Oracle Distributed Transactions

Written and presented
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Mini-Lesson Objectives

- Connectivity Overview
- Distributed Database Characteristics
- Remote and Distributed Queries
- Remote and Distributed Transactions
- Distributed Transaction Branches and RAC
- Two-Phase In-Doubt Transactions
- The RECO Process In-Doubt Resolution
- Manual In-Doubt Resolution
- Data Dictionary Entries and Cleanup
- 2 Phase Commit Crash Recovery
- Distributed Systems Recovery

Distributed Database Architecture

- A distributed database system allows users to access data from local and remote databases.
- The two types of distributed database systems are:
  - Homogenous distributed database systems
  - Heterogeneous distributed database systems using Heterogeneous Services commonly referred to as Gateways

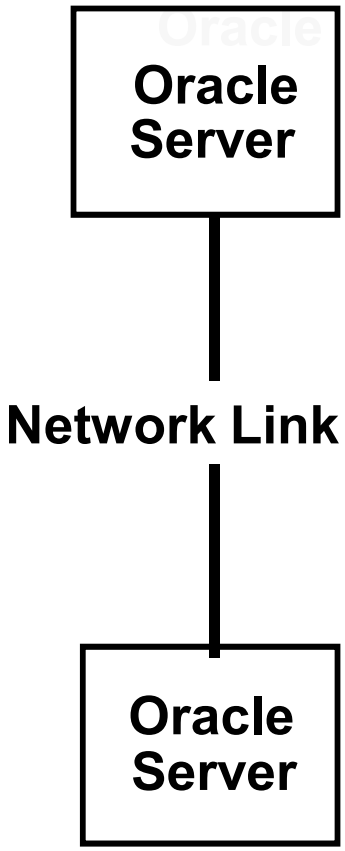
Oracle Distributed Databases

- Local autonomy
- No reliance on a central site
- Continuous operation
- Location independence
- Fragmentation independence
- Replication independence

Oracle Distributed Database

- Distributed query processing
- Distributed transaction management
- Hardware independence
- Operating system independence
- Network independence
- DBMS independence

Server-Server Connectivity




```
SQL> CREATE DATABASE LINK
ANGEL CONNECT TO HR
IDENTIFIED BY HR USING
'ANGEL';
```

```
SQL> SELECT  * FROM
EMPLOYEES@ANGEL;
```

Was Covered in the Database Links Master Class

Remote and Distributed Systems Concepts

- Remote Queries
- Distributed Queries
- Remote Transactions
- Distributed Transactions
- Transaction Branches
- Single Phase Commit
- Two Phased Commit
- Commit Point Site
- Global System Change Numbers
- In-Doubt Transaction Resolution

Remote Queries

- Session is connected to a local instance and a database link is used to query data from one remote database instance.
- The local instance sends the entire query to the remote database instance for processing
- Query may access one or more tables, or views possibly using synonyms
- The remote instance returns data to the local instance

Distributed Queries

- Session is connected to a local instance and database links are used to query data from two or more database instances possibly including the local one
- The query is always executed from the local database instance
- The local instance decomposes the query into subqueries to be sent to each remote database instance.
- The local instance retrieves data from remote instances and performs any necessary post-processing.

Remote Transactions

- Session is connected to a local instance and a DB link is used to insert, update or delete data using one instance of a remote database.
- The local instance sends the entire DML statement to the remote database instance for processing.
- The statement may access one or more tables, or views possibly using synonyms
- The remote instance returns DML results to the local instance
- Single Phase Commit is used at transaction end

Distributed Transactions

- Session is connected to a local database instance and DB links used to perform DML on tables in two or more of the databases
- Only one instance used for each remote database
- Multiple DMLs may be sent to any of the databases involved in the transaction
- The local instance retrieves the status from the remote instances for each DML
- Two Phased Commit is used to Commit or Rollback the transaction guaranteeing consistency across all the databases involved in the transaction

Distributed Transactions

- The following DDL and DML commands are
- supported in distributed transactions:
  - `CREATE TABLE AS SELECT`
  - `DELETE`
  - `INSERT`
  - `LOCK TABLE`
  - `SELECT`
  - `SELECT FOR UPDATE`

