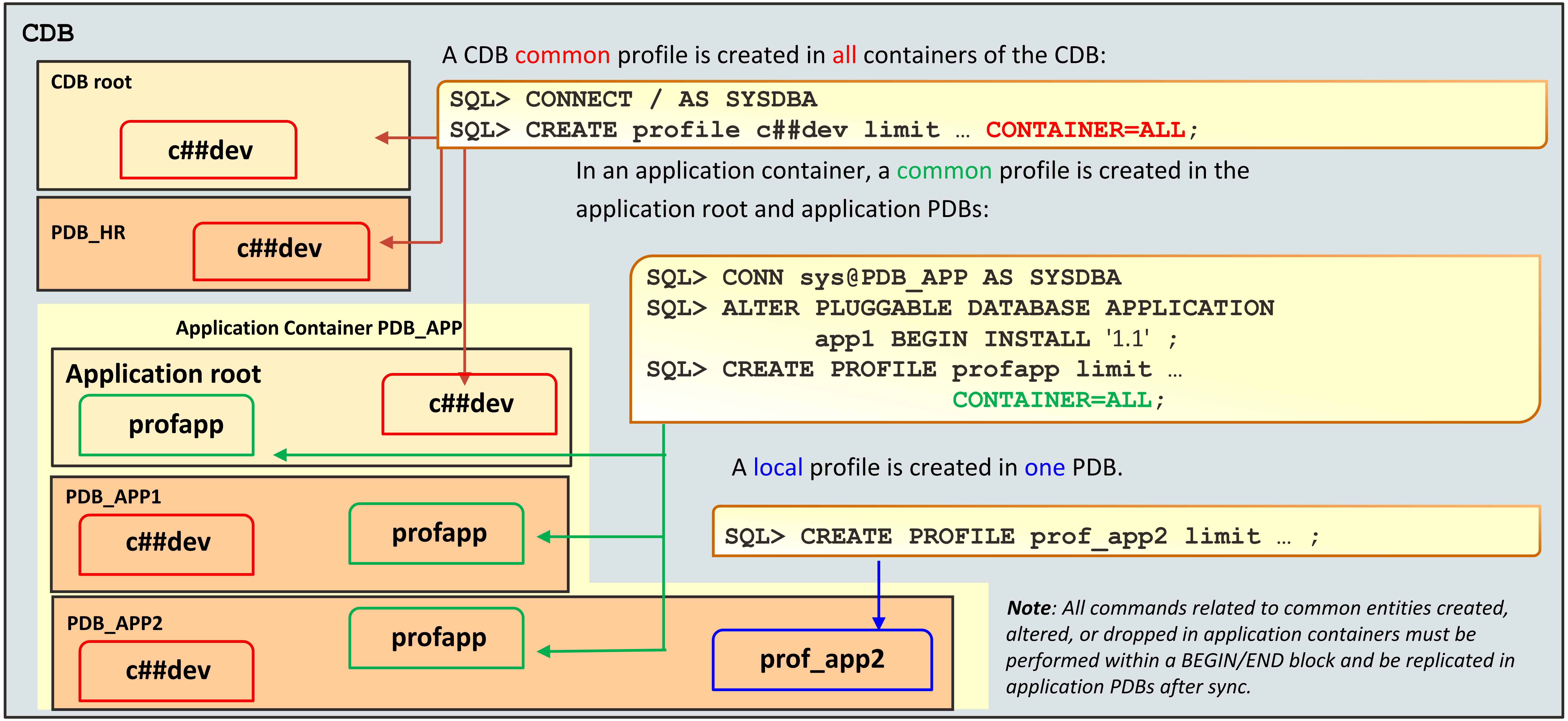
```
SQL> CONN sys@PDB_APP AS SYSDBA
SQL> GRANT sysdba TO app_u1 CONTAINER=ALL;
```

A local privilege is granted to grantees in one single PDB.

```
SQL> GRANT logmining TO l_user1;
```

Note: *All commands related to common entities created, altered, or dropped in application containers must be performed within an INSTALL/UPGRADE/PATCH BEGIN/END block and be replicated in application PDBs after sync.*

Creating Common Profiles in the CDB and PDBs



A CDB common profile is created in all containers of the CDB:

```
SQL> CONNECT / AS SYSDBA
SQL> CREATE profile c##dev limit … CONTAINER=ALL;
```

In an application container, a common profile is created in the application root and application PDBs:

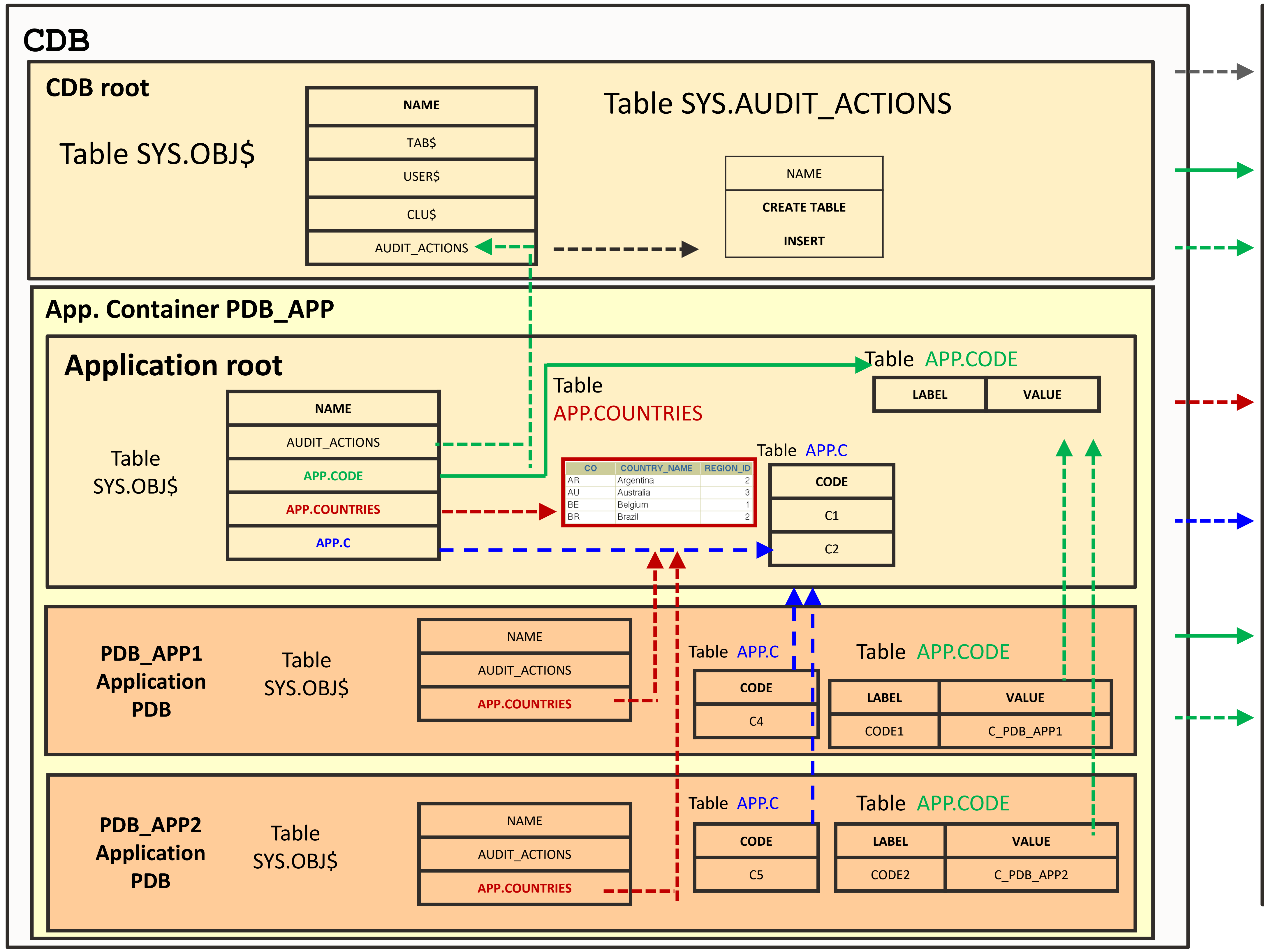
```
SQL> CONN sys@PDB_APP AS SYSDBA
SQL> ALTER PLUGGABLE DATABASE APPLICATION
            app1 BEGIN INSTALL '1.1' ;
SQL> CREATE PROFILE profapp limit …
                    CONTAINER=ALL;
```

