Datenbanken II B: DBMS-Implementierung

Chapter 2: Basic Oracle Architecture and Administration

Prof. Dr. Stefan Brass
Martin-Luther-Universität Halle-Wittenberg
Wintersemester 2019/20

http://www.informatik.uni-halle.de/~brass/dbi19/

Objectives

After completing this chapter, you should be able to:

- create users in Oracle.
- enumerate processes, files, memory structures of the Oracle architecture.
- explain why delayed writing of changed database blocks is a good idea, and how the logfile protects changes.
- start and stop the Oracle server,
  enumerate different system states of the server.

Inhalt

Object Privileges (1)

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

```
GRANT  SELECT ON EMP  TO   SMITH
REVOKE INSERT ON DEPT FROM MILLER
```

  Actually, they are quadruples: Who has given whom what right on which database object? This is important when rights are revoked.

- Rights can also be granted "`TO PUBLIC`".

  All users, including users created in future.

- Rights can be given "`WITH GRANT OPTION`".

  Then the grantee can grant the right to further users. The owner of a table (the user who created it) automatically holds all rights on it `WITH GRANT OPTION`. For views this is more complicated.

Object Privileges (2)

- USER_TAB_PRIVS: Grants on objects for which the current user is owner, grantor, or grantee.

USER_TAB_PRIVS					
GRANTEE	OWNER	TABLE_NAME	GRANTOR	PRIVILEGE	GRANTABLE
PUBLIC	SCOTT	DEPT	SCOTT	SELECT	N
SMITH	SCOTT	EMP	SCOTT	SELECT	Y
MILLER	SCOTT	EMP	SMITH	SELECT	N
SMITH	SCOTT	EMP	SCOTT	INSERT	N

I.e. all users have read access to the table DEPT. SMITH got read access to EMP WITH GRANT OPTION, and has given the right to MILLER. In addition, SMITH can append rows to EMP.

In contrast to other data dictionary tables, the prefix USER here does not mean that only tables owned by the current user are listed.

Object Privileges (3)

- Columns of USER_TAB_PRIVS:
  - OWNER and TABLE_NAME identify the table.
  - GRANTEE: The user who got the privilege.
  - GRANTOR: The user who gave the privilege.

    Because of the grant option, not only the owner can be grantor.
  - PRIVILEGE: The right, e.g. 'SELECT'.
  - GRANTABLE: 'YES' if right includes grant option.
- In this way, the SQL GRANT commands are stored in the data dictionary.

Object Privileges (4)

- USER_TAB_PRIVS_MADE is the subset of USER_TAB_PRIVS with OWNER=USER.
- USER_TAB_PRIVS_RECD is the subset of USER_TAB_PRIVS with GRANTEE=USER.
- The user might also have access to database objects because of grants to PUBLIC, which are not listed in these tables (but see ALL_TAB_PRIVS).

  Unless, of course, they are made by the current user or refer to tables of the current user. Otherwise, the name of the current user is neither OWNER, nor GRANTOR, nor GRANTEE, therefore the grant is not shown.

Object Privileges (5)

- The `INSERT` and `UPDATE` right can be given selectively for certain columns.

  An insert right for only part of the columns means that the other columns cannot be explicitly specified, and thus get their declared default value (or null).

- `USER_COL_PRIVS`: Grants that refer to single columns.

  `USER_COL_PRIVS` looks like `USER_TAB_PRIVS`, but has the additional column `COLUMN_NAME`.

- Grants for whole tables are not repeated here.

- `USER_COL_PRIVS_MADE`, `USER_COL_PRIVS_RECD`: Subsets with current user as owner/grantee (as above).

System Privileges (1)

- Commands like "`CREATE TABLE`" cannot be restricted with this standard security model.

  A user who is only supposed to enter data does not need to create new tables. For a secure system, every user should only be able to execute the commands he/she is supposed to execute.

- Therefore, Oracle has also "system privileges".

  Every major DBMS vendor has a to the problem (all different).

- In contrast to "object privileges", these refer to the execution of specific commands, not to DB objects.

- E.g. one needs the system privilege "`CREATE TABLE`" in order to be able to execute this command.