Distributed Transaction Locking

- Normal Deadlock detection mechanism is not available when two or more instances are involved
- Use `DISTRIBUTED_LOCK_TIMEOUT` parameter to specify the maximum time in seconds that the instance waits for locked resources
- Defaults to 60 seconds

Distributed Transaction Branches and RAC

- In RAC all transaction branches involving the same database must be connected to the same instance
- Instance specific DB Links from a local Instance permitting connection to two or more remote instances of the same database leads to errors when doing commit or rollback of a distributed transaction
- DB Links from one RAC instance to another when used to try a “distributed” transaction leads to errors when doing commit or rollback
- Not protected by the RAC services model and DTP=TRUE.

Single Phase Commit

- **Used for:**
  - **Single Database Commits and Rollbacks**
  - **Remote Transactions**
  - **Tightly coupled transaction with XA**
- **The local instance sends a commit request to a single remote instance**
- **The remote instance either commits or rolls back**
- **Result of the request at the remote instance is returned to the local instance**
- **DB Links use loosely coupled transactions and require 2 phase commit**

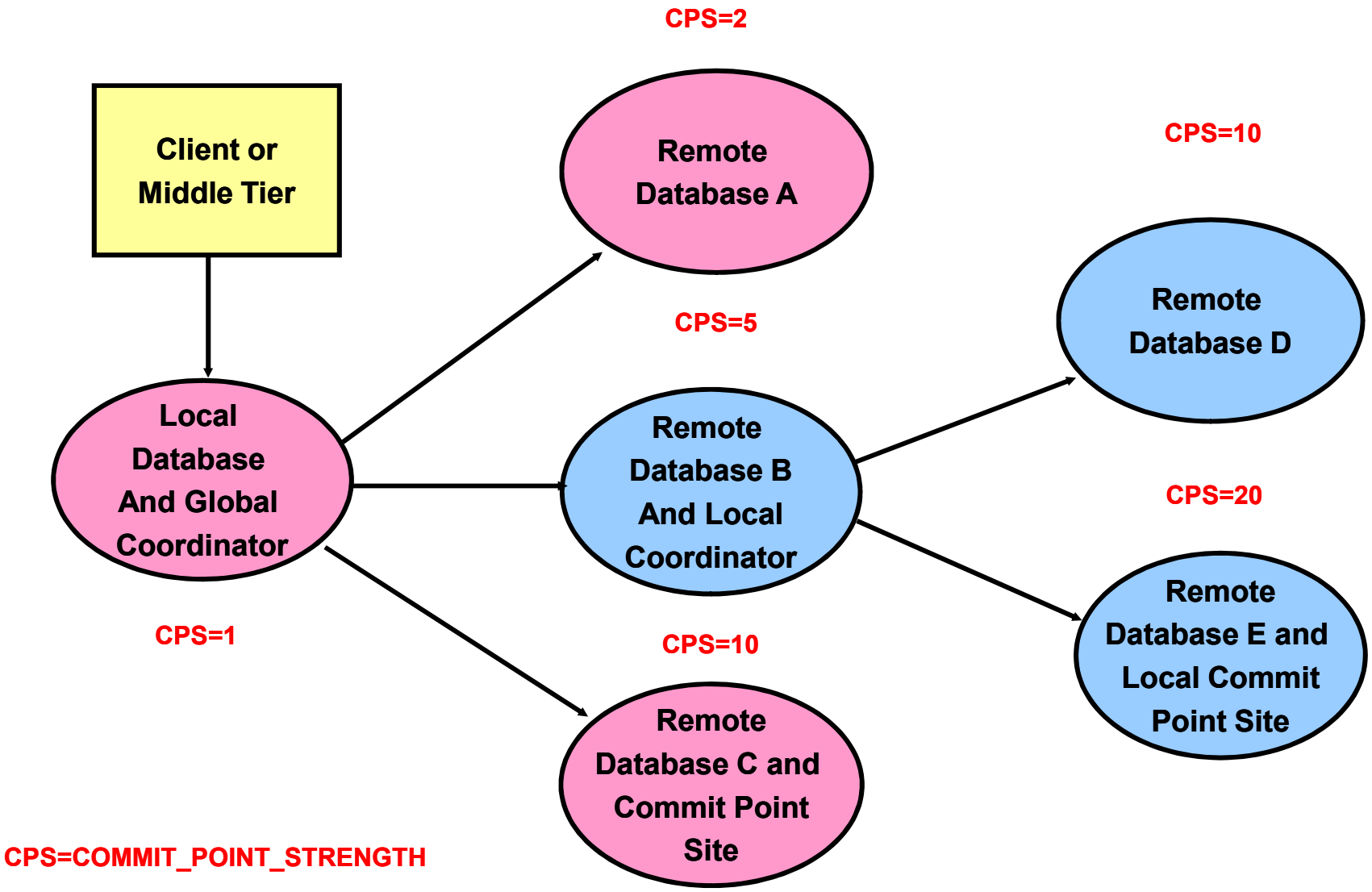
Two Phase Commit

- **Each database instance involved in a two phase commit operation performs one or more roles based on its position in the Session Tree:**
  - **Client - Issues transactional requests over DB Links to one or more Servers**
  - **Database Server - Receives transactional requests over a DB Link**
  - **Global Coordinator – Originating node for the distributed transaction. Sends prepare, commit or rollback statements to other adjacent nodes**
  - **Local Coordinator – References nodes which are non-adjacent to the Global Coordinator and coordinates those nodes to prepare, commit or rollback.**
  - **Commit Point Site – Node which is first to commit as part of the two-phase commit process**

The Commit Point Site

- In a two phase commit process, one site or node is the designated "Commit Point Site"
- This is determined by the values of the `COMMIT_POINT_STRENGTH` parameter in all the database instances involved in the transaction which are adjacent to and include the Global Coordinator
- The values range from 0 to 255 and if not set then the is determined by the software
- The `COMMIT_POINT_STRENGTH` parameter in non-adjacent nodes is only used to resolve who will be the recursive"Commit Point Site" when a Local Coordinator is the main "Commit Point Site"

Distributed Transaction Roles



Global System Change Numbers

- Determined by the highest SCN from amongst all the databases participating in the distributed transaction
- The commit global SCN is sent to all the databases participating in the distributed transaction
- Each database also has its own local SCN and this will equal the global SCN one one of the databases
- If failures occur during two phased commit, the Global Commit SCN is used to coordinate recovery so that all the databases are consistent with each other

Two-Phase Commit Phases

- There are three steps in Two-Phase Commit processing:
  - Prepare
  - Commit
  - Forget

The Prepare Phase

- **Steps in the Prepare phase:**
  - **Global Coordinator sends a request to each instance except for the Commit Point Site , asking for a guarantee that a commit or rollback request at a later stage will be done if requested even if an intervening instance failure occurs**
  - **When asked to `PREPARE` a site does the following:**
    - **Replies with " READ ONLY" if no updates done on node**
    - **Locks all tables in the transaction for both read and write**
    - **Flushes Redo to disk to guarantee ability to commit or rollback later when asked even if the instance fails after this point**
    - **Exchanges `SCN`s with all involved Instances to determine the Global Commit `SCN` for the transaction**
    - **If a site is a Local Coordinator then it recursively issues `PREPARE` commands to its own adjacent nodes**
  - **The Commit Point Site is not asked to prepare. If all sites prepare then it will be asked to commit. If at least one site rejects the prepare, then it will be asked to rollback**

The Commit Phase

- **Steps in the Commit phase when committing:**
  - **The Global Coordinator sends a commit request to the Commit Point Site**
  - **If the Commit Point Site is also a Local Coordinator then it must recursively prepare all but one of its own adjacent nodes and then issue a commit to its local Commit Point Site**
  - **The Commit Point Site commits, releases locks and forgets about the transaction removing it from the dictionary**
  - **The Global Coordinator sends commit requests to adjacent prepared nodes**
  - **If any adjacent nodes are Local Coordinators then commits are propagated to their adjacent nodes**
  - **These nodes then commit, release locks and signal that they have committed**
- **Note that "READ ONLY" sites are not asked to commit**