A local profile is created in one PDB.

```
SQL> CREATE PROFILE prof_app2 limit … ;
```

***Note**: All commands related to common entities created, altered, or dropped in application containers must be performed within a BEGIN/END block and be replicated in application PDBs after sync.*

Common Objects in Application Containers



CO	COUNTRY_NAME	REGION_ID
AR	Argentina	2
AU	Australia	3
BE	Belgium	1
BR	Brazil	2

CDB level:
• A data-linked object and its data reside in the CDB root only and are shared by all PDBs.
• Metadata-linked objects store metadata about dictionary objects only in the CDB root.
Each PDB has a private data copy of an object pointing to a metadata link stored in the CDB root.

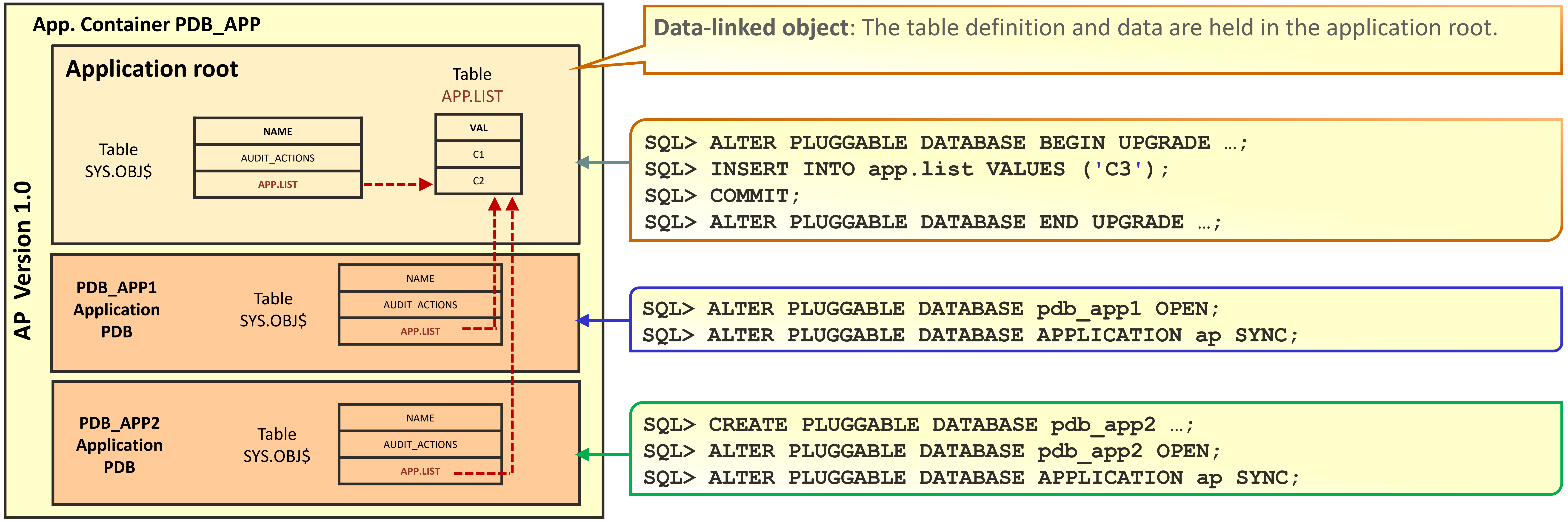
Application container level:
A data-linked object and its data reside in an application root only and are shared by all application PDBs.
An extended data-linked object combines data found in a table in an application PDB with data from a corresponding table in the application root.
A metadata-linked object stores the object definition in an application root only.
Each application PDB has a private data copy pointing to a metadata-linked object that is stored in an application root.

PDB level: A local object contains the definition and private data in the application PDB where it is created.

Operations on Data-Linked Objects

Apply **recorded DDL or DML** statements at synchronization:

- To new application PDBs
- To PDBs that were closed when the DDL or DML statements were issued



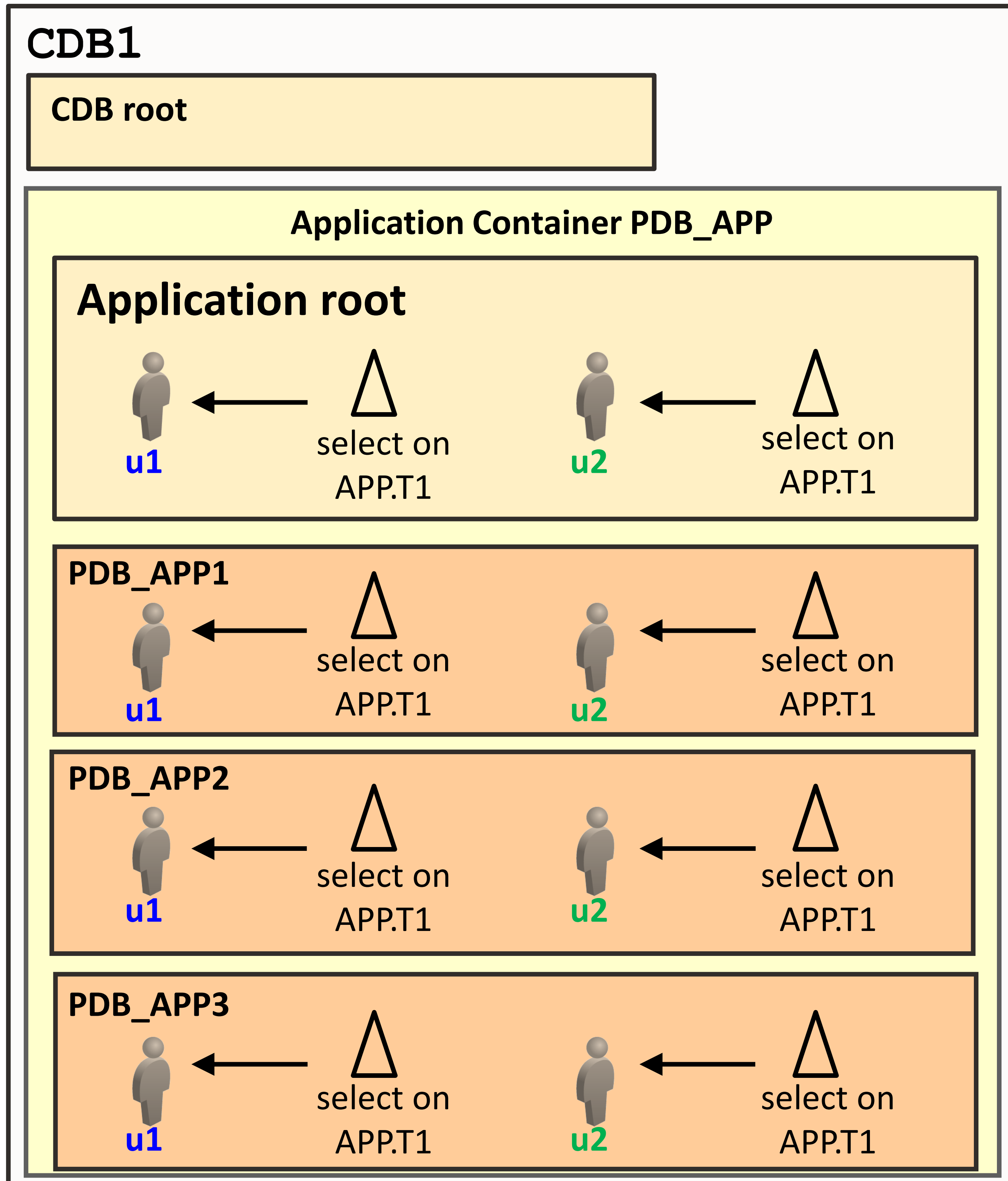
Data-linked object: The table definition and data are held in the application root.

```
SQL> ALTER PLUGGABLE DATABASE BEGIN UPGRADE …;
SQL> INSERT INTO app.list VALUES ('C3');
SQL> COMMIT;
SQL> ALTER PLUGGABLE DATABASE END UPGRADE …;
```

```
SQL> ALTER PLUGGABLE DATABASE pdb_app1 OPEN;
SQL> ALTER PLUGGABLE DATABASE APPLICATION ap SYNC;
```

```
SQL> CREATE PLUGGABLE DATABASE pdb_app2 …;
SQL> ALTER PLUGGABLE DATABASE pdb_app2 OPEN;
SQL> ALTER PLUGGABLE DATABASE APPLICATION ap SYNC;
```

