Part 14: More Info for Oracle DBAs

References:

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Objectives

After completing this chapter, you should be able to:

- enumerate tasks of the database administrator.
- create users in Oracle.
- enumerate processes, files, memory structures of the Oracle architecture.
- start and stop the Oracle server, enumerate different system states of the server.

Overview

Access Rights in Oracle (1)

Object Privileges:

- Access rights in standard SQL are a set of triples: Who can execute which command on which DB object?

```
GRANT  SELECT ON EMP  TO   BRASS
REVOKE INSERT ON DEPT FROM SCOTT
```

- Rights can be given `WITH GRANT OPTION`.
- The owner of an object (the user who created the table) automatically holds all rights on it `WITH GRANT OPTION`.
- However, commands like `CREATE TABLE` cannot be restricted with this standard security model.

Access Rights in Oracle (2)

System Privileges:

- Most/all DBMS vendors extended the standard security model. In Oracle, system privileges were introduced in addition to the standard object privileges.
- System privileges define whether a user is allowed to execute a command, e.g.

  ```
  GRANT CREATE TABLE TO BRASS
  ```

- Oracle 8i (8.1.6) has 119 different system privileges. Most of them are important only for DBAs (e.g. `SELECT ANY TABLE`, `DROP ANY TABLE`), but some are important for every user (e.g. without `CONNECT` the user cannot log into the system).

Access Rights in Oracle (3)

Roles:

- It is difficult to manage a large set of users who basically should have the same access rights.
- Therefore, Oracle has introduced the concept of roles.
- A role is a named set of access rights (similar to: user group).
- After the role is created, access rights can be granted to the role, and the role can be granted to users.

  It is also possible to grant a role A to a role B: $A \subseteq B$.
- Then the users have all rights granted to the role.
- If a role is not a default role, the user must explicitly activate it, before he/she can use the rights (`SET ROLE`).

Creating Users in Oracle (1)

User Authentication:

- Oracle can perform the user authentication itself, then users have to enter a user name and a password:

  ```
  CREATE USER sbrass IDENTIFIED BY my_password
  ```

  Passwords have the same syntax as table names: If they include non-alphanumeric characters, use `"..."`. They are case-insensitive.
- Oracle can also rely on the authentication done by the OS:

  ```
  CREATE USER ops$sbrass IDENTIFIED EXTERNALLY
  ```

  So when the UNIX user `sbrass` logs into Oracle (with empty username/password), he becomes the Oracle user `ops$sbrass`.
- An external network authentication service can also be used.

Creating Users in Oracle (2)

Giving System Privileges to New Users:

- A user created as explained above has no rights, not even the system privilege to connect to the DB.
- So the necessary privileges must be given explicitly, e.g.

  ```
  GRANT connect, resource TO sbrass
  ```

- After the `GRANT`, these roles can be made default roles, so that they are automatically activated when the user logs in:

  ```
  ALTER USER sbrass DEFAULT ROLE ALL
  ```

  It seems that roles without a password automatically become default roles (?). So this command might not be necessary.

Creating Users in Oracle (3)

Defining Tablespaces and Quotas:

- A tablespace is a data file / collection of DB files.
- ```
  CREATE USER sbrass IDENTIFIED BY my_password
                     DEFAULT TABLESPACE user_data
                     TEMPORARY TABLESPACE temporary_data
                     QUOTA 2M ON user_data
                     QUOTA UNLIMITED ON temporary_data
  ```
- `DEFAULT TABLESPACE` is used for tables created by the user.
  If he/she does not specify a tablespace. Default is `SYSTEM`.
- Without `QUOTA` clauses, the user has no right to access the tablespaces (unless he/she has "`UNLIMITED TABLESPACE`").
  Use: `REVOKE UNLIMITED TABLESPACE FROM sbrass`

Creating Users in Oracle (4)

Changing and Deleting Users:

- If a user has forgotten his/her password:
  `ALTER USER sbrass IDENTIFIED BY new_password`
- A user without tables can be deleted in this way:
  `DROP USER sbrass`
- To delete the user including all his/her data, use:
  `DROP USER sbrass CASCADE`
- The following command ensures that the user can no longer log in, but leaves his/her data untouched:
  `ALTER USER sbrass ACCOUNT LOCK`
  Or: `REVOKE CONNECT FROM sbrass` (and roles that include it).

