Lecture 1 :

Oracle Database 12c Architecture

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Agenda

- Oracle Database 12c Objects
- Interacting with Oracle Database 12
- DBA Tasks
- Physical Storage Structures
- Logical Storage Structures
- Database Architecture: Databases and Instances
- Memory Architecture
- Multitenant Architecture
- Extra Reading
- Review Questions
Reference and Credits

Oracle® Database Concepts
12c Release 1 (12.1)
E41396-13
https://docs.oracle.com/database/121/CNCPT/toc.htm

Oracle Open World 2015 Session Catalog

OCA: Oracle® Database 12c Administrator Certified Associate Study Guide

Oracle Essentials(Oracle Database 12c), 5th; O'Reilly, 2013

Apress Expert Oracle RAC 12c Aug 2013

Oracle Enterprise Manager 12c Administration Cookbook ISBN 1849687404 2013
RDBMS

- Relational database management system (RDBMS)
- Most Common
- Different RDBMS have different architecture
- Basic storage of data in RDBMS is a table. Relations are implemented in tables, where data is stored in rows and columns.

**EMP (Employee Table)**

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>JOB</th>
<th>MGR</th>
<th>HIREDATE</th>
<th>SAL</th>
<th>COMM</th>
<th>DEPTNO</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>7902</td>
<td>17-DEC-8</td>
<td>0800</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
<td>7698</td>
<td>20-FEB-8</td>
<td>11600</td>
<td>300</td>
<td>30</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
<td>7698</td>
<td>22-FEB-8</td>
<td>11250</td>
<td>500</td>
<td>30</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
<td>7839</td>
<td>02-APR-8</td>
<td>12975</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>SALESMAN</td>
<td>7698</td>
<td>28-SEP-8</td>
<td>11250</td>
<td>1400</td>
<td>30</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>MANAGER</td>
<td>7839</td>
<td>07-MAY-8</td>
<td>12850</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>7844</td>
<td>URNER</td>
<td>SALESMAN</td>
<td>7698</td>
<td>08-SEP-8</td>
<td>11500</td>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>

**DEPT (Department Table)**

<table>
<thead>
<tr>
<th>DEPTNO</th>
<th>DNAME</th>
<th>LOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>ACCOUNTING</td>
<td>NEW YORK</td>
</tr>
<tr>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>40</td>
<td>OPERATIONS</td>
<td>BOSTON</td>
</tr>
</tbody>
</table>

Primary Key Column

Foreign Key Column
# Oracle Database 12c Objects

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table</td>
<td>Basic form of data storage. A table has columns and stores rows of data.</td>
</tr>
<tr>
<td>View</td>
<td>A stored query. No data-storage space is occupied for view data.</td>
</tr>
<tr>
<td>Index</td>
<td>An optional structure that is useful for fetching data faster.</td>
</tr>
<tr>
<td>Materialized view</td>
<td>Used to summarize and store data. They are similar to views but take up storage space to store data</td>
</tr>
<tr>
<td>Index-organized table</td>
<td>Stores the table data along with the index, instead of storing table and index separately</td>
</tr>
<tr>
<td>Cluster</td>
<td>A group of tables sharing a common column. The cluster stores the rows of the tables together with the common columns stored once.</td>
</tr>
<tr>
<td>Constraint</td>
<td>A stored rule to enforce data integrity.</td>
</tr>
<tr>
<td>Sequence</td>
<td>A sequence provides a mechanism for the continuous generation of numbers.</td>
</tr>
<tr>
<td>Synonym</td>
<td>Alias for a database schema object</td>
</tr>
</tbody>
</table>
## Oracle Database 12c Objects

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger</td>
<td>A PL/SQL program unit that is executed when an event occurs.</td>
</tr>
<tr>
<td>Stored function</td>
<td>A PL/SQL programs that can be used to create user-defined functions to return a value.</td>
</tr>
<tr>
<td>Stored procedure</td>
<td>A PL/SQL programs to define a business process.</td>
</tr>
<tr>
<td>Package</td>
<td>A collection of procedures, functions, and other program constructs.</td>
</tr>
<tr>
<td>Java</td>
<td>Stored Java procedures can be created in Oracle to define business processes.</td>
</tr>
<tr>
<td>Database link</td>
<td>Database links are used to communicate between databases to share data.</td>
</tr>
<tr>
<td>.Net Extension</td>
<td>Stored .Net procedures and functions can be created in Oracle on windows platforms only.</td>
</tr>
</tbody>
</table>

Use SQL to create database objects and to interact with application data.
Interacting with Oracle Database 12c

- SQL is the language used to interact with Oracle Database 12c.
- Common tools for DBA to administer Oracle Database 12c:
  - SQL*Plus command-line interface utility
  - A New Command Line Interface, SQLcl
  - SQL Developer: a GUI tool to explore and manage the database using predefined menu actions and SQL statements
  - Oracle Enterprise Manager Database Express 12c, a GUI tool for database administration
  - Oracle Grid Control
Interacting with Oracle Database 12c

• SQL*Plus is the primary tool for an Oracle DBA to administer the database using SQL commands.
• You can run SQL statements, you must connect to Oracle Database 12c.
• Start SQL*Plus from a Windows command prompt using SQLPLUS.EXE $ORACLE_HOME/bin/sqlplus executable on the Unix/Linux platform.
• connecting to SQL*Plus from a Linux workstation
• SQL*Plus is the primary tool for an Oracle DBA to administer the database using SQL commands.

• Before you can run SQL statements, you must connect to Oracle Database 12c.

• start SQL*Plus from a Windows CMD using the SQLPLUS.EXE or using $ORACLE_HOME/bin/sqlplus executable on Unix/Linux platform.
FREE Oracle Database IDE/GUI
Windows, OS X, *NIX
More than 4,100,000 users worldwide
My Oracle Support available via your DB license
Oracle SQL Developer


• **FREE** Oracle Database IDE/GUI
  - Allows database users and administrators to do their database tasks easy with GUI.
  - Support Oracle DB 10g, 11g, and 12c
  - Run on any operating system that supports Java: Windows, OS X, *NIX
  - More than 4,100,000 users worldwide

• **For Developer**
  Provides powerful editors for working with SQL, PL/SQL, Stored Java Procedures, and XML. Run queries, generate execution plans, export data to the desired format (XML, Excel, HTML, PDF, etc.), execute, debug, test, and document your database programs, and much more with SQL Developer.

• **For DBA**
  Provided database administrators a set of interfaces for their most critical tasks:
  - Recovery Manager (RMAN)
  - Oracle Auditing
  - User and Role management
  - Storage management
  - Resource Manager
  - Diagnostic Pack features

• **For the Application Architect & Data Modeler**
  - Logical, relational, physical, dimensional modeling
Oracle SQL Developer is a free integrated development environment that simplifies the development and management of Oracle Database in both traditional and Cloud deployments. SQL Developer offers complete end-to-end development of your PL/SQL applications, a worksheet for running queries and scripts, a DBA console for managing the database, a reports interface, a complete data modeling solution, and a migration platform for moving your 3rd party databases to Oracle.
A New Command Line Interface, SQLcl- Early Adopter

- 12 MB Download
- Extract & Run, no clients required!
- SQL*Plus cmd support
- Better formatting, editing
- New commands!
- SQL History Recall
- Still in Beta/EA
Oracle Enterprise Manager Express

• Enables you to perform administrative tasks such as managing user security and managing database memory and storage.
• View performance and status information about your database.

Getting Started with Oracle Enterprise Manager Express
Oracle Enterprise Manager Cloud Control 12c

- Oracle’s integrated enterprise management administrative tool, providing complete cloud management solutions.
- You can manage multiple databases and all products under the Oracle stack.
- It is a complete cloud lifecycle management answer to quickly set up, administer, and support enterprise clouds and Oracle environments from applications to storage.
- Provides market-leading management and automation support for Oracle applications, databases, middleware, hardware and engineered systems.
- Oracle’s Database management capabilities make DBA lives easier by providing a full-lifecycle solution encompassing change and configuration management, patching, provisioning, testing, masking/subsetting, performance management and automatic tuning.
- Not part of the Oracle Database 12c software. Must be downloaded and installed separately.
Oracle Enterprise Manager is Oracle’s on-premises management platform, providing a single pane of glass for managing all of a customer’s Oracle deployments, whether in their data centers or in the Oracle Cloud. Through deep integration with Oracle’s product stack, Enterprise Manager provides market-leading management and automation support for Oracle applications, databases, middleware, hardware and engineered systems.
SQL Developer Data Modeler

Included for free, also available as a separate download/program

Oracle SQL Developer Data Modeler is a free graphical tool that enhances productivity and simplifies data modelling tasks. Using Oracle SQL Developer Data Modeler users can create, browse and edit, logical, relational, physical, multi-dimensional, and data type models. The Data Modeler provides forward and reverse engineering capabilities and supports collaborative development through integrated source code control. The Data Modeler can be used in both traditional and in Cloud environments.
SQL Developer Data Modeler

Strategy and Analysis

Import Models → ERD → Logical
Domains → DFD → Multidimensional

Database Design

Relational → Star Schema
Physical

Reporting

SQL
DBA Tasks

- Selecting the server hardware on which the database software will run
- Installing and configuring the Oracle Database 12c software on the server hardware
- Deciding to use Oracle Database 12c Container or a traditional single database non-Pluggable Database (PDB).
- Creating Oracle Database 12c database
- Creating and managing the tables and other objects used to manage the application data
- Creating and managing database users
- Establishing reliable backup and recovery procedure for the database
- Monitoring and tuning database performance
- Analyzing trends and forecasting resource and storage requirements
- Decide on Service Level Agreements (SLAs) and build High Availability (HA) and Disaster Recovery Process (DRP)
What Is a Schema?

• A schema can be related to a real person
  – example: user of your HR database who with Login and password they use to access DB.
  – This user may or may not own any schema objects.

• Schema is a collection of objects
  – DBAs\Developers often define a schema to represent a collection of objects that are related to specific applications or tasks using a common schema name.
  – The schema is a logical collection of objects associated with an application and is not tied to any specific user
  – Example **HR.EMPLOYEES, SALES.ORDERS** tables

• The main difference is that users are the entities that perform work, and schemas are the collections of objects on which users perform work.
Oracle Database Storage Structures

• RDBMS is the independence of logical data structures such as tables, views, and indexes from physical storage structures.
• physical and logical structures are separate, you can manage physical storage of data without affecting access to logical structures.
  – EX : renaming a database file does not rename the tables stored in it.
Physical Storage Structures

- **An Oracle database** is a set of files that store Oracle data in persistent disk storage.
- **A data file** is a physical file on disk that was created by Oracle DB and contains data structures such as tables and indexes.
- **A temp file** is a data file that belongs to a temporary tablespace.
- DB writes data to these files in an Oracle proprietary.
- **Control files**
  - A root file that tracks the physical components of the database, information required to recover DB including checkpoints (SCN).
- **Online redo log files**
  - Set of files containing records of changes made to data.
- **A database instance** is a set of memory structures that manage database files.

![Diagram of database structures](image.png)
Logical Storage Structures

- Oracle Database allocates logical space for all data in database.
- Logical units of database space allocation are **data blocks, extents, segments, and tablespaces**.
- At a physical level, the data is stored in data files on disk.

Figure 12-1 is an entity-relationship diagram for physical and logical storage. The crow's foot notation represents a one-to-many relationship.
At the finest level of granularity, Oracle DB stores data in data blocks.

One Logical data block corresponds to a specific number of bytes of physical disk space, for example, 2 KB.

**Data blocks** are the smallest units of storage that Oracle Database can use or allocate.

An extent is a set of logically contiguous data blocks allocated for storing a specific type of information. Ex: the 24 KB extent has 12 data blocks, while the 72 KB extent has 36 data blocks.

A segment is a set of extents allocated for a specific database object, such as a table. Ex: Data for the employees table is stored in its own data segment, whereas each index for employees is stored in its own index segment.

Every database object that consumes storage consists of a single segment.

Each segment belongs to one and only one tablespace. Thus, all extents for a segment are stored in the same tablespace.

Within a tablespace, a segment can include extents from multiple data files.
Overview of Data Files

- Each **tablespace** consists of one or more data files.
- The data for a database is collectively stored in the data files.
- A **segment** can span one or more data files, but it cannot span multiple tablespaces.
- A database must have the **SYSTEM** and **SYSAUX** tablespaces.
- **SYSTEM** tablespace contains the data dictionary, a set of tables that contains database metadata.
- Database also has an **undo tablespace** and a **temporary tablespace** (TEMP).
Data Files Structure

- The data file header contains metadata about the data file such as its size and checkpoint SCN.
- Each header contains an absolute file number, which uniquely identifies the data file within the database, and a relative file number, which uniquely identifies a data file within a tablespace.
- When Oracle Database first creates a data file, the allocated disk space is formatted but contains no user data. However, the database reserves the space to hold the data for future segments of the associated tablespace.
- As the data grows in a tablespace, Oracle Database uses the free space in the data files to allocate extents for segment.
Online Redo Log Switches

- log writer is the background process responsible for writing transaction information from redo log buffer (in the SGA) to the online redo log files (on disk).
- Log writer flushes the contents of the redo log buffer when any of the following are true:
  - A COMMIT is issued.
  - A log switch occurs.
  - Three seconds go by.
  - Redo log buffer is one-third full.
  - Redo log buffer fills to one megabyte.
Reuse of Online Redo Log

- **At time 1**, Block A is read from Data File AA into the buffer cache and modified.
- **At time 2** the redo-change vector information (how the block changed) is written to the log buffer.
- **At time 3** the log-writer process writes the Block A change-vector information to online redo log 1.
- **At time 4** a log switch occurs, and online redo log 2 becomes the current online redo log.

**Reuse of Online Redo Log Files**
Data Blocks and Operating System Blocks

- An operating system block is the minimum unit of data that the OS can read or write.

- Oracle block is a logical storage structure whose size and structure are not known to OS.

- The database requests data in multiples of data blocks, not OS blocks.

- Applications do not need to determine the physical addresses of data on disk.

- Database data can be striped or mirrored on multiple physical disks.

Reuse of Online Redo Log Files
Data Block Format

- **Block header**
  - This part contains general information about the block, including disk address and segment type.
  - *For blocks that are transaction-managed, the block header contains active and historical transaction information.*
  - A transaction entry is required for every transaction that updates the block.

- **Table directory**
  - For a heap-organized table, contains metadata about tables whose rows are stored in this block.

- **Row directory**
  - For a heap-organized table, this directory describes the location of rows in the data portion of the block.
Database Architecture: Databases and Instances

- **Instance** memory Structures (RAM) and Background processes (CPU) that uses the physical components to manipulate and retrieve data.

- **Database** set of physical files (Datafiles) saved on the disk that store information. created by the CREATE DATABASE statement.

- One instance communicates with one database.

- The host machine is where users and applications connect and interact.

- If the machine goes down for some reason, DB will be unavailable. The solution: *Real Application Clusters (RAC)*.
Database Architecture: Databases and Instances

Rules:

- An instance can exist without a database.
- Database can exist without an instance but would be useless.
- Every running Oracle database is associated with at least one Oracle database instance.
- An instance can access only one database. When you start your instance, the next step is to mount that instance to a database. An instance can mount only one database at a time.
- You can set up multiple instances to access the same set of files or one database. Clustering is the basis for the Oracle Real Application Clusters feature.
- Reason to distinguish between Instance and Database
  1. Single Instance VS RAC
  2. Relationship through separation.
  3. Other RDBMS like SQL Server, Sybase, DB2 terms means different things.
Oracle Database 12c Architecture

- DB components: memory structures, process structures, and storage structures.
- Process and memory structures together are called an **instance**;
- Storage structure is called a **database**.
- Instance and DB are called an **Oracle server**.
- One instance communicates with one database.
- The host machine is where users and applications connect and interact.
- If the machine goes down for some reason, DB will be unavailable. Solution: **Real Application Clusters (RAC)**
Each Oracle database consists of several **schemas** that reside in tablespaces.

**Tablespace** is a logical storage structure at the highest level in the database.

Each tablespace consists of one or more **data files**.

The database has user data and overhead like database dictionary, memory, control files, archived log files, flashback files, etc.
A database instance is a set of memory structures that manage database files.

When an instance is started, Oracle Database allocates a memory area called the **system global area (SGA)** and starts one or more **background processes**.

**SGA** serves various purposes:
- Maintaining internal data structures that many processes and threads access concurrently.
- Caching data blocks read from disk.
- Buffering redo data before writing it to the online redo log files.
- Storing SQL execution plans.
Database Instance Configurations

• Single-instance configuration
  – A one-to-one relationship exists between the database and a database instance.
• Oracle Real Application Clusters (Oracle RAC) configuration
  – A one-to-many relationship exists between the database and database instances
Phases of Oracle startup

- When you issue a STARTUP statement without any parameters, Oracle automatically steps through the three startup phases (nomount, mount, open)
  - **Most Cases**

```sql
$ sqlplus / as sysdba
SQL> startup;
ORACLE instance started.
Total System Global Area 313159680 bytes
Fixed Size 2259912 bytes
Variable Size 230687800 bytes
Database Buffers 75497472 bytes
Redo Buffers 4714496 bytes
Database mounted.
Database opened.
```
Oracle database server - Real Application Cluster

- More than one instance communicates to a single database.

- If an instance fails, the remaining instances in the RAC pool remain open and active. Connections from failed instances can be failed-over to active instances.

- Oracle manages the connection load balancing and failover automatically.
Basic Memory Structures

• System global area (SGA)
  – Data and control information for one Oracle DB. All server and background processes share the SGA. Ex: cached data blocks and shared SQL areas.

• Program global area (PGA)
  – A nonshared memory region that contains data and control information exclusively for use by an Oracle process. Oracle Database creates the PGA when an Oracle process starts. One PGA exists for each server process and background process. The collection of individual PGAs is instance PGA.

• User global area (UGA)
  – memory associated with a user session.

• Software code areas used to store code that is being run or can be run.
Types of Processes

- A client process runs the application or Oracle tool code.

- An Oracle process
  - A background process performs maintenance tasks like: instance recovery
  - A server process performs work based on a client request: processes parse SQL query

- A system global area (SGA) and background processes using dedicated server connections.

- For each user connection, a client process runs the application
  - Each client process is associated with its own server process, which has its own program global area (PGA)
User and Server Processes

- At the user level, two types of processes allow a user to interact with instance and DB: the user process and the server process.

- When a user runs an application, Oracle starts a user process to support the user’s connection to the instance.
  - Either on the user’s own computer or on the middle-tier application server depending on architecture of the application.

- User process then initiates a connection to the instance. The process of initiating and maintaining communication between the user process and the instance a **connection**.

- Once the connection is made, the user establishes a **session** in the instance.

- After establishing a session, each user starts a server process on the host server itself.

- Server process is responsible for performing the tasks that actually allow the user to interact with the database.

- Server processes are allowed to interact with the instance, but not the user process directly.

- Examples: sending SQL statements to DB, retrieving needed data from the database’s physical files, and returning that data to the user.

- **Each user process connects to one and only one server process. In some Oracle configurations, multiple user processes can share a single server process.**
User and Server Processes

• Additional memory structure: *program global area* (PGA) is also created for each server process.
• PGA stores user-specific session information like bind variables and session variables.
• Every server process on the server has a PGA memory area.

![Diagram showing user process communicating with server process using PGA](image-url)
User and Server Processes

- PGA memory is not shared. Each server process has a PGA associated with it and is exclusive.
- As a DBA, you set the total memory that can be allocated to all the PGA memory allocated to all server and background processes.
- Components of PGA:
  1. SQL Work Area  Area used for memory-intensive operations such as sorting or building a hash table during join operations.
  2. Private SQL Area  Holds information about SQL statement and bind variable values.
- The PGA can be configured to manage automatically by setting the database parameter PGA_AGGREGATE_TARGET. Oracle then contains the total amount of PGA memory allocated across all database server processes and background processes within this target.
User and Server Processes

Example On a Unix system:

1. User initiates SQL*Plus to connect to Oracle database. User process with process ID 10704 by david.
2. This starts another server process that connects to the instance with process ID 10706 owned by database server user oracle.

$ ps -ef | grep sqlplus | grep -v grep

david 10704 10511 0 03:51 pts/2 00:00:00 sqlplus

$ ps -ef | grep 10604 | grep -v grep

david 10704 10511 0 03:51 pts/2 00:00:00 sqlplus

oracle 10706 10704 0 03:52 ? 00:00:00 oracleC12DB1

(DESCRIPTION=(LOCAL=YES)(ADDRESS=(PROTOCOL=tcp)))
Connections and Sessions

- A database **connection** is a physical communication pathway between a client process and a database instance.
- A database session is a logical entity in the database instance memory that represents the state of a current user login to a database.
- A session lasts from the time the user is authenticated by the database until the time the user disconnects or exits the database application.
- A single connection can have 0, 1, or more sessions established on it.
- The sessions are independent: a commit in one session does not affect transactions in other sessions.
Oracle Database 12c Architecture:

**Major background processes**

- **DBWn**: The database writer writes blocks from the database buffer cache to the data files.
- **CKPT**: The checkpoint process writes checkpoint information to the control files and data file headers.
- **LGWR**: The log writer writes redo information from the log buffer to the online redo logs.
- **ARCn**: The archiver copies the content of online redo logs to archive redo log files.
Oracle Database 12c Architecture
major background processes

- **DBWn**: The database writer writes blocks from the database buffer cache to the data files.
- **CKPT**: The checkpoint process writes checkpoint information to the control files and data file headers.
- **LGWR**: The log writer writes redo information from the log buffer to the online redo logs.
- **ARcn**: The archiver copies the content of online redo logs to archive redo log files.
- **RVWR**: The recovery writer maintains before images of blocks in the fast recovery area.
- **MMON**: The manageability monitor process gathers automatic workload repository statistics.
- **MMNL**: The manageability monitor lite process writes statistics from the active session history buffer to disk.
- **SMON**: The system monitor performs system level clean-up operations, including instance recovery in the event of a failed instance, coalescing free space, and cleaning up temporary space.
- **PMON**: The process monitor cleans up abnormally terminated database connections and also automatically registers a database instance with the listener process.
- **RECO**: The recoverer process automatically resolves failed distributed transactions.
Oracle Database 12c Architecture

• Communication with the database is initiated through a sqlplus user process. Typically, the user process connects to the database over the network. This requires that you configure and start a listener process.
• Listener process hands off incoming connection requests to an Oracle server process, which handles all subsequent communication with the client process.
• The instance consists of memory structures and background processes.
• When the instance starts, it reads the parameter file, which helps establish the size of the memory processes and other characteristics of the instance.
• When starting a database, the instance goes through three phases: nomount (instance started), mount (control files opened), and open (data files and online redo logs opened).
• The number of background processes varies by database version (more than 300 in the latest version of Oracle).
• You can view the names and descriptions of the processes via this query:
  • SQL> select name, description from v$bgprocess;
Checkpoint Process (CKPT)

- **Mandatory Background Processes**
  - Updates the control file and data file headers with **checkpoint information** and signals DBW to write blocks to disk.

- **Checkpoint information** includes the checkpoint position, SCN, location in online redo log to begin recovery, and so on

- CKPT does not write data blocks to data files or redo blocks to online redo log files
How Many Databases on One Server?

• **Architecture with one server per database**
  
  – Profitable for the hardware vendor but in many environments isn’t an economical use of resources.
How Many Databases on One Server?

- **Multiple databases sharing one set of Oracle binaries on a server**
  - If you have enough memory, CPU, and disk resources consider creating multiple databases on one server.
  - You can create a new installation of the Oracle binaries for each database or have multiple databases share one set of Oracle binaries.
  - If you have requirements for different versions of Oracle binaries, you must have multiple Oracle homes.
How Many Databases on One Server?

- **One database used by multiple applications and users**
  - If you don’t have the CPU, memory, or disk resources to create multiple databases on one server
  - To save Oracle License because it is usually per cpu core.
  - Be careful not to use public synonyms, because there may be collisions between applications.
  - It’s typical to create different schemas and tablespaces to be used by different applications in such environments.
How Many Databases on One Server?

• *One container database with multiple pluggable databases*
  
  – With Oracle Database 12c you have the option of using the pluggable database feature.
  – This technology allows you to house several pluggable databases within one container database.
  – Pluggable databases share the instance, background processes, undo, and Oracle binaries but function as completely separate databases.
  – Each pluggable database has its own set of tablespaces (including SYSTEM) that are not visible to any other pluggable databases within the container database. This allows you to securely implement an isolated database that shares resources with other.
The need for Database Consolidation

- Large enterprises may use hundreds or thousands of databases.
- Often these databases run on different platforms on multiple physical servers.
- Because of improvements in hardware technology, servers are able to handle heavier workloads than before.
- A database may use only a fraction of the server hardware capacity.
- This approach wastes both hardware and human resources.
- For example, 100 servers may have one database each, with each database using 10% of hardware resources and 10% of an administrator's time.
- A team of DBAs must manage the SGA, database files, accounts, security, and so on of each database separately, while system administrators must maintain 100 different computers.
Benefits of the Multitenant Architecture for Database Consolidation

- Cost reduction
- Easier management and monitoring of the physical database
- Separation of data and code
- Secure separation of administrative duties
- Ease of performance tuning
- Support for Oracle Database Resource Manager
- Fewer database patches and upgrades
Oracle Database 12c — Multitenant architecture with pluggable databases Application Cluster

- Oracle Database 12c comes with a major architectural change compared to its predecessors.

- Oracle Database 12c allows multitenancy: you can have more than one database in a structure called a container database. The database overhead will be shared by all the databases in the container database.

- The databases in the container database are called pluggable databases.

- Administration and resource overhead are reduced.
Oracle Database 12c — Multitenant architecture with pluggable databases

- Container database (CDB) that includes zero, one, or many pluggable databases (PDBs).

- All databases created prior to Oracle Database 12c are non-CDB;

- A pluggable database appears as a non-CDB to the application, so existing code and application need not be changed when

- The PDBs belonging to a CDB share the database overhead such as redo, undo, and memory.

- Oracle RDBMS is responsible for keeping the pluggable databases separate, private for the application, and secure.
ミنصوص מערכות מסדי נתונים (236510)

• Extra Reading
Database Consolidation
Requirements

- No change to applications
- No performance degradation
- Centralized resource management
- Isolation between environments
- Simplify patching and upgrades
- Performance and Scalability
Multitenant Architecture + Pluggable Databases

- Oracle Database 12c lets you have many *pluggable databases* (PDBs) in a single *multitenant container database* (CDB)
- PDBs share common resources
- The application connects to the PDB and sees it just like a pre-12c database
- The system administrator connects to the CDB as a whole and sees a single system image
Infrastructure Density

High consolidation density, manage many as one, transparent to existing application
Multitenant Architecture advantages

- Self-contained PDB for each application
  - Applications run unchanged
  - Rapid provisioning (via clones)
  - Portability (via pluggability)

- Common operations performed at CDB level
  - Manage many as one (upgrade, HA, backup)
  - Granular control when appropriate

- Shared memory and background processes
  - More applications per server

Complementary to VMs but More Efficient Without
Multitenant Architecture advantages

Architecture Simplicity and Operational Efficiency

Typical Hypervisor Approach to Database Deployment on an x86 Server

<table>
<thead>
<tr>
<th>Hypervisors</th>
<th>VM’s</th>
<th>Linux O/S</th>
<th>Oracle builds</th>
<th>Databases Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Virtualization and Consolidation with Oracle 12c Multitenant on an x86 Server

<table>
<thead>
<tr>
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<th>VM’s</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1-3</td>
<td>20 - 40</td>
</tr>
</tbody>
</table>
Managing Shared Resources

Resource management for consolidated databases

- High Priority
- Medium Priority
- Low Priority
Pluggable vs Separate Databases
Highly Efficient: 6x Less H/W Resource, 5x more Scalable

OLTP benchmark comparison

Only 3GB of memory vs. 20GB memory used for 50 databases

Pluggable databases scaled to over 250 while separate database instances maxed at 50
Manage Many Databases as One

Backup databases as one, recover at pluggable database Level

One Backup

Point-in-time recovery at pluggable database level
Manage Many Databases as One

One standby database covers all pluggable databases
Simplified Patching

Apply changes once, all pluggable databases updated
Simplified Upgrades

Flexible choice when patching & upgrading databases
Creating Databases for Test and Development

Fast, flexible copy and snapshot of pluggable databases
Oracle Database 12c Multitenant Architecture

Benefits

- Reduced TCO
  - Administrative costs
  - Operational costs
  - Data Center costs
  - Storage costs
  - Contingency costs

- Improved ...
  - Resource utilization
  - Manageability
  - Service Management
# Oracle Database 12c
## Alternative Architectures

<table>
<thead>
<tr>
<th>Business Value</th>
<th>Many databases on one machine</th>
<th>Many databases as schemas in one database</th>
<th>Many databases as PDBs in one CDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation</td>
<td>Easy</td>
<td>Difficult*</td>
<td>Easy</td>
</tr>
<tr>
<td>Isolation</td>
<td>Highest</td>
<td>Limited</td>
<td>High</td>
</tr>
<tr>
<td>Availability</td>
<td>High</td>
<td>Highest</td>
<td>Highest</td>
</tr>
<tr>
<td>Scalability</td>
<td>Limited</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Performance</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Resource management</td>
<td>Fair</td>
<td>Severely limited</td>
<td>Excellent</td>
</tr>
<tr>
<td>ROI</td>
<td>Low</td>
<td>High</td>
<td>Highest</td>
</tr>
</tbody>
</table>

* Need to validate application schemas can co-exist
Pluggable Database

- A PDB feels and operates identically to a non-CDB Database
- You cannot tell, from the viewpoint of a connected client, if you’re using a PDB or a non-CDB Database
- A new PDB can be created in seconds
Pluggable Database

Simply unplug...

- Moving between CDBs is a simple case of moving a PDBs metadata
- PDBs can be moved using
  - SQL Developer
  - Enterprise Manager 12c
  - SQL commands
  - Database Configuration Assistant (DBCA)
Pluggable Databases

And if you can have one...

- The Pluggable Databases architecture can currently support up to 252 PDBs in a single CDB Database.

- You can utilize Database Links between PDBs and between PDBs and non-CDB databases.
Shared Resources

- Background processes
- Shared/process memory
- Oracle metadata
- Control files
- Redo Log files
Files in PDBs

- Each PDB has its own set of tablespaces including SYSTEM and SYSAUX
- PDBs share UNDO, REDO and control files
- By default the CDB has a single TEMP tablespace, but PDBs may create their own
Users

- PDB Users are the successors for users in a non-CDB
- Local users can administer PDBs
- A special class of users “Common Users” has the same identity in all PDBs
- Common users can log into any database they have “create session” privilege for
- Common users own the Oracle system
- PDBs can be administered by a common user, too
Review Questions

• Choose two SGA structures that are required in every Oracle instance.
  A. Large pool
  B. Shared pool
  C. Buffer cache
  D. Java pool

• 2. Which statement is true?
  A. A database can have only one control file.
  B. A database must have at least two control files.
  C. A database may have zero or more control files.
  D. A database must have at least one control file.

• 3. Which component is configured at database startup and cannot be dynamically managed?
  A. Redo log buffer
  B. Streams pool
  C. Java pool
  D. Shared pool
  E. None of the above
Review Questions

4. Which component is not part of an Oracle instance?
   A. System global area
   B. Process monitor
   C. Control file
   D. Shared pool
   E. None

5. Which background process guarantees that committed data is saved even when the changes have not been recorded in data files?
   A. DBWn
   B. PMON
   C. LGWR
   D. CKPT
   E. ARCn

6. Which of the following best describes a RAC configuration?
   A. One database, multiple instances
   B. One instance, multiple databases
   C. Multiple databases plugged in from multiple servers
   D. Multiple databases, multiple instances
Review Questions

8. Choose two SGA structures that are required in every Oracle instance.
   A. Large pool
   B. Shared pool
   C. Buffer cache
   D. Java pool

9. Which statement is true?
   A. A database can have only one control file.
   B. A database must have at least two control files.
   C. A database may have zero or more control files.
   D. A database must have at least one control file.

10. Which component is configured at database startup and cannot be dynamically managed?
    A. Redo log buffer
    B. Streams pool
    C. Java pool
    D. Shared pool
    E. None of the above
Review Questions

11. Which component is not part of an Oracle instance?
   - A. System global area
   - B. Process monitor
   - C. Control file
   - D. Shared pool
   - E. None

12. Which background process guarantees that committed data is saved even when the changes have not been recorded in data files?
   - A. DBWn
   - B. PMON
   - C. LGWR
   - D. CKPT
   - E. ARCn

13. Which of the following best describes a RAC configuration?
   - A. One database, multiple instances
   - B. One instance, multiple databases
   - C. Multiple databases plugged in from multiple servers
   - D. Multiple databases, multiple instances
Review Questions

• 14. Which component of the SGA contains the parsed SQL code?
   A. Database buffer cache
   B. Dictionary cache
   C. Library cache
   D. Parse cache

• 15. Which tasks are accomplished by the SMON process? (Choose all that apply.)
   A. Performs recovery at instance startup
   B. Performs cleanup after a user session is terminated
   C. Starts any server process that stopped running
   D. Coalesces contiguous free space in dictionary-managed tablespaces

• 16. Choose the best statement from the options related to segments.
   A. A contiguous set of blocks constitutes a segment.
   B. A nonpartitioned table can have only one segment.
   C. A segment can belong to more than one tablespace.
   D. All of the above are true.
17. Two structures make up an Oracle server: an instance and a database. Which of the following best describes the difference between an Oracle instance and a database?

A. An instance consists of memory structures and processes, whereas a database is composed of physical files.
B. An instance is used only during database creation; after that, the database is all that is needed.
C. An instance is started whenever the demands on the database are high, but the database is used all the time.
D. An instance is configured using a pfile, whereas a database is configured using a spfile.