Enabling Common Users to Access Data in PDBs



1.Enable data access to application metadata-linked tables:

```
SQL> CONNECT sys@pdb_app AS SYSDBA
SQL> ALTER TABLE app.t1 ENABLE CONTAINER_DATA;
```

2.Enable common users to access data related to specific PDBs:

```
SQL> ALTER USER u1 SET CONTAINER_DATA =
   (PDB_APP, PDB_APP1, PDB_APP2, PDB_APP3)
    FOR app.t1 CONTAINER=CURRENT;
```

```
SQL> ALTER USER u2 SET
          CONTAINER_DATA=(PDB_APP, PDB_APP1)
          FOR app.t1 CONTAINER=CURRENT;
```

3.U1 views all rows in APP.T1:

C1	CON_ID
VAL1	3
VAL2	4
VAL3	5
VAL4	6

U2 views some rows:

C1	CON_ID
VAL1	3
VAL2	4

Finding Information About CONTAINER_DATA Attributes

Find information about the default (user-level) and object-specific CONTAINER_DATA attributes that are explicitly set to a value other than DEFAULT.

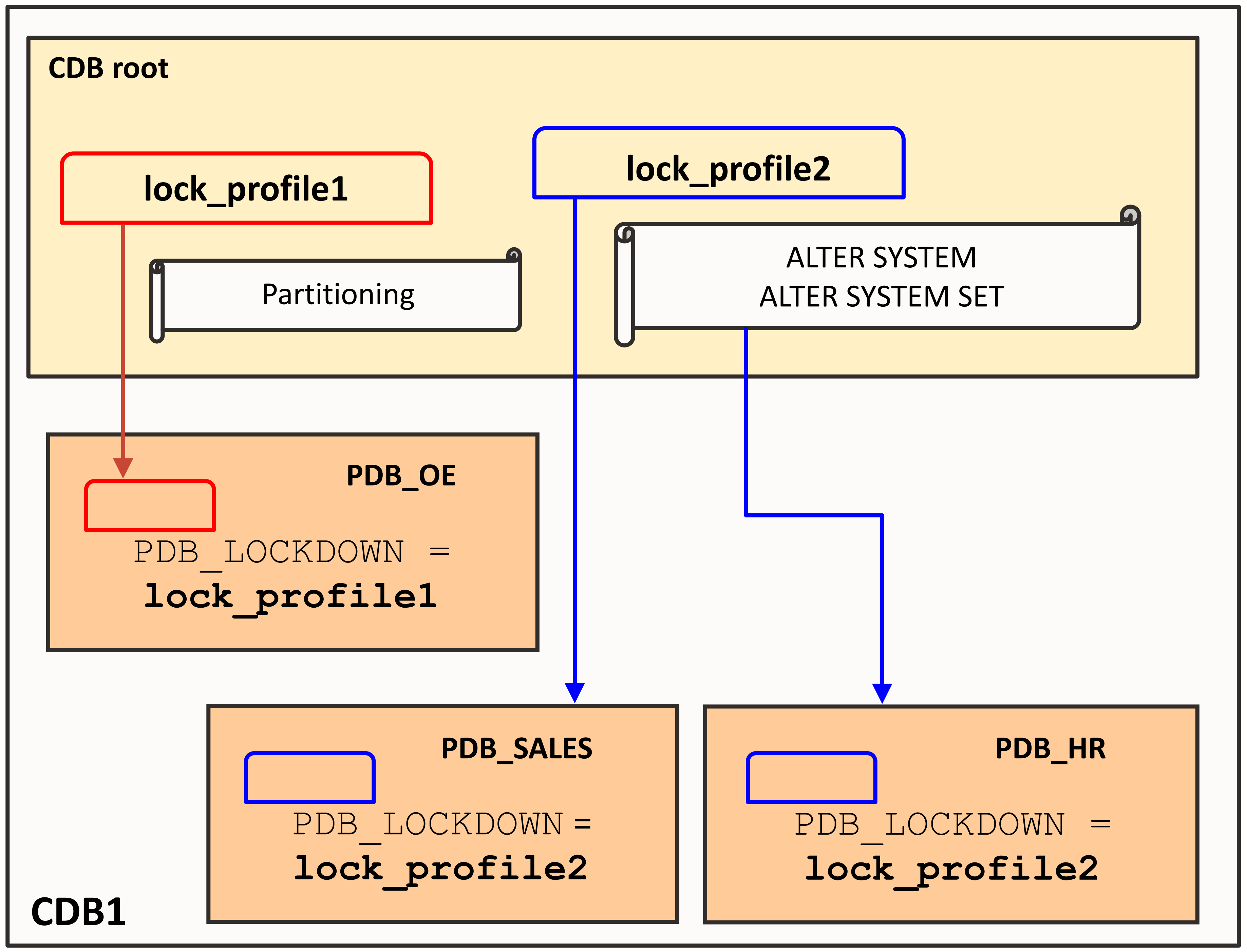
```
SQL> SELECT username, default_attr, object_name, all_containers, container_name,
            con_id
     FROM   cdb_container_data ORDER BY object_name;

USERNAME          DEFAULT OBJECT_NAME    ALL CONTAINER_   CON_ID
----------------- ------- --------------- --- ----------  ------
C##JIM             N      V$SESSION        N   PDB_HR          1
C##JIM             N      V$SESSION        N   CDB$ROOT        1
C##JIM             N      V$SESSION        N   PDB2_2          1
SYSTEM             Y                       Y                   1
DBSNMP             Y                       Y                   1
SYSBACKUP          Y                       Y                   1
SYS                Y                       Y                   1
```

Restricting Operations with PDB Lockdown Profiles

- A potential for elevation of privileges exists where identity is shared between PDBs.
- You can restrict operations, features, and options used by users connected to a given PDB by using three `ALTER SYSTEM` clauses.

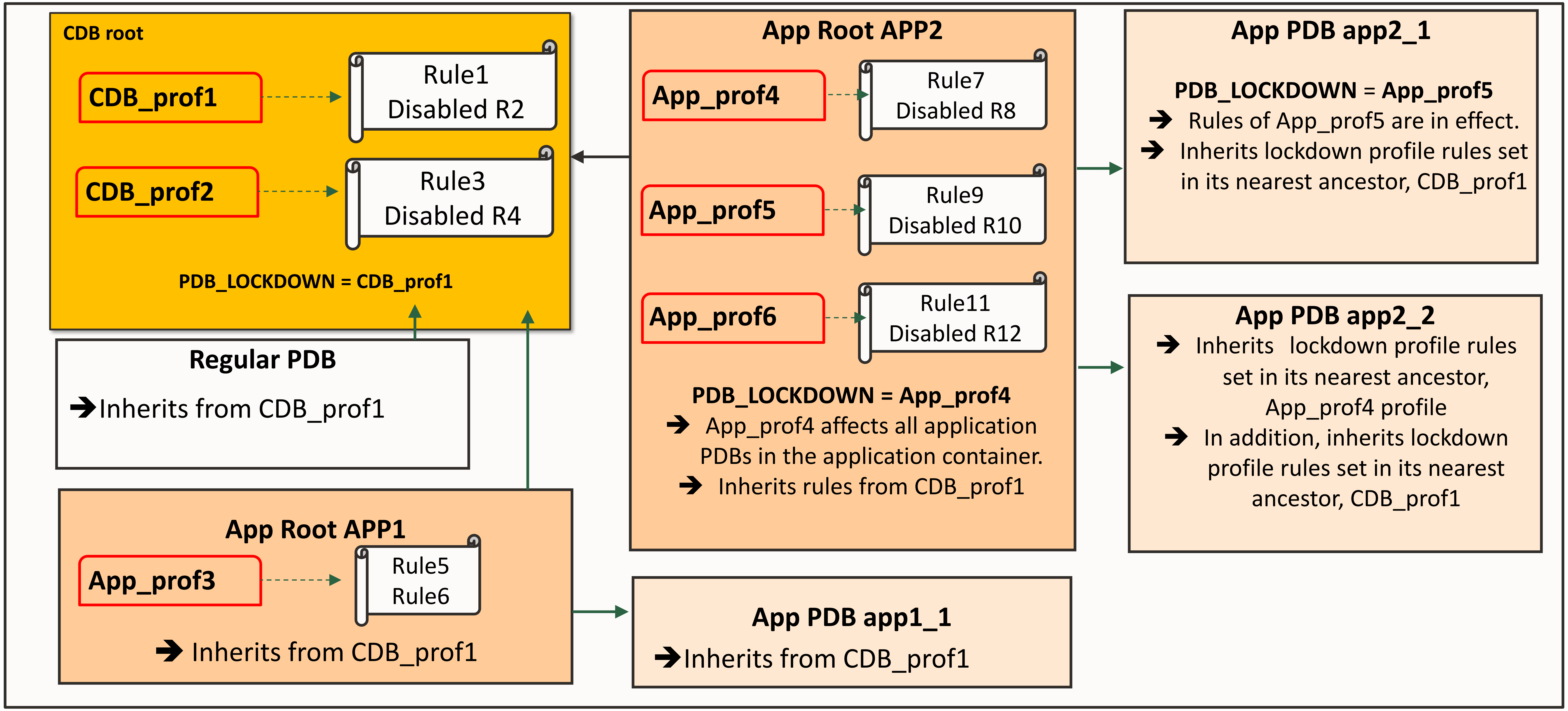
STATEMENT	FEATURE	OPTION
ALTER SYSTEM FLUSH SHARED_POOL, CHECKPOINT, SWITCH LOGFILE, SET	NETWORK_ACCESS UTL_TCP, UTL_SMTP, UTL_HTTP, UTL_INADDR, XDB_PROTOCOLS, DBMS_DEBUG_JDWP	Partitioning
	COMMON_SCHEMA_ACCESS	Advanced Queuing
	OS_ACCESS UTL_FILE, JAVA_OS_ACCESS, EXTERNAL_PROCEDURES	Real Application Clusters
	XDB_PROTOCOLS	Oracle Data Guard
	JAVA, JAVA_RUNTIME	

Restricting Operations in a PDB Lockdown Profile

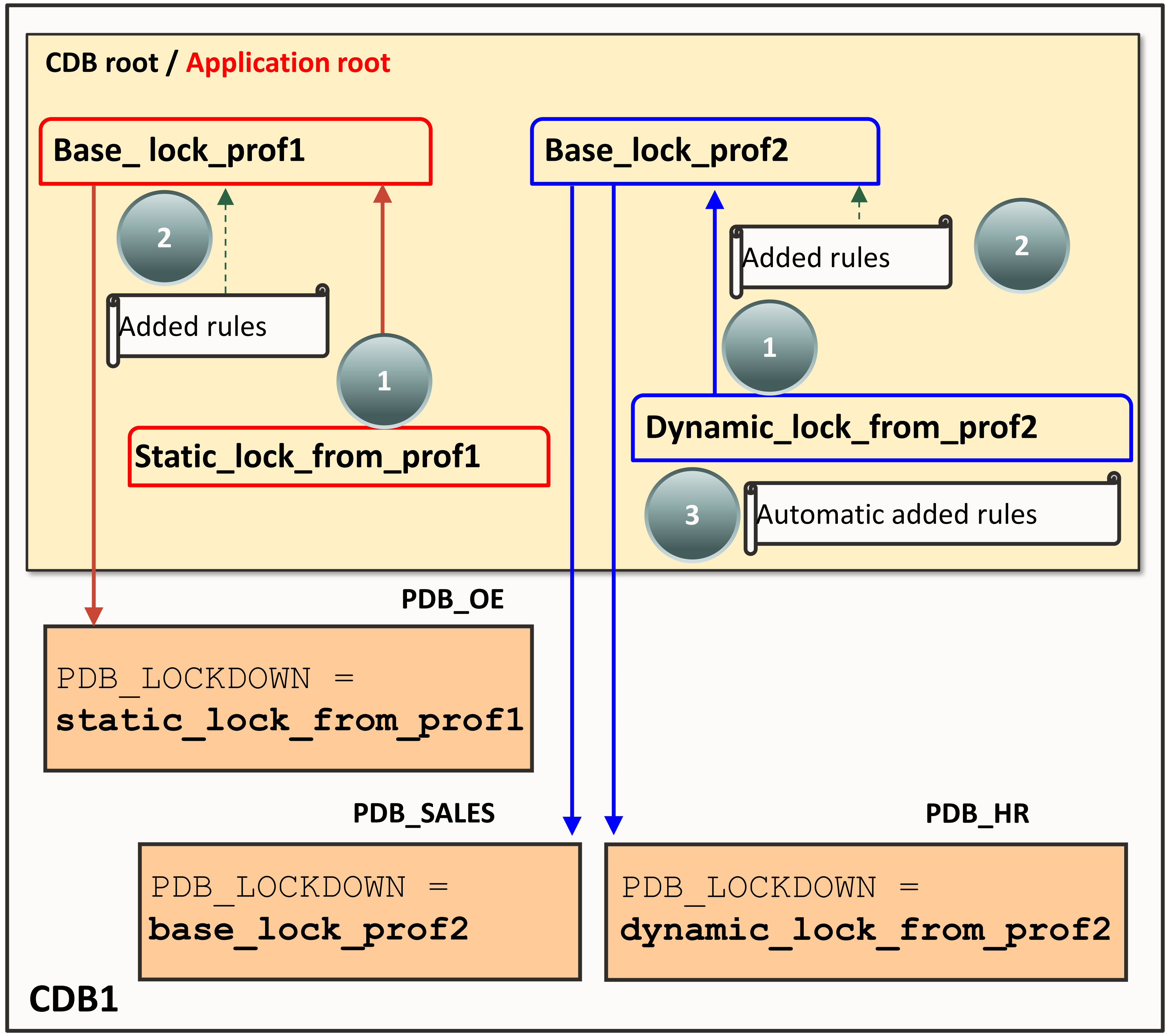


1. Create PDB lockdown profiles.
2. Define enabled and disabled:
   - Statement and clauses
   - Feature
   - Option
3. Set the `PDB_LOCKDOWN` parameter to a PDB lockdown profile for all PDBs.
4. Optionally set the `PDB_LOCKDOWN` parameter to another PDB lockdown profile for a PDB.

PDB Lockdown Profiles Inheritance


CDB root
CDB_prof1
Rule1
Disabled R2
CDB_prof2
Rule3
Disabled R4
PDB_LOCKDOWN = CDB_prof1
Regular PDB
➔Inherits from CDB_prof1
App Root APP1
App_prof3
Rule5
Rule6
➔ Inherits from CDB_prof1
App Root APP2
App_prof4
Rule7
Disabled R8
App_prof5
Rule9
Disabled R10
App_prof6
Rule11
Disabled R12
PDB_LOCKDOWN = App_prof4
➔ App_prof4 affects all application PDBs in the application container.
➔ Inherits rules from CDB_prof1
App PDB app1_1
➔Inherits from CDB_prof1
App PDB app2_1
PDB_LOCKDOWN = App_prof5
➔ Rules of App_prof5 are in effect.
➔ Inherits lockdown profile rules set in its nearest ancestor, CDB_prof1
App PDB app2_2
➔ Inherits lockdown profile rules set in its nearest ancestor, App_prof4 profile
➔ In addition, inherits lockdown profile rules set in its nearest ancestor, CDB_prof1

Static and Dynamic PDB Lockdown Profiles



There are two ways to create lockdown profiles by using an existing profile:

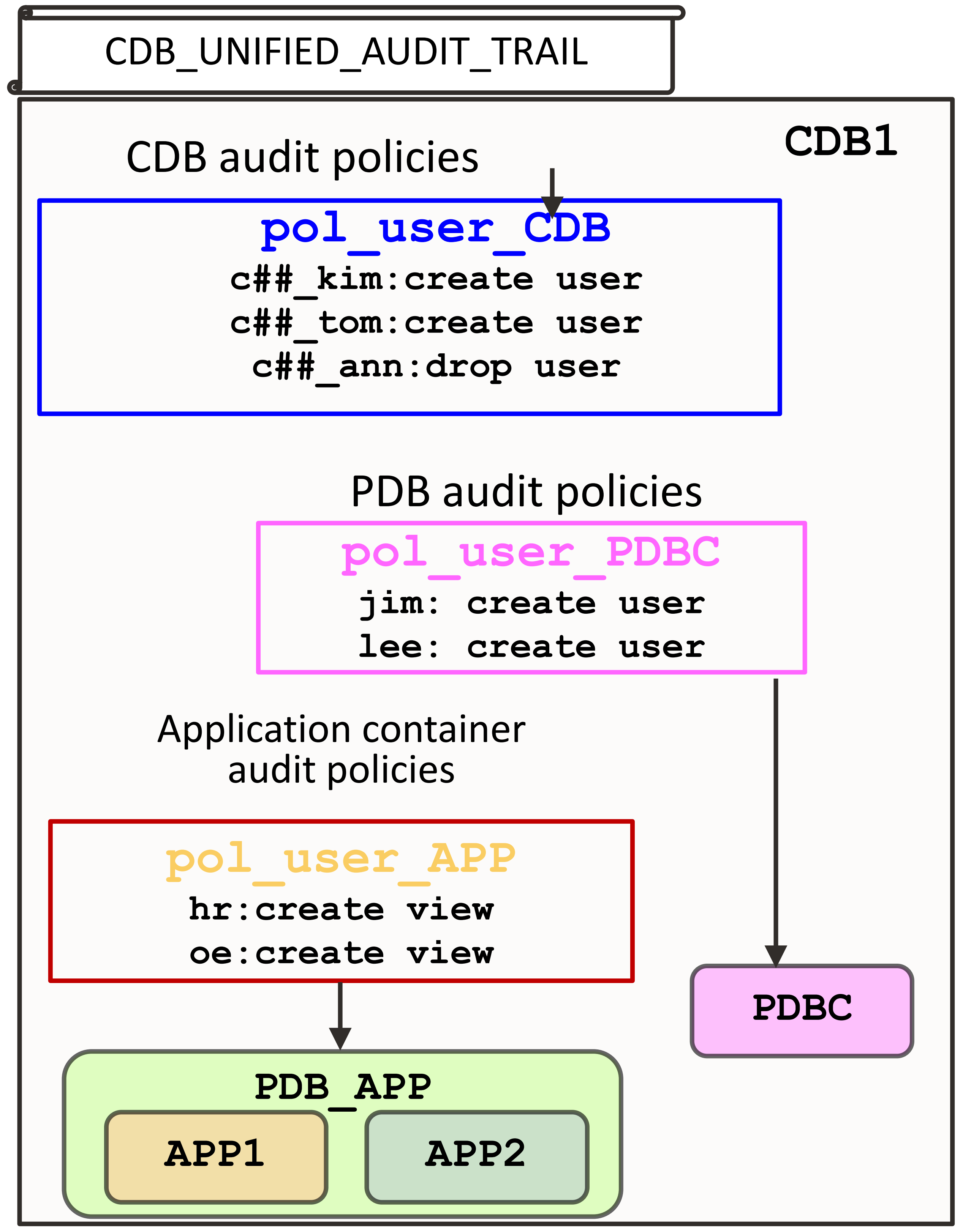
- Static lockdown profiles:

```
SQL> CREATE LOCKDOWN PROFILE prof3
       FROM base_lock_prof1;
```

- Dynamic lockdown profiles:

```
SQL> CREATE LOCKDOWN PROFILE prof4
       INCLUDING base_lock_prof2;
```

Auditing Actions in the CDB and PDBs



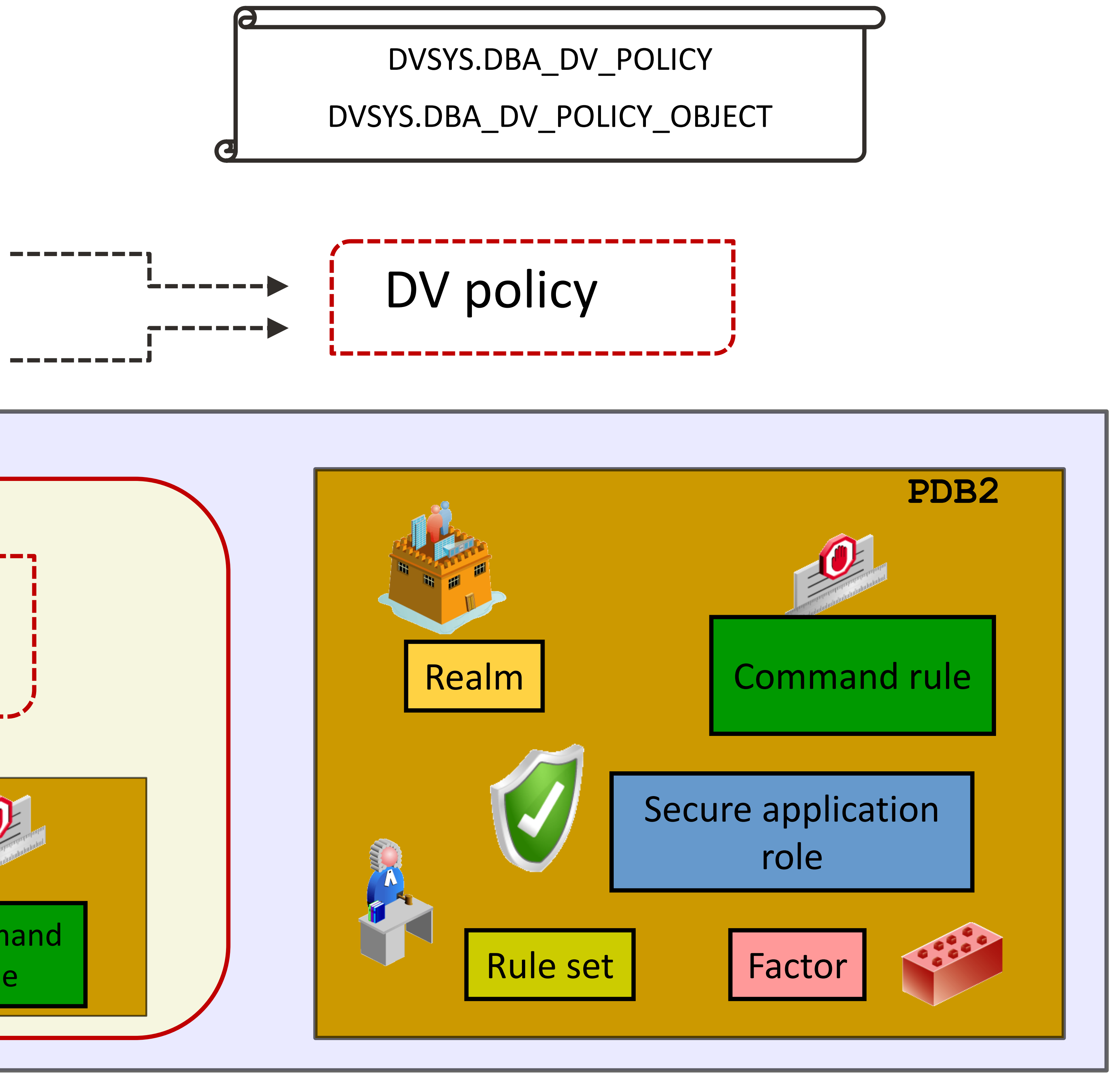
1. Connect to the CDB root or to an application root or to a regular PDB.
2. Create common or local unified audit policies:
   - For all PDBs (*connect to CDB root*)
   - For all application PDBs of an application container (*connect to the application root*)
   - For a regular PDB or a specific application PDB (*connect to the PDB*)
3. Enable/disable audit policies:
   - Define users or users being granted roles to be audited (*DBA role*)
   - Use `AUDIT POLICY` and `NOAUDIT POLICY` commands

Managing Other Types of Security Policies in Application Containers

Policy Type	Compatible in Application Containers	Created in Install / Upgrade / Patch BEGIN-END block	Automatic synchronization in application PDBs
Unified Audit	Y	Y (explicit or implicit)	Y (explicit or implicit)
FGA	Y	Y	N
Application Context & VPD	Y	Y	N
TSDP	Y	N	n/a
OLS	N	n/a	n/a

Securing Data with Oracle Database Vault

- Each PDB has its own Database Vault metadata.
- Database Vault common protection can protect the common objects of an application container:
  - Database Vault common realm
  - Database Vault common command rule



Oracle Database Vault-Enabled Strict Mode

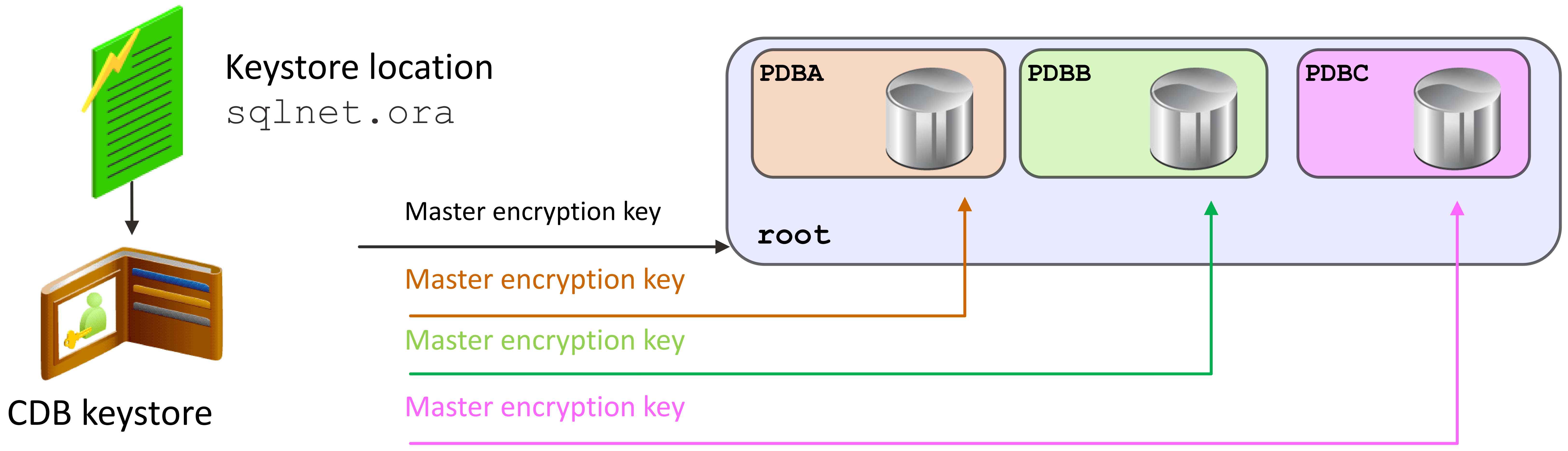
- Mixed mode:
  - Both Database Vault enabled and disabled PDBs can work together in the same application container.

    ➔
  - Database Vault common protection does not protect the common objects in the Database Vault disabled PDBs.
- Strict mode:
  - The common protection must cover the common objects in every PDB in the same application container.

    ➔
  - The Database Vault disabled PDBs are opened in restricted mode.

Managing Keystore in the CDB and PDBs

- There is one TDE master encryption key per PDB to encrypt PDB data.
- The TDE master encryption key must be transported from the source database keystore to the target database keystore when a PDB is moved from one host to another.



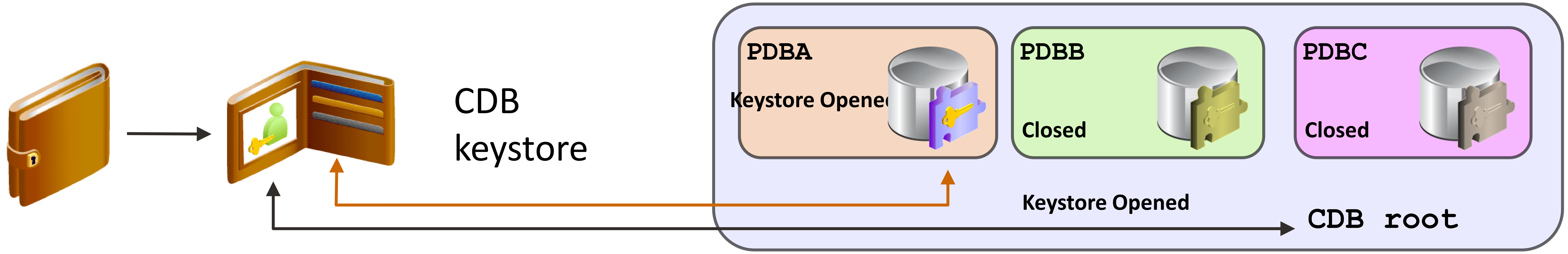
Creating and Opening a Keystore

- Create the unique keystore in the CDB root.

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE
               'u01/app/oracle/product/19.1.0/dbhome_1/wallet'
               IDENTIFIED BY k_password;
```

- Open the keystore in the CDB root and then for a specific PDB.

```
SQL> CONNECT john@PDBA AS SYSKM
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY k_password
                CONTAINER = CURRENT;
```

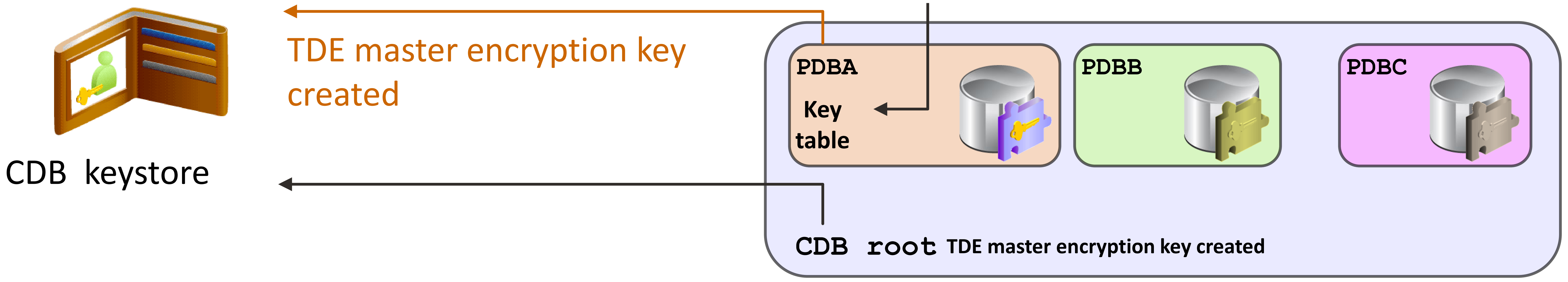


Setting TDE Master Encryption Keys

3. Set the TDE master encryption key for a PDB.

```
SQL> CONNECT john@PDBA AS SYSKM
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY k_password WITH BACKUP
                CONTAINER = CURRENT;
```

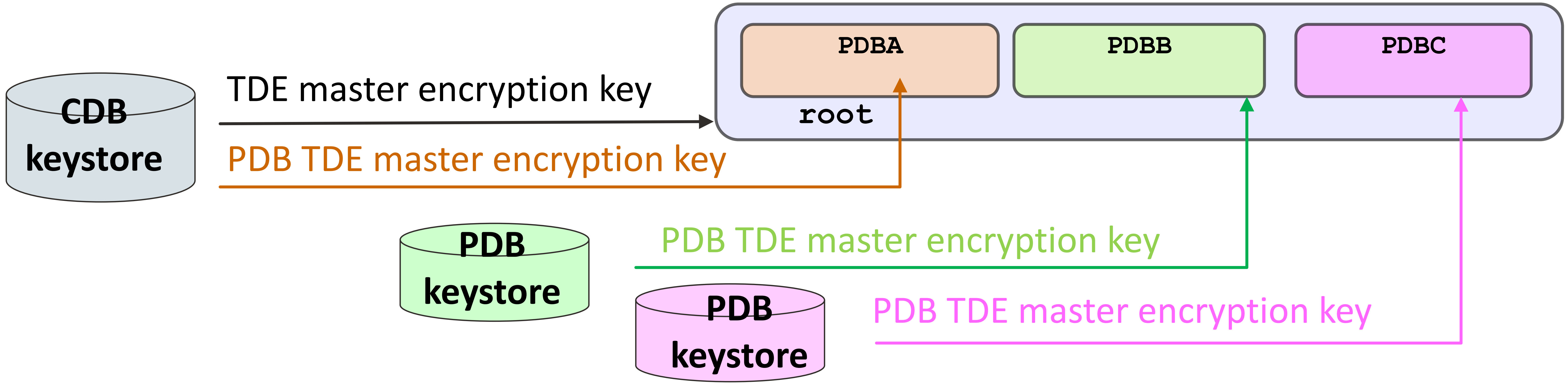
```
SQL> CREATE TABLE hr.tab_sec
          (C1 NUMBER ENCRYPT);
```


TDE master encryption key created
CDB keystore
PDBA
Key table
PDBB
PDBC
CDB root TDE master encryption key created

You can now encrypt data in tablespaces and tables.

Managing Keystore in the CDB and PDBs

- There is still one single keystore for the CDB and optionally one keystore per PDB.
- There is still one TDE master encryption key per PDB to encrypt PDB data, stored in the PDB keystore.
- Modes of operation
  - United mode: PDB keys are stored in the unique CDB root keystore.
  - Isolated mode: PDBs keys are stored in their own keystore.
  - Mixed mode: Some PDBs use united mode; some use isolated mode.


CDB keystore
TDE master encryption key
PDB TDE master encryption key
PDBA
PDBB
PDBC
root
PDB keystore
PDB TDE master encryption key
PDB keystore
PDB TDE master encryption key

Keystore Management Changes for PDBs

```
V$ENCRYPTION_WALLET
ENCRYPTION_MODE = NONE
```

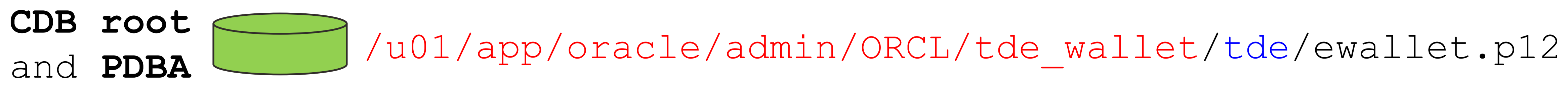
- PDBs can optionally have their own keystore, allowing tenants to manage their own keys.
- Define the shared location for the CDB root and PDB keystores:

```
SQL> ALTER SYSTEM SET wallet_root = /u01/app/oracle/admin/ORCL/tde_wallet;
```

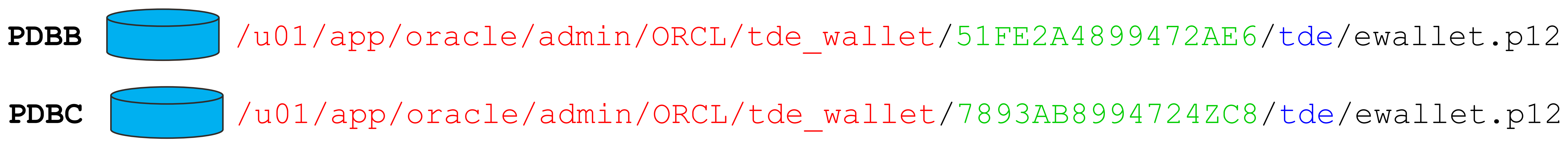
- Define the default PDB keystore type for each future isolated PDB and then define a different file typ in each isolated PDB if necessary:

```
SQL> ALTER SYSTEM SET tde_configuration = 'KEYSTORE_CONFIGURATION=FILE';
```

  - United: ➔ WALLET_ROOT/component/ewallet.p12



  - Isolated: ➔ WALLET_ROOT/pdb_guid/component/ewallet.p12


PDBB
/u01/app/oracle/admin/ORCL/tde_wallet/51FE2A4899472AE6/tde/ewallet.p12
PDBC
/u01/app/oracle/admin/ORCL/tde_wallet/7893AB8994724ZC8/tde/ewallet.p12

Defining the Keystore Type

Values of keystore types allowed:

- FILE
- OKV (Oracle Key Vault)
- HSM (Hardware Security Module)
- FILE|OKV: Reverse-migration from OKV to FILE has occurred.
- FILE|HSM: Reverse-migration from HSM to FILE has occurred.
- OKV|FILE: Migration from FILE to OKV has occurred.
- HSM|FILE: Migration from FILE to HSM has occurred.

In isolated mode, when the CDB is in mounted state:

```
SQL> STARTUP MOUNT
SQL> ALTER SYSTEM SET tde_configuration='CONTAINER=pdb1; KEYSTORE_CONFIGURATION=FILE';
```

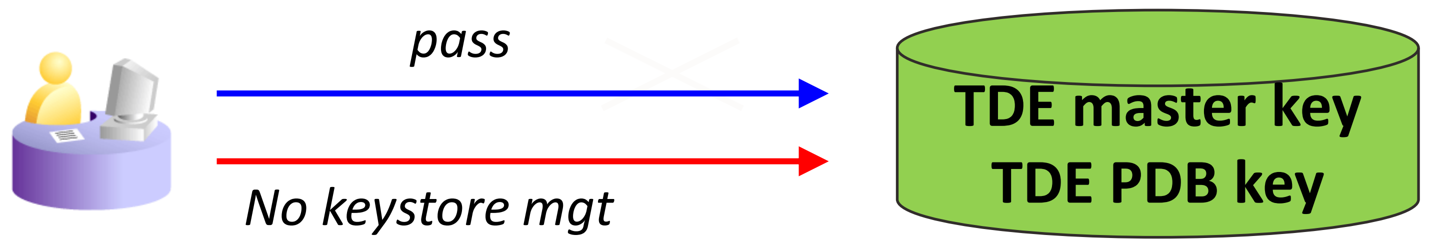
Isolating a PDB Keystore

```
V$ENCRYPTION_WALLET
ENCRYPTION_MODE = ISOLATED
```

- Create / open the CDB root keystore:

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

- Connect as the PDB security admin to the newly created PDB to:
  - Create the PDB keystore.



WALLET_ROOT/*pdb_guid*/tde/ewallet.p12

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE
                               IDENTIFIED BY isolated_keystore_pass;
```

  - Open the PDB keystore.

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN
                               IDENTIFIED BY isolated_keystore_pass;
```

  - Create the TDE PDB key in the PDB keystore.

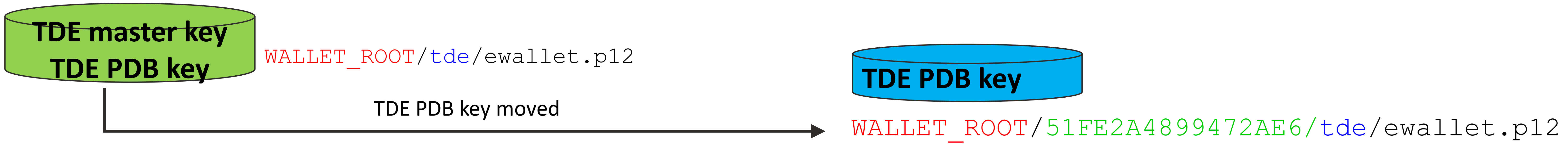
```
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY isolated_keystore_pass
                               WITH BACKUP;
```

Converting a PDB to Run in Isolated Mode

```
V$ENCRYPTION_WALLET
ENCRYPTION_MODE = ISOLATED
```

- In the CDB root:
  - Create a common user to act as the security officer
  - Grant the `ADMINISTER KEY MANAGEMENT` privilege commonly
- Connect as the security officer the PDB and create the keystore in the PDB.

```
SQL> ADMINISTER KEY MANAGEMENT ISOLATE KEYSTORE
        IDENTIFIED BY isolated_keystore_password
        FROM ROOT KEYSTORE IDENTIFIED BY [EXTERNAL STORE | <united_keystore_password>]
        WITH BACKUP;
```

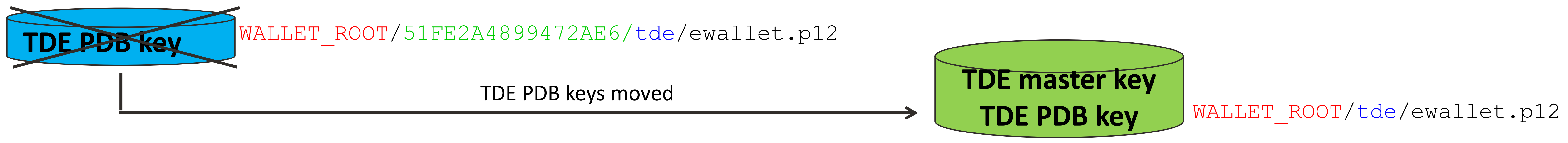

TDE master key
TDE PDB key
WALLET_ROOT/tde/ewallet.p12
TDE PDB key moved
TDE PDB key
WALLET_ROOT/51FE2A4899472AE6/tde/ewallet.p12

Converting a PDB to Run in United Mode

```
V$ENCRYPTION_WALLET
ENCRYPTION_MODE = UNITED
```

1. In the CDB root:
   a. The security officer of the CDB exists.
   b. The security officer of the CDB is granted the `ADMINISTER KEY MANAGEMENT` privilege commonly.
2. Connect as the security officer to the PDB and unite the TDE PDB key with those of the CDB root.

```
SQL> ADMINISTER KEY MANAGEMENT UNITE KEYSTORE
       IDENTIFIED BY isolated_keystore_password
       WITH ROOT KEYSTORE IDENTIFIED BY [EXTERNAL STORE | united_keystore_password]
       [WITH BACKUP [USING backup_id]];
```


~~TDE PDB key~~
WALLET_ROOT/51FE2A4899472AE6/tde/ewallet.p12
TDE PDB keys moved
TDE master key
TDE PDB key
WALLET_ROOT/tde/ewallet.p12

Migrating a PDB Between Keystore Types

To migrate a PDB from using wallet as the keystore to using Oracle Key Vault if the PDB is running in isolated mode:

1. Upload the TDE encryption keys from the isolated keystore to Oracle Key Vault by using a utility.
2. Set the `TDE_CONFIGURATION` parameter of the PDB to the appropriate value:

```
SQL> ALTER SYSTEM SET tde_configuration = 'KEYSTORE_CONFIGURATION=OKV';
```

Unplugging and Plugging a PDB with Encrypted Data

- Unplugging an encrypted PDB exports the master encryption key of the PDB.

```
SQL> ALTER PLUGGABLE DATABASE pdb1
          UNPLUG INTO '/tmp/pdb1.xml'
          ENCRYPT USING "tpwd1";
```

PDB wallet opened

- Plugging the encrypted PDB imports the master encryption key of the PDB into the CDB keystore.

```
SQL> CREATE PLUGGABLE DATABASE pdb1
          USING '/tmp/pdb1.xml'
          KEYSTORE IDENTIFIED BY keystore_pwd1
          DECRYPT USING "tpwd1";
```

Target CDB wallet opened

Per-PDB Wallet for PDB Certificates

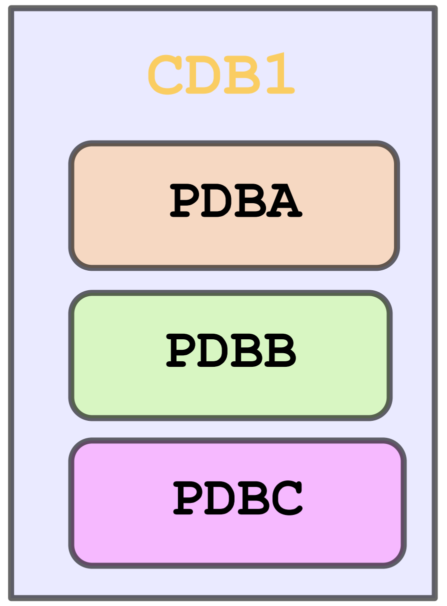
- There is only one `sqlnet.ora` file and one `WALLET_LOCATION` parameter per CDB.
- Each PDB has its own keystore to store the TLS credentials and identity to communicate with other PDBs.

`sqlnet.ora:` `WALLET_LOCATION = /home/oracle/wallet`

➔
`/home/oracle/wallet/20DCA332` contains certificate for PDBA

`/home/oracle/wallet/20DCA331` contains certificate for PDBB

`/home/oracle/wallet/20DCA334` contains certificate for PDBC



Summary

In this lesson, you should have learned how to:

- Manage common and local users, roles, privileges, and profiles in PDBs
- Manage common and local objects in application containers
- Enable common users to access data in PDBs
- Manage PDB lockdown profiles
- Audit users in CDB and PDBs
- Manage other types of policies in application containers
- Protect data with Database Vault policies in CDB and PDBs
- Encrypt data in PDBs
- Configure isolated PDB keystores
- Unplug and plug an encrypted PDB in a one-step operation
- Allow per-PDB wallets for certificates