Some Predefined Users

- `SYS`: Owner of the system tables (data dictionary).
  This is the most powerful account. The default password is: `CHANGE_ON_INSTALL`.
- `SYSTEM`: The default database administrator.
  For most administration tasks. Default password: `MANAGER`.
- `SCOTT`: Guest and demonstration account.
  Default password: `TIGER`.
- `OUTLN`: Schema contains information for optimizer.
  Default password: `OUTLN`.
- `DBSNMP`: Information for "intelligent agent" which allows remote administration via the "enterprise manager".
  Default password: `DBSNMP`.

Other Security Features in Oracle

- Limit the resource usage of database users can be restricted by creating a "profile" for them. This defines e.g.
  - How many concurrent sessions the user can have.
  - After what idle time he/she is logged off.
  - How much CPU time is allowed per session/per call.
  - How many logical reads (disk accesses) are allowed per session/per call.
  - After what time a password must be changed.
  - Which function should be used to check the password complexity.
- Oracle also has an `AUDIT` command (see manual).
  ```

Overview

1. Creating Users in Oracle
2. Oracle Architecture
3. Starting/Stopping Oracle

Oracle Files (1)

Data Files:

- Oracle normally stores table data in operating system files.
  Windows e.g.: `C:\Oracle\ORADATA\orcl\System01.dbf`
  UNIX e.g.: `/ora8/oradata/ifidb/system01.dbf`
- For performance reasons, Oracle can also manage raw devices (direct disk access, not via the OS).
- Oracle does not use one file per table or per user.
  Any number of tables, indexes, etc. can be stored in the same file. Simplest case: Entire DB in a single file.
- The files can only be processed by Oracle (no standard format).
- However, the data is not encrypted. Persons who can access the data files can circumvent the Oracle access control.

Oracle Files (2)

- The data dictionary view `DBA_DATA_FILES` lists all files for storing table data. Columns are:
  - `FILE_NAME`: Filename with path.
  - `FILE_ID`: Numeric file identification.
  - `TABLESPACE_NAME`: Logical collection of data files.
  - `BYTES`, `BLOCKS`: Current file size.
  - `STATUS`: `AVAILABLE` or `INVALID` (not in use).
  - `RELATIVE_FNO`: Used in ROWIDs to refer to the file.
  - `AUTOEXTENSIBLE`: Oracle can make the file larger.
  - `MAXBYTES`, `MAXBLOCKS`, `INCREMENT_BY`: Parameters for autoextension.

Oracle Files (3)

Control Files:

- When Oracle starts, it reads the names and locations of the datafiles from a "control file".
  Windows e.g.: `C:\Oracle\ORADATA\orcl\Control01.ctl`.
  UNIX e.g.: `/ora8/oradata/ifidb/control01.ctl`.
- For safety reasons, there should normally be more than one control file (on different disks).
- `V$CONTROLFILE`: List of control files. Columns are:
  - `STATUS`: Normally null. Can be `INVALID`.
  - `NAME`: Path and name of the control file.

  Information from the control file is e.g. contained in: `V$DATAFILE`, `V$DATABASE`, `V$LOG`, `V$LOG_HISTORY`.

Oracle Files (4)

Redo Log Files:

- Besides data files, Oracle also has log files, which are needed for transaction processing (Recovery after a system crash.)

  Windows e.g.: `C:\Oracle\ORADATA\orcl\Redo01.log`.

  UNIX e.g. `/ora8/oradata/ifidb/redo01.log`
- All changes to the data files are logged in these files.
- `V$LOGFILE`: List of all log files.
  - `GROUP#`: Logfiles with the same group number are copies of each other (for safety reasons).
  - `STATUS`: Usually null, can be `INVALID`, `STALE`, `DELETED`.
  - `MEMBER`: File name of the log file.

Oracle Files (5)

Redo Log Files, Continued:

- Redo log files are reused in a cyclic way, e.g. the output first goes to group 1, then to group 2, then to group 3, and then again to group 1.

Oracle Files (6)

Initialization Parameters:

- When Oracle is started, it reads a parameter file `init.ora`.

  `C:\Oracle\Admin\orcl\pfile\init.ora`

  `/ora8/product/8.1.6/admin/ifidb/pfile/initifi.ora`
- It contains the settings of important tuning parameters, as well as the location of the control files.

  Standard ASCII file: can be viewed with any text editor.
- `V$PARAMETER`: Settings of the initialization parameters.
- E.g. location of the control files:

```
SELECT VALUE FROM V$PARAMETER
WHERE  NAME = 'control_files'
```


Oracle Files (7)

ALERT file:

- The alert file of the DB contains e.g. information about
  - each time the server is started or stopped,

    At startup, the size of the shared memory areas and the started background processes are shown.
  - important administrative operations (e.g. adding files),
  - errors.
- The DBA should carefully monitor the alert file.

  `C:\Oracle\Admin\orcl\Bdump\orclALRT.log`

  `/ora8/product/8.1.6/admin/ifidb/bdump/alert_ifi.log`
- In addition, each Oracle process has a trace file.

  Server processes only if `SQL_TRACE` is set to `TRUE`.

Oracle Architecture (1)

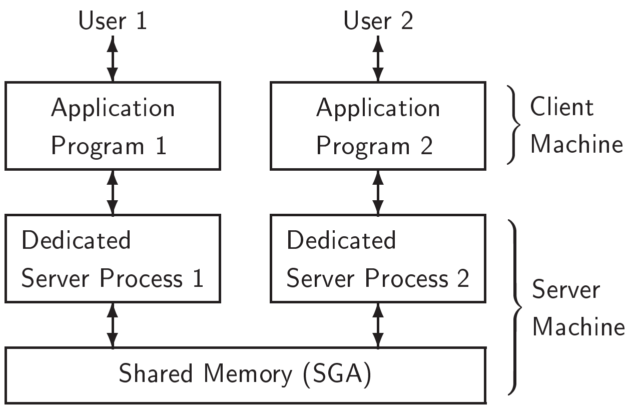
- Clients (such as SQL*Plus or an application program written in Pro*C) connect over the network to the DB server.
- The server part of Oracle consists of several processes and a shared memory area (SGA = System Global Area).

  SGA is sometimes also read as "Shared Global Area".
- In the dedicated server architecture, there is one server process for every client (started when the client connects to Oracle and terminated when it logs off).

  An alternative is the multithreaded server architecture (MTS) with a pool of server processes and a dispatcher which sends client requests to one of the servers. It is advantageous when a large number of concurrent clients must be served.

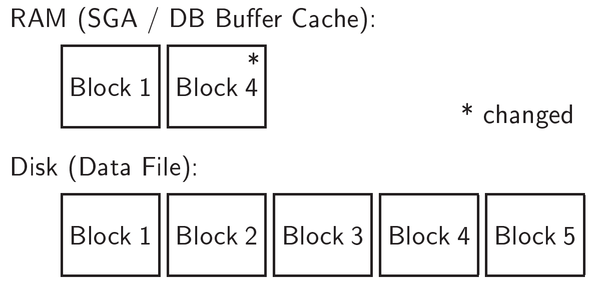
Oracle Architecture (2)

Dedicated Server Architecture:



Oracle Architecture (3)

- Part of the SGA is the database buffer cache. It stores recently accessed DB blocks (containing e.g. table data).



- Accesses to RAM are much faster than accesses to disk, but the RAM is usually much smaller (and volatile).

Oracle Architecture (4)

- When a server process needs a block from a datafile, it first checks whether the block is already in the DB buffer cache.
- If the block is already in the buffer cache, the server process can directly access the data there (unless it is locked).
- If not, the server process allocates a free buffer in the DB buffer cache, and reads the block into that buffer.

  The block then remains some time in the buffer, in case it is needed again. Buffering is explained in more detail below.
- Even if the server process changes the block in the buffer, it is not responsible for writing it back to disk.

  This is the task of the "DB writer" background processes.

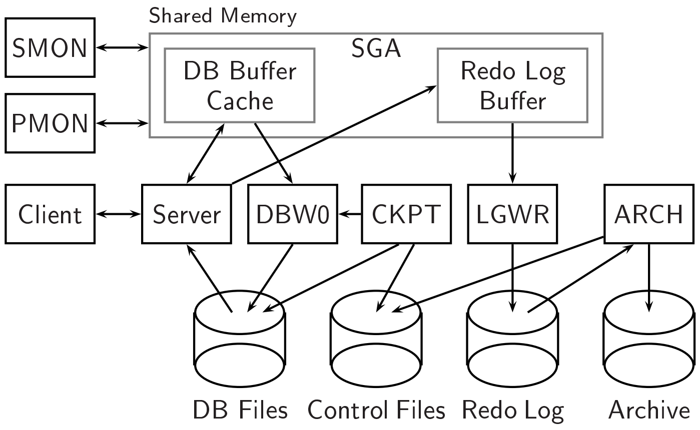
Oracle Architecture (5)

- Oracle uses a set of 5 or more background processes.
- The “DB writer” background processes (DBW0, DBW1, . . .) save changed blocks periodically back to the disk.

  Because of the delayed writing, it might be that the block is changed many times before it is finally written back.
- Another part of the SGA is the Redo Log Buffer.

  It stores a transcript of all changes to DB blocks. This information is needed e.g. if the system should crash before the DB Writer saved a block back to disk. The Log entries are written to disk at commit time (or earlier).
- The log writer process (LGWR) saves the entries from the log buffer to the current redo log file.

Oracle Architecture (6)



Oracle Architecture (7)

More Background Processes:

- Checkpoint Process (CKPT)

  CKPT ensures that from time to time all changed blocks are written back to disk so that older log files are only needed in case of disk failures, but not for “normal” system crashes.

  It calls the DB writer process and updates the controlfiles.

  A checkpoint is set (minimally) every time a log file becomes full. One can configure more frequent checkpoints (`init.ora`).
- Archiver Process (ARCH)

  ARCH writes full redo log files to tape storage or another archive location (if the DB runs in ARCHIVELOG mode).

  If the data files should be damaged, all redo log files generated since the last backup are needed.

Oracle Architecture (8)

Oracle Background Processes, Continued:

- System Monitor Process (SMON)

  SMON performs recovery after a system crash and does some clean-up tasks regularly. E.g. it merges contiguous free extents etc.
- Process Monitor Process (PMON)

  PMON performs clean-up tasks when a user process fails (e.g. remove its locks).

Oracle Instance:

- An Oracle instance consists of an SGA (system global area) and a set of background processes.

Oracle Architecture (9)

Main Networking Process:

- Listener

  The network listener process accepts connections from clients and creates dedicated server processes. It can also manage pre-spawned server processes.

Processes for Multithreaded Servers:

- Dispatcher Processes (Dnnn)

  In the multithreaded configuration, these processes distribute client requests over shared DB servers.

- Shared Server Processes (Snnn)

  DB Server for the multithreaded configuration.

Oracle Architecture (10)

Processes for Distributed Databases:

- Recoverer Process (RECO)

  This process connects to other nodes in a distributed DB to resolve in-doubt transactions (no final COMMIT/ABORT).

- Job Queue Processes (SNPn)

  These processes automatically update table snapshots in a distributed database.

Processes for Oracle Parallel Server:

- Lock Process (LCK0)

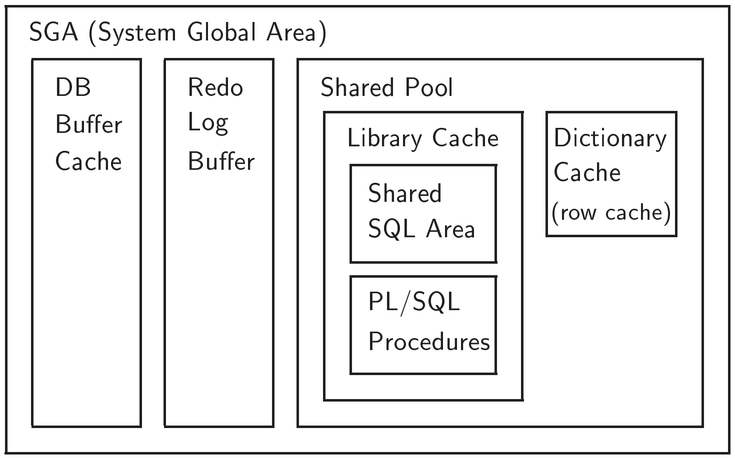
  Manages locks between different Oracle instances (each instance has its own SGA and background processes).

Oracle Architecture (11)

Memory Structures:

- Besides the DB buffer cache and the redo log buffer, the SGA (System Global Area) contains also the "Shared Pool".
- The shared pool contains e.g.
  - a cache for rows from the data dictionary ("row cache").
  - the library cache.
- The library cache contains e.g.
  - the Shared SQL Area (recently executed SQL statements together with the query evaluation plans).
  - PL/SQL procedures and packages in compiled form.

Oracle Architecture (12)



Oracle Architecture (13)

Program Global Area (PGA):

- The PGA is memory that is allocated inside the dedicated server process (i.e. not shared).
- It contains e.g.
  - Stack area (session-specific variables, arrays, etc.)
  - Private SQL areas (bind information, runtime buffers, etc.)
- The private SQL areas contain also the sort areas.

  Sorting can run faster with more memory. Only the retained portion of the sort area is part of the private SQL area.
- In the multithreaded server configuration, the private SQL areas are allocated in the SGA (in the shared pool).

Oracle Architecture (14)

- `V$PROCESS` lists the Oracle processes.

  `V$BGPROCESS`: brief description of background processes.
- `V$BUFFER_POOL`: Size of DB buffer cache (buffer pools).

  Buffering is explained in more detail in a later chapter.
- `V$RESOURCE_LIMIT`: Sizes of some arrays in the SGA.

  E.g. there is an array for the currently active transactions. `V$RESOURCE_LIMIT` also reports the use of these resources, e.g. how many transactions are currently active or were ever active concurrently (since instance startup).
- `V$SGA`: Size of the components of the SGA.
- `V$SGASTAT`: Detailed information about the size of memory structures, listing components of the shared pool individually.

Some Initialization Parameters

- `DB_BLOCK_SIZE`: Size (in bytes) of a single DB block.
- `DB_BLOCK_BUFFERS`: Number of buffer frames.

  So the total memory needed is `DB_BLOCK_BUFFERS * DB_BLOCK_SIZE`.
- `LOG_BUFFER`: Size of the redo log buffer (in bytes).
- `SHARED_POOL_SIZE`: Size (in bytes) of the cache for data dictionary rows, SQL statements with execution plans, etc.
- `DB_FILE_MULTIBLOCK_READ_COUNT`: Number of blocks that will be read in one OS call during e.g. a full table scan.
- There are more than 200 such parameters.

  See: Oracle8i Reference, Chap. 1: Initialization Parameters.

Overview

1. Creating Users in Oracle
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Controlling Oracle (1)

- Until Oracle 8.0, a program called "Server Manager" (svrmgrl/svrmgr30) was the main administration tool.

  To get the DBA privileges, one enters the command "connect internal". With the right OS privileges, no password is required. Otherwise the default is ORACLE.
  Of course, there are commands help and quit.
- Now this function was integrated into SQL*Plus:

```
UNIX> sqlplus /nolog
SQL> connect sys as sysdba
```

- In addition, there is a powerful tool with graphical interface called Enterprise Manager (separate product).

  Smaller version: DBA Studio (comes with Personal Oracle 8i).

Controlling Oracle (2)

- As long as the database does not run, the passwords for SYS etc. stored in it cannot be accessed.
- There are two possibilities to authenticate DBAs:
  - OS Authentication: Members of an operating system group called dba may start/stop the DB.

    E.g. the OS user who owns the Oracle programs and files (usually oracle). On other systems, only the OS administrator (root) may perform this task.
  - Password File: There is a password file in addition to the passwords stored in the database.

    It contains the passwords of all users who have been granted the SYSDBA or SYSOPER system privileges.

Controlling Oracle (3)

- The password file is e.g. stored in

```
C:\orawin95\database\pwdorcl.ora
```

  (The same directory that also contains the data files).
- The password file is created with the orapwd utility program. One must specify an initial password for SYS/INTERNAL:

```
ORAPWD FILE=ifi.pwd PASSWORD=nina ENTRIES=5
```

- ENTRIES is the maximal number of users that can have SYSDBA/SYSOPER rights (i.e. their password stored in this file).
- If one forgot the password: Delete (or rename) the password file and recreate it.

  Then the SYS passwords in the file and in the DB don't agree.

Controlling Oracle (4)

- If one wants to use a password file, the initialization parameter REMOTE_LOGIN_PASSWORD_FILE must be set to EXCLUSIVE.

  It is NONE by default which means OS authentication.
- On Windows, the internal password is stored in the registry: DBA_AUTHORIZATION in HKEY_LOCAL_MACHINE/SOFTWARE/ORACLE.

  This is used for the automatic start and stop of the DBMS.
- The special user INTERNAL and all users who connect AS SYSDBA are mapped to SYS when they access the DB.
- The DBA usually works while logged into the server machine.

  It is possible to do administration remotely, but then a copy of the initialization parameter file must be available on the client. One should use a password file.

Starting Oracle (1)

- Starting Oracle proceeds in three steps. Normally, they are automatically done one after the other, but the DBA can choose to remain in an intermediate state:
  - The instance is started.

    This means the parameter file (`init.ora`) is read, the SGA is allocated, and the background processes are started. In this state a new database can be created.
  - The database is mounted.

    The control file is read, but the data files are not yet open. E.g. data files can be renamed in this state.
  - The database is open.

    The database is available for normal operations.

Starting Oracle (2)

- The commands for starting Oracle in one of the intermediate states are:
  - `STARTUP NOMOUNT`: Only processes started.
  - `STARTUP MOUNT`: Only controlfiles open.
  - `STARTUP` or `STARTUP OPEN`: Full startup.
- It is possible to add the keyword `FORCE`, this e.g. kills processes remaining from a previous instance.
- It is possible to explicitly specify the parameter file and/or the DB name: `STARTUP OPEN ifi PFILE=initifi.ora`
- `STARTUP RESTRICT` opens the database, but allows only users with the `RESTRICTED SESSION` privilege to connect.

Shutting Oracle Down (1)

- The shutdown proceeds in the same three steps as the startup (in inverse order):
  - The database is closed.

    The contents of the DB buffer cache and the redo log buffer is written to disk and the files are closed. The control files remain open.
  - The database is dismounted.

    The control files are closed.
  - The instance is shut down.

    The background processes are terminated, the SGA memory is given back to the operating system.

Shutting Oracle Down (2)

- There are four different shutdown modes:
  - `SHUTDOWN NORMAL`

    The shutdown waits until all users logged off from Oracle. No new users can log into Oracle.
  - `SHUTDOWN TRANSACTIONAL`

    The shutdown waits until all active transactions are finished. No new transactions can be started.
  - `SHUTDOWN IMMEDIATE`

    All active transactions are rolled back. Then all buffers are written and the shutdown proceeds normally.
  - `SHUTDOWN ABORT`

    The Oracle processes are killed. Recovery will be needed.

Killing Sessions (1)

- All currently active sessions (i.e. users that logged in, but do not yet log out) are listed in `V$SESSION`. Columns are, e.g.:
  - `SADDR`: Memory address of session data in DBMS.
  - `SID`: Session identifier.

    Note that `SID` also means "system identifier", used to identify an Oracle instance.
  - `SERIAL#`: Serial number of the session.

    The `SID` is reused for another session when one user logs out and the next logs in. This makes it unique.
  - `USERNAME`: Oracle user name.
  - `OSUSER`: Operating system user name.
  - `PROGRAM`: Operating system program name.

Killing Sessions (2)

- `V$TRANSACTION` lists the currently active transactions (a transaction is started at the first `INSERT`/`UPDATE`/`DELETE` and ends with `ROLLBACK` or `COMMIT`). One of its attributes is

  `SES_ADDR`: Memory address of the session data.
- One can list the owners of currently active transactions with

```
SELECT USERNAME
FROM   V$TRANSACTION X, V$SESSION Y
WHERE  X.SES_ADDR = Y.SADDR
```

- The DBA can kill a session with the following command:

```
ALTER SYSTEM KILL SESSION '8,5948'
```

  Here 8 is the `SID` and 5948 is the `SERIAL#` of the session.