Lecture 1

Oracle Database 12c/18c Architecture Part1

By David Yitzhak, 26.3.2018

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http://www.ildba.co.il/author/cimid/
http://www.sqlserver.co.il/?cat=940

3rd Israeli Conference on Software Architecture
http://www.iltam.org/sw-arch2016/arch2016_page#OpenSource

Global Hebrew Virtual PASS Chapter:
https://www.youtube.com/watch?v=x4hGjYGBfkY
https://www.youtube.com/watch?v=eJO8G9f3EY

Sqlsaturday Israel 2016:

Sqlsaturday Israel 2017:
http://www.sqlsaturday.com/623/Sessions/Detail
Reference and Credits

Oracle Open World 2017 session catalog

Run SQL with Oracle Live SQL

Oracle Database 12c Release 2 Help Center
Agenda

- RDBMS
- DB-Engines Ranking
- Oracle Database 12c/18c Objects
- Interacting with Oracle Database 12
- Schema
- Table Types in Oracle Database 12c/18C
- B-Tree Indexes
  Physical Storage Structures
- Logical Storage Structures
- Data Files Structure
- Data Blocks and Operating System Blocks
- How Data is Stored in Oracle Database 12c
- Types of Processes
- Dedicated & Shared Server Architecture
- Overview of Oracle Networking Architecture
- Oracle DB 12C Memory Structures
What is Oracle database 12C/18C

- A DB is an organized collection of data that is treated as a unit

- RDBMS (relational database management system)
  1. Infrastructure supporting multi-user DB access
  2. Most Common
  3. Different RDBMS have different architecture

- Secure data storage, quick retrieval by using SQL.

- Object-Relational database

Current Versions:
- Oracle 12c released in 2014 (c = cloud)
- Oracle 18C released in 2018, currently on cloud only & autonomous DB.
The DB-Engines Ranking ranks database management systems according to their popularity. The ranking is updated monthly.

Read more about the method of calculating the scores.

341 systems in ranking, March 2018

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mar 2018</th>
<th>Feb 2018</th>
<th>Mar 2017</th>
<th>DBMS</th>
<th>Database Model</th>
<th>Score</th>
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</tbody>
</table>
## Oracle Database 12c/18c 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/18c 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>
Schema

- A database schema is a logical container for data structures, called schema objects. Example: tables, indexes, PL/SQL packages.
- You create and manipulate schema objects with SQL.
- A database user account has a password and specific database privileges.
- Each user account owns a single schema, which has the same name as the user.
- The schema contains the data for the user owning the schema.
- In general, schema = user.
- Within a schema, each schema object of a particular type has a unique name.
  - HR.EMPLOYEES, SALES.ORDERS tables.
- Schema owner usually represents a database application.
- Schemas have no direct relationship to tablespaces.
Table Types in Oracle Database 12c/18c

• Heap-organized is the default
  – Row order is not specified in the relational model

• Index-organized tables
  – Rows structured according to an index (B-tree being the most common)

• Tables can be permanent or temporary

• Creation rules
  – CREATE TABLE DDL statement
  – Names consist of 1-30 characters, no reserved words, alphanumerics
B-Tree Indexes

- Great for accelerating query performance
- To limit having Oracle do full table scans
- We can partition data across tablespaces (datafiles) for better performance
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 manage DB & Develop
  – Oracle Enterprise Manager Database Express 12c, a GUI tool for database administration
  – Oracle Enterprise Manager Cloud Control 12c
SQL*Plus

- Primary tool for an Oracle DBA to administer DB using SQL commands.
- Before you can run SQL statements, you must connect to Oracle Database 12c.
- Start SQL*Plus using $ORACLE_HOME/bin/sqlplus executable on Unix/Linux/windows platform
Oracle SQL Developer

• PL/SQL IDE
• SQL editor
• GUI for browsing and managing database objects
• Ad Hoc reporting
• Database Design & Data Modeling
• Database Administration
• 3rd Party RDBMS Migrations to Oracle
• Deploy and Administer Oracle REST Data Services
• REST Enablement of the Database
• Command Line Interface
Command Line Interface (SQLcl)

- 15 MB download
- No client required
- Built in editor
- Automatic formatting
- Full SQL*Plus support
- SQL History
- Object name completion
- New commands e.g. CTAS, DDL, SSHTUNNEL, History
- Client-side javascript

Connect

```
I am on > connect HR/oracle@jdbc:oracle:orest:@http://localhost:8888/ords/hr/ Connected.
```

Run your stuff

```
I am HR on jdbc:oracle:orest:@http://localhost:8888/ords/hr/ > select max(salary), department_id
2 from hr.employees
3 group by department_id
4 order by 1 desc
5 fetch first 2 rows only;
```

```
DEPARTMENT  DEPARTMENT
  24000         90
  14000         80
```
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.
Oracle Enterprise Manager Cloud Control 13c

- Cloud Management
- Enterprise Reporting
- Capacity Planning
- Infrastructure Management
- Configuration Management
- Provisioning and Patching
- Application Quality Management
- Database Management
- Middleware Management

- Deployed Applications
- Application Framework
- Runtime
- Web & Application Server
- Database
- Integration
- Operating System
- Compute
- Storage

OTN : Enterprise Manager
SQL Developer Data Modeler

Free graphical tool, Available as a separate download/program

Create, browse and edit, logical, relational, physical, multi-dimensional, and data type models.

Provides forward and reverse engineering capabilities

Supports collaborative development through integrated source code control

Modeler can be used in both traditional and in Cloud environments

Examples:
- Custom Scripting
- Versioning
- Good for team & individuals
- Import data dictionaries
- Print Diagrams
- Compare
- Generate DDL
- Reporting
Physical Storage Structures

- An **Oracle database** is a set of files that store Oracle data in persistent disk storage.
- **Data files**
  Every Oracle DB has one or more physical data files, Data of logical DB structures, (tables, indexes etc.) is physically stored in the data files.
- **Temp file**
  Data file that belongs to a temporary tablespace for sorting and temporary object.
- **Control files**
  Every Oracle database has a control file. A control file contains metadata specifying the physical structure of the database, including the database name and the names and locations of the database files. Information required to recover DB including checkpoints (SCN).
- **Online redo log (ORL) files**
  Every Oracle Database has an online redo log, which is a set of two or more online redo log files. An online redo log is made up of redo entries (also called redo log records), which record all changes made to data.
- **Database instance** is a set of memory structures that manage database files.
Logical Storage Hierarchy

- **Data blocks**: Smallest units of storage that Oracle DB can use or allocate. One data block corresponds to a specific number of bytes on disk. (2 KB, 8K, 16k, 32k, 64k..)

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

- **Segments**: A segment is a set of extents allocated for a user object (table, index …), undo data, or temporary data. Every DB object that consumes storage consists of a single segment.

- **Tablespaces**: DB is divided into logical storage units called tablespaces. A tablespace is the logical container for a segment. Each tablespace consists of at least one data file.
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.
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.
- DB also has an **undo tablespace** and a **temporary tablespace** (TEMP).
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.
Database Block

- Block size range from 2K to 32K
  - 8K is typical

- Block header
  - Block Type Information in (like disk address and segment type).
  - For blocks that are transaction-managed, 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.

- Row Data
  - Free Space allow for insertion of new rows
  - Some free space left at the end of each row
How Data is Stored in Oracle Database 12c

- Row pieces can become chained within a block or between blocks (fragmentation)
- Blocks consist of row data, free space, and a header that contains metadata about that block
Types of Processes

1. A **client process** runs application or Oracle tool code.

2. An **Oracle process**
   - A **background process** perform maintenance tasks like: instance recovery, cleaning up processes.
   - A **server process** communicate with client processes and interact with Oracle DB to fulfill requests.
   - **Dedicated server VS Shared server**.

- **Dedicated server**
  - VS
  - **Shared server**.

- **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).
Dedicated Server Architecture

- Server process created on behalf of each client process is called a dedicated server process separate from the client process.
- A one-to-one ratio exists between the client processes and server processes.
- Sometimes result in inefficient use of operating system resources, e.g., order entry system.
Shared Server Architecture

- Dispatcher directs multiple incoming network session requests to a pool of shared server processes, eliminating the need for a dedicated server process for each connection. An idle shared server process from the pool picks up a request from a common queue.

**Advantages:**
- Reduces the number of resources on the OS
- Reduces instance PGA memory
- Increases application scalability and number of clients that can simultaneously connect to the database
- May be faster than dedicated server when the rate of client connections and disconnections is high
Overview of Oracle Networking Architecture

- Oracle Net Listener (Listener)
  1. A client process or another database requests a connection.
  2. Listener selects an appropriate service handler to service the client request and forwards the request to the handler.
  3. Client process connects directly to the service handler. The listener is no longer involved in the communication.
Oracle DB 12C Memory Structures

1. **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.

2. **Program global area (PGA)**
   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.

3. **Software code areas** used to store code that is being run or can be run.

4. **User global area (UGA)**
   Memory associated with a user session.
Program Global Area (PGA)

- Memory assigned to process when it connects to Oracle that contains session-dependent variables required by a dedicated or shared server process.
- Instance PGA (collection of all PGAs) for an instance that is not configured for shared servers.
- PGA stores user-specific session information like bind variables and session variables.
- SQL Work Area
  - Sorting Data
- Private SQL Area
  - Value of bind variables
  - Query execution state information
- Because PGA is process-specific, it is never allocated in the SGA.
Database Buffer Cache

- Largest components of SGA
- All SQL Statement need to access blocks of data

Goals
  - Used to cache data blocks (both table and index) from disk
  - Reading from memory much faster than disk
  - Keep frequently accessed blocks in the buffer cache and write infrequently accessed blocks to disk

Buffer Replacement Algorithms
  - LRU-based, block-level replacement algorithm
  - Temperature-based, object-level replacement algorithm

Buffer Search

Reading Blocks into buffer Cache

buffer cache hit ratio
Measure of how often the database found a requested block in the buffer cache without needing to read it from disk.
Shared pool

- Caches various types of program data. EX: stores parsed SQL, PL/SQL code, system parameters, and data dictionary information.
- Involved in almost every operation that occurs in the database.
- Divided into several subcomponents
  - Data Dictionary Cache.
    - Database object definitions & Object Permissions
  - Shared SQL Area
    - Cached SQL statements and execution plans
  - Reserved Pool
    - Borrows memory for short term operations
Redo Log Buffer

- A **circular** buffer in SGA that stores redo entries describing changes made to DB.

- A redo record is a data structure that contains the information necessary to reconstruct, or redo, changes made to the database by DML or DDL operations.

- DB recovery applies redo entries to data files to reconstruct lost changes.

- DB processes copy redo entries from the user memory space to the redo log buffer in the SGA.

- Redo entries take up continuous, sequential space in the buffer.
Oracle DB In-Memory: Dual Format Architecture

1. New pool in SGA: Column store
2. BOTH row and column formats for same table
   – Simultaneously active and consistent
3. OLTP uses existing row format
4. Analytics uses new In-Memory Column format
5. Seamlessly built into Oracle Database
6. Huge performance boost for full table scans and analytics queries.