The Commit Phase

- **Steps in the Commit phase when Rolling Back:**
  - **The Global Coordinator sends a commit request to the Commit Point Site**
  - **If the Commit Point Site is also a Local Coordinator then it must recursively prepare all but one of its own adjacent nodes and then issue a commit to its local Commit Point Site**
  - **If any site is unable to commit for any reason, then it rolls back, releases locks and propagates the rollback to the Local Coordinator or Global Coordinator as appropriate**
  - **Any Local Coordinators sends rollback requests to adjacent subordinate prepared nodes and back to the Global Coordinator**
  - **The Global Coordinator then rolls back and sends rollback requests to all the adjacent nodes**

The Forget Phase

- **Steps in the Forget Phase:**
  - **Any site that is the Global Coordinator updates the data dictionary to remove reference to the transaction when all have finished committing or rolling back**
  - **Any site that is not a coordinator may forget the transaction when it has either committed or rolled back**

In-Doubt Transaction Failure

- **Failure Reported During Commit**

```
SQL> Commit;

ORA-02054 transaction 1.44.99 in-doubt
```

Resolving In-Doubt Transactions

- In Doubt Transaction may be caused by:
  - Network Failure
  - System Failure
  - System Crash
- Tables Remain Locked for Reads and Writes until In-Doubt state is resolved
- Resolving In-Doubt Transactions
  - Automatically done by the RECO Process
  - Manually using `COMMIT FORCE`
  - Manually using `ROLLBACK FORCE`

RECO Process In-Doubt Resolution

- If a failure occurs during any of the phases
  - Data integrity may be compromised
- RECO resolves failures when systems restored:
  - If PREPARE sent by Global Coordinator but crash occurs before Commit Point Site commits then ROLLBACK is done when connectivity is restored
  - If COMMIT sent by Global Coordinator and crash occurs after Commit Point Site receives it from Local or Global Coordinator then COMMIT is done when connectivity is restored
  - If ROLLBACK sent by Global Coordinator and crash occurs before Commit Point Site receives request from the Local or Global Coordinator then ROLLBACK is done when connectivity is restored
  - If FORGET is sent and a crash occurs then it is done after recovery
- RECO then removes entries from the dictionary

Manual In-Doubt Resolution

- Manual In-Doubt resolution should only be done if:
  - The in-doubt transaction has locks on critical data or undo segments
  - The cause of the machine, network, or software failure cannot be resolved quickly
  - If one of the participating databases is lost forever
- Requires Knowledge of the Data and Current State at each remaining database
- Uses Views:
  - `DBA_2PC_PENDING` based on `pending_trans$`
  - `DBA_2PC_NEIGHBORS` based on `ps1$ & pss1$`
  - Also check `v$global_transaction`
- May require manual removal from Data Dictionary
- Contact Oracle Support if you are uncertain

DBA_2PC_PENDING Data Dictionary View

- **local_tran_id** Local tran ID (format x.y.z)
- **global_tran_id** Global tran ID format global_name.hhhhhhhh.local_txn_id
- **state** Collecting, Prepared,Committed,Forced Commit,Forced Abort
- **mixed** YES means Mixed Outcome on different nodes
- **advice** C (commit), R (rollback), or null for no advice
- **tran_comment** Contains comments from application `COMMIT` command
- **fail_time** Timestamp of when the row was inserted
- **force_time** Timestamp of manual force decision or else null
- **retry_time** Timestamp of when `RECO` last tried to recover the transaction
- **os_user** Operating system account for the user
- **os_terminal** Operating system terminal ID for the user
- **host** Name of the host machine
- **db_user** Oracle username at the commit point site
- **Commit#** Global commit number for committed transactions

DBA_2PC_PENDING STATES

- The STATE column of DBA_2PC_PENDING may contain:
  - **Collecting:** Applies to coordinators. The node is collecting information from adjacent database servers before deciding whether it can prepare.
  - **Prepared:** The node has prepared and may or may not have acknowledged this to its local coordinator but no **COMMIT** has been received. The node continues holding any local resource locks necessary for the transaction to commit
  - **Committed:** The node has committed the transaction, but the transaction is still pending at one or more sites
  - **Forced Commit:** A pending transaction was manually force committed at the local node by the DBA
  - **Forced Abort:** A pending transaction was manually force Rolled Back at the local node by the DBA

DBA_2PC_NEIGHBORS Data Dictionary View

- **local_tran_id** Local transaction ID (format x.y.z)
- **in_out** IN for incoming transaction, OUT for outgoing transactions
- **database**
  - Incoming transactions - the name of the client database
  - Outgoing transactions - the name of the database link
- **dbuser_owner** l
  - Incoming transactions - the name of the local user
  - Outgoing transactions - the owner of the database link
- **interface**
  - C - request for commit
  - N - prepared or read-only
- **dbid** Remote database ID
- **sess#** Local session number
- **branch** Local transaction branch ID

V$GLOBAL_TRANSACTION View

- **FORMATID** Format identifier of the global transaction
- **GLOBALID** Global transaction identifier of the global transaction
- **BRANCHID** Branch qualifier of the global transaction
- **BRANCHES** Total number of branches in the global transaction
- **REFCOUNT** Number of siblings for the global transaction is same as branches
- **PREPARECOUNT** Number of branches of the global transaction that have prepared
- **STATE** State of the branch of the global transaction
- **FLAGS** The numerical representation of the state
- **COUPLING** are branches are FREE, LOOSELY COUPLED, or TIGHTLY COUPLED
- **CON_ID** container identifier for multitenant architecture

Manual In-Doubt Resolution Procedure

```
SQL> COMMIT;

ORA-02054 transaction 1.44.99 in-doubt
```

- Note the transaction ID number from the error
- Query the local database `DBA_2PC_PENDING` view

```
SQL> SELECT LOCAL_TRAN_ID, GLOBAL_TRAN_ID,
     STATE, COMMIT#
     FROM SYS.DBA_2PC_PENDING
     WHERE LOCAL_TRAN_ID = '1.44.99';
```

Manual In-Doubt Resolution Procedure

- If the `STATE = COMMIT` then local Database committed
  - Examine the global_tran_id and commit#
  - Compare with the same on other nodes when accessible
  - If RECO resolved no matches will exist on those nodes
  - If matching PREPARED rows found they may be committed
- If the `STATE = PREPARED` then local Database not committed
  - Examine the global_tran_id and commit#
  - Examine `DBA_2PC_NEIGHBORS` for other Databases
  - Compare with the same on other nodes when accessible
  - If no other nodes are found prepared it is safe to `COMMIT`
  - If other nodes prepared they may all be committed or rolled back
- Use the Global SCN to Force commit

Manual In-Doubt Resolution Advice

- Developers may provide advice to DBAs
- This appears in `DBA_2PC_PENDING.ADVICE`
- May contain “R”, “C” or nulls
- Application May set this with:

```
SQL> ALTER SESSION ADVISE [COMMIT |ROLLBACK | NOTHING];

                          or

DBMS_TRANSACTION.ADVISE_[COMMIT |ROLLBACK | NOTHING];
```

- Developer must know the implications of forced commit or rollback.

Force COMMIT

- To force COMMIT a transaction use the command:

```
SQL> COMMIT COMMENT 'XXX' [WORK] FORCE
     'tranid', 'integer';
                or
DBMS_TRANSACTION.COMMIT_FORCE
     ('tranid','integer')
```

  - 'tranid' is the local transaction ID
  - 'integer' is the SCN number
  - 'XXX' is any comment and is optional
- Requires the FORCE [ANY] TRANSACTION Privilege

Force ROLLBACK

- To force ROLLBACK a transaction use the command:

```
SQL> ROLLBACK [WORK] FORCE 'tranid';
                    or
DBMS_TRANSACTION.ROLLBACK_FORCE ('tranid')
```

  - 'tranid' is the local transaction ID
  - 'XXX' is any comment and is optional

- Requires the FORCE [ANY] TRANSACTION Privilege

Data Dictionary Cleanup - Purging Mixed

- **Required after Mixed Result**
  - **"Force" has been done resulting in a Mixed Result**
  - **`DBA_2PC_PENDING.MIXED` will be `'YES'`**
  - **`RECO` unable to clean up**
  - **Cleaned up with `DBMS_TRANSACTION.PURGE_MIXED`**

```
EXEC DBMS_TRANSACTION.PURGE_MIXED ('tranid')
```

  - **'*tranid*' is the local transaction ID**

Data Dictionary Cleanup - Purging Lost DB

- **Required after Lost or Recreated Database**
  - `DBA_2PC_PENDING.MIXED` **will be** `'YES'`
  - `RECO` **unable to clean up**
  - **New Database will have new** `DBID`
  - **Attempt to recover –** `ORA02062`
  - **Cleaned up with**
    - `DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY`

```
EXEC DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY ('tranid')
```

  - **'*tranid*' is the local transaction ID**

Summary of Dictionary Cleanup Options

Pending State Column	State of Global Transaction	State of Local Transaction	Normal DBA Action	Alternative DBA Action
collecting	rolled back	rolled back	none	`purge_lost_db_entry`
committed	committed	committed	none	`purge_lost_db_entry`
prepared	unknown	prepared	none	force commit or rollback
forced commit	unknown	committed	none	`purge_lost_db_entry`
forced rollback	unknown	rolled back	none	`purge_lost_db_entry`
forced commit	mixed	committed	Manually remove inconsistencies then use `purge_mixed`	----------
forced rollback	mixed	rolled back	Manually remove inconsistencies then use `purge_mixed`	----------

Practicing Manual Resolution With Crash Tests

- Use the 2PC Crash Test Facility:
  - First Disable RECO

```
SQL> ALTER SYSTEM DISABLE DISTRIBUTED RECOVERY;
```

```
SQL> COMMIT COMMENT 'ORA-2PC-CRASH-TEST-<num>'
```

- 1 - Crash commit point site after collect
- 2 - Crash non-commit point site after collect
- 3 - Crash non-commit point site before prepare
- 4 - Crash non-commit point site after prepare
- 5 - Crash commit point site before commit
- 6 - Crash commit point site after commit
- 7 - Crash non-commit point site before commit
- 8 - Crash non-commit point site after commit
- 9 - Crash commit point site before forget
- 10 - Crash non-commit point site before forget

Recovery Strategy for Distributed Databases

- Complete Recovery
  - All changes committed up to the moment of failure are recovered
- Tablespace or Table Point in Time Recovery
  - Committed changes up to a point *before* the failure are recovered
  - Time, LogSeq or SCN
- Database Point in Time Recovery
  - Committed changes up to a point *before* the failure are recovered
  - Time, Cancel or SCN

Complete Database Recovery

- Complete recovery Implications:
- Distributed transaction metadata restored to state prior to failure
- RECO then automatically resolves any in-doubt transactions
- It is autonomously performed so there is no impact on dependencies between databases
- May be done by the Recovering Instance in RAC

Tablespace or Table Point In Time Recovery

- May be required for corruption or logical errors
- Data in one or more tablespaces or tables are restored and recovered to a point in the past
- Tables involved in 2PC may have lost updates
- Data in other Databases must be restored and recovered to same point
  - Using TSPITR in Remote Database
  - Using TPITR in Remote Databases
  - Using DBPITR in Remote Database
- Use the SCN or Time of recovery from the first TSPITR to do the remaining recovery operations

Database Point In Time Recovery - DBPITR

- Also known as Incomplete Recovery
- Data in one Database are restored and recovered to a point in the past
- Tables involved in 2PC may have lost updates
- Data in one or more additional Databases must be restored and recovered to same point with DBPITR
  - Using DBPITR in Remote Database
  - Obtain SCN from recovered Database
    - Alert log
    - V$DATABASE.RESETLOGS_CHANGE#
  - On all other Databases do:

```
SQL> RECOVER DATABASE UNTIL CHANGE <SCN>;
```

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