System Privileges (2)

- In order to log into Oracle, one needs the system privilege "`CREATE SESSION`".

  An account can be locked by not granting (or revoking) this privilege. It is still possible to access tables, views, etc. under this account via synonyms or "⟨`User`⟩.⟨`Table`⟩" (if one has the necessary access rights).

- Many system privileges are only for DBAs, e.g.:
  - "`SELECT ANY TABLE`" (read access to all tables),
  - "`DROP ANY TABLE`" (delete data of arbitrary users),
  - "`CREATE USER`" (create a new user).

System Privileges (3)

- Since the usual privileges of a DBA are separated into different system privileges, it is possible to have several DBAs with different responsibilities.

  Of course, one can still have one DBA with all privileges.

- There are currently 157 different system privileges.

  Basically, every administration command corresponds to a system privilege. Different kinds of `CREATE` commands also correspond to system privileges (since these commands could not be restricted otherwise). Most commands also have an `ANY`-version as a system privilege (allows one to apply the command to objects of any user). `CREATE ANY TABLE`: create tables in any schema.

System Privileges (4)

- If a user has a system privilege "`WITH ADMIN OPTION`", he/she can give it to other users:

  ```
  GRANT CREATE TABLE TO SCOTT
  ```

  Adding "`WITH ADMIN OPTION`" gives `SCOTT` the right to grant "`CREATE TABLE`", too.

- When a system privilege is revoked from a user A who had it "`WITH ADMIN OPTION`", privileges are not recursively revoked from users B who got it from A.

  This might be the reason why it was not called "`GRANT OPTION`". But it is very similar ("`GRANT OPTION`" can be used only for object privileges).

System Privileges (5)

- SYSTEM_PRIVILEGE_MAP: List of all system privileges.

SYSTEM_PRIVILEGE_MAP	
PRIVILEGE	NAME
⋮	⋮
-5	CREATE SESSION
⋮	⋮
-40	CREATE TABLE
⋮	⋮
-47	SELECT ANY TABLE
⋮	⋮

System Privileges (6)

- USER_SYS_PRIVS: System privileges granted to the current user or to PUBLIC.

  Columns are: USERNAME (always the name of the current user, not very useful), PRIVILEGE (name of the system privilege, no join with SYSTEM_PRIVILEGE_MAP necessary), ADMIN_OPTION (similar to grant option for object privileges).

- DBA_SYS_PRIVS: System privileges for each user.

  For DBA only. It has the columns GRANTEE, PRIVILEGE, ADMIN_OPTION.

- Only directly granted privileges are listed.

  Additional system privileges might have been granted via roles (see below). Therefore, USER_SYS_PRIVS is often empty, although the user actually has many system privileges.

Roles (1)

- It is difficult to grant privileges to many users one by one. In one way or another, all modern DBMS support groups of users with similar privileges.
- Oracle has the concept of "roles", which are sets of privileges that can be granted to users:

```
CREATE ROLE MANAGEMENT
```

This command requires DBA rights (system privilege "`CREATE ROLE`").

- Access rights are granted to a role in the same way as they are granted to a user:

```
GRANT SELECT ON EMP TO MANAGEMENT
```

Roles (2)

- Roles can be granted to users (by their owner or users who got them `WITH ADMIN OPTION`):

  ```
  GRANT MANAGEMENT TO JIM, MARY
  ```

- When a user A is granted a role R, A receives all privileges that were or will be granted to R.

  But if "`MANAGEMENT`" is not one of the default roles of these users, which are automatically activated when they log in, they must explicity execute "`SET ROLE MANAGEMENT`" in every session in which they want to use these privileges. (This is not enforced in Oracle 8.0.) Roles can be protected by passwords. Then `SET ROLE` requires a password.

- If role A is granted to role B, B includes all rights of A. Thus, B is more powerful than A.

Roles (3)

- Several roles are predefined in Oracle 8, e.g.
  - `CONNECT`: Basic usage rights.

    This corresponds to the system privileges: `CREATE SESSION`, `ALTER SESSION`, `CREATE DATABASE LINK`, `CREATE SYNONYM`, `CREATE TABLE`, `CREATE CLUSTER`, `CREATE VIEW`, `CREATE SEQUENCE`.
  - `RESOURCE`: Rights for advanced users.

    This includes e.g. `CREATE TABLE`, `CREATE PROCEDURE`, `CREATE TRIGGER`. Students in this course were granted `CONNECT` and `RESOURCE` (but `UNLIMITED TABLESPACE` was revoked).
  - `DBA`: Right to do everything.
- In older Oracle versions, users were classified into these three types.

Roles (4)

- DBA_ROLES: List of all roles defined in the system.

  It has the columns ROLE, PASSWORD_REQUIRED. Only the DBA can create roles, and only the DBA can see the list of all roles.

- USER_ROLE_PRIVS: Roles granted to the current user.

  Roles granted to PUBLIC are also listed: All users have the rights included in such roles. Columns are: USERNAME, GRANTED_ROLE, ADMIN_OPTION, DEFAULT_ROLE, OS_GRANTED.

- DBA_ROLE_PRIVS: Which roles are granted to which user? Also role-to-role grants are shown.

  Columns: GRANTEE, GRANTED_ROLE, ADMIN_OPTION, DEFAULT_ROLE. GRANTEE can be a user or another role.

Roles (5)

- The following tables/views list the access rights included in roles accessible to the current user:
  - `ROLE_ROLE_PRIVS`: Roles implied by a role.

    Columns are: `ROLE`, `GRANTED_ROLE`, `ADMIN_OPTION`.

    All rights in `GRANTED_ROLE` are included in `ROLE`.
  - `ROLE_SYS_PRIVS`: System privileges in a role.

    Columns are: `ROLE`, `PRIVILEGE`, `ADMIN_OPTION`.
  - `ROLE_TAB_PRIVS`: Table privileges granted to roles.

    Columns are: `ROLE`, `OWNER`, `TABLE_NAME`, `COLUMN_NAME` (null if right for entire table), `PRIVILEGE`, `GRANTABLE`.

Creating Users (1)

User Authentication:

- Oracle can perform the user authentication itself. One must specify a user name and a password:

```
CREATE USER BRASS IDENTIFIED BY ABC_78
```

  Passwords have the same syntax as table names: They are not case-sensitive and `"..."` is needed to include special characters.

- Oracle can also rely on the authentication done by the operating system or a network service:

```
CREATE USER OPS$BRASS IDENTIFIED EXTERNALLY
```

  So when the UNIX user `BRASS` logs into Oracle (with empty username/password), he becomes the Oracle user `OPS$BRASS`.

Creating Users (2)

- A user created as explained above has no rights, not even the system privilege to connect to the DB.
- The necessary privileges can be given e.g. with:

```
GRANT CONNECT, RESOURCE TO BRASS
```

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

```
ALTER USER BRASS DEFAULT ROLE ALL
```

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

Tablespaces and Quotas (1)

- A tablespace is a database file or a collection of DB files (storage space, container for tables).
- All tablespaces are listed in the system catalog table DBA_TABLESPACES.

  E.g. use "SELECT TABLESPACE_NAME FROM DBA_TABLESPACES" to list all tablespaces. This query must be executed by a DBA. All users have read access to USER_TABLESPACES (tablespaces that are accessible by the current user). The files for each tablespace are listed in DBA_DATA_FILES. It has e.g. the columns FILE_NAME, FILE_ID, TABLESPACE_NAME, BYTES. See also DBA_FREE_SPACE/USER_FREE_SPACE and DBA_FREE_SPACE_COALESCED.
- The tablespace "SYSTEM" contains e.g. the data dictionary (collection of system tables).

Tablespaces and Quotas (2)

- ```
  CREATE USER BRASS IDENTIFIED BY MY_PASSWORD
         DEFAULT TABLESPACE USER_DATA
         TEMPORARY TABLESPACE TEMPORARY_DATA
         QUOTA 2M ON USER_DATA
         QUOTA UNLIMITED ON TEMPORARY_DATA
  ```
- A tablespace can be defined when a table is created.

  Otherwise it is stored in the user's `DEFAULT TABLESPACE` (which is `SYSTEM` if it is not set in the `CREATE USER`).
- Without quota (and "`UNLIMITED TABLESPACE`"), the user cannot create tables on the tablespace.

  Use: `REVOKE UNLIMITED TABLESPACE FROM BRASS`
  ```

Data Dictionary: Users (1)

- ALL_USERS: List of all users, accessible by all users:
  - USERNAME: Name of the Oracle account.
  - USER_ID: Internal number of the account.
  - CREATED: Date/time when account was created.

ALL_USERS		
USERNAME	USER_ID	CREATED
SYS	0	29-JAN-98
SYSTEM	5	29-JAN-98
SCOTT	20	29-JAN-98
BRASS	24	13-MAY-01
⋮	⋮	⋮

Data Dictionary: Users (2)

- DBA_USERS: Full information about all users.
  Only the DBA can look at this table.

  It has the following columns: USERNAME, USER_ID, PASSWORD (stored in encrypted form), DEFAULT_TABLESPACE, TEMPORARY_TABLESPACE, CREATED, PROFILE, ACCOUNT_STATUS (indicates whether account is locked, expired, or unlocked), LOCK_DATE, EXPIRY_DATE, INITIAL_RSRC_CONSUMER_GROUP, EXTERNAL_NAME.

- USER_USERS: Single row with information about the current user.

  It has the following columns: USERNAME, USER_ID, ACCOUNT_STATUS, LOCK_DATE, EXPIRY_DATE, DEFAULT_TABLESPACE, CREATED, EXTERNAL_NAME.

Data Dictionary: Quotas

- DBA_TS_QUOTAS: How many bytes/blocks on which tablespace are charged to which user, and what is the allowable maximum (quota)?

  Columns of this table are: TABLESPACE_NAME, USERNAME, BYTES, MAX_BYTES, BLOCKS, MAX_BLOCKS. The columns BYTES and MAX_BYTES are derived from the information in blocks.

- USER_TS_QUOTAS: The current and maximal file space usage of the current user.

- All table data is charged to the table owner (even if other users actually inserted the rows).

Some Predefined Users (1)

- SYS: Owner of the system tables (data dictionary).

  Most powerful account. Default password: CHANGE_ON_INSTALL.

- SYSTEM: The default database administrator.

  For most administration tasks. Default password: MANAGER.

- SCOTT: Guest and demonstration account.

  Default password: TIGER. Sometimes there are additional accounts used in tutorials: ADAMS, BLAKE, CLARK, JONES.

- OUTLN: Schema contains information for optimizer.

  Default password: OUTLN.

Some Predefined Users (2)

- DBSNMP: Information for the "intelligent agent".

  It is used for remote administration via the "enterprise manager". Default password: DBSNMP.

- One should check the list of users in the system table ALL_USERS and lock all users that are currently not needed (or change their passwords).

  There is also a table DBA_USERS with more information. The list of users created during the installation can change with new versions. Also, when one installs additional software (e.g. the Oracle application manager), more accounts are created.

- Hackers know all the default passwords!

Changing and Deleting Users

- If a user has forgotten his/her password:

```
ALTER USER BRASS IDENTIFIED BY NEW_PASSWORD
```

- A user without tables can be deleted in this way:

```
DROP USER BRASS
```

- To delete the user including all his/her data, use:

```
DROP USER BRASS CASCADE
```

- The following command ensures that the user can no longer log in, but leaves his/her data untouched:

```
ALTER USER BRASS ACCOUNT LOCK
```

External Password File

- Whereas the above passwords are stored in the database (encrypted), there usually is an additional file that contains passwords of administrators who need e.g. to start up the database.

  When the database is not running, passwords stored in the database cannot be accessed. If you use `CONNECT INTERNAL` in the server manager (`svrmgrl`) or `CONNECT SYS AS SYSDBA`, the default password is `ORACLE`. Actually, the `SYS` password in the password file and in the database can be different. The password file is generated by the `orapwd` utility program. Later, every user granted `SYSDBA`/`SYSOPER` rights is also stored in the password file. Instead of using a password file, you can use OS authentication. This depends on the parameter `REMOTE_LOGIN_PASSWORDFILE`

Other Security Features (1)

- The resource usage of DB users can be restricted by creating a "profile" for them. This defines e.g.
  - How many concurrent sessions the user can have (number of windows with DB applications).
  - After what idle time he/she is logged off.
  - How much CPU time and how many logical reads (disk accesses) are allowed per session/per call.
  - After what time a password must be changed.
  - Which function is used to check the password complexity.

Other Security Features (2)

- Oracle also has an `AUDIT` command for defining which user actions are logged in system tables, so that one can later find out who did what.
  - E.g. all insertions should be logged that were executed (not refused):

```
AUDIT INSERT ON SCOTT.EMP
BY SESSION WHENEVER SUCCESSFUL;
```

    "`BY SESSION`" means that only one record is written for an entire session that did this operation (default). Alternative: "`BY ACCESS`".
  - E.g. log all unsuccessful login attempts:

```
AUDIT CONNECT WHENEVER NOT SUCCESSFUL;
```

Inhalt

Oracle Files: Data Files (1)

- Oracle normally stores table data in standard operating system files.

  Windows e.g.: `C:\Oracle\ORADATA\orcl\System01.dbf`
  UNIX e.g.: `/ora8/oradata/ifidb/system01.dbf`

- Alternatively, Oracle can store the data on raw devices (direct disk access, not via the OS): Better performance, but more complicated administration.

- The files can only be processed by Oracle (no standard format, the format is also not documented).

  Every DBMS vendor tries to beat the other vendors in performance benchmarks. Therefore, each vendor uses its own data structures.

Oracle Files: Data Files (2)

- 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 relationship between tables and data files is many to many (via tablespaces):

Oracle Files: Data Files (3)

- The data is not encrypted:
  - Persons who can access the data files can circumvent the Oracle access control.
  - OS access rights must be used so that only the DBA can access the data files.
- Data files can be autoextensible or have fixed size.

  In order to avoid fragmentation, data files are normally made large when they are created (the DBA can specify any size). Then Oracle manages the free space within them. If Oracle should ever run out of space, it can request more space from the operating system (make the file bigger) if the file was declared as autoextensible.

Oracle Files: Data Files (4)

- 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: File ID used in ROWIDs.
  - AUTOEXTENSIBLE: Oracle can make the file larger.
  - MAXBYTES, MAXBLOCKS: Limit for autoextension.
  - INCREMENT_BY: Step size for autoextension.

Oracle Files: Tempfiles (1)

- When large tables/query results must be sorted, Oracle needs temporary space on the disk.

  Small sorts are done in main memory.

- This is allocated in temporary segments.

  Temporary segments are also used for temporary tables.

- At the beginning, temporary segments were allocated in normal tablespaces, then Oracle introduced temporary tablespaces, and finally (8i) temporary datafiles (tempfiles) for temporary tablespaces.

Oracle Files: Tempfiles (2)

- Each variant of temporary data management is more efficient than the previous one, but all old variants are still supported.
- No backup copies of tempfiles are ever needed.

  Remember that the correctness of all information in this course is not guaranteed. You cannot sue me or my university for errors.
- Tempfiles are listed in
  - `DBA_TEMP_FILES`
  - `V$TEMPFILE`.
- Tempfiles typically have the extension "`.tmp`".

Oracle Files: Control Files (1)

- 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`.

- The control file contains also backup and recovery information.

- For safety reasons, there should normally be more than one control file (on different disks).

  If all copies of the controlfile are lost, the DBA is in big trouble.

Oracle Files: Control Files (2)

- V$CONTROLFILE: List of control files. Columns are:
  - STATUS: Normally null. Can be INVALID.
  - NAME: Path and name of the control file.
- Information from the control file is shown in, e.g.:
  - V$DATAFILE,
  - V$DATABASE,
  - V$LOG,
  - V$LOG_HISTORY.

Oracle Files: Redo Log (1)

- When data file blocks are updated, they are not immediately written back to the disk.

  A block is the unit of exchange between disk and main memory: E.g., the system reads and writes always 8 KB. For performance reasons, disk blocks from the data files are kept for some time in a main memory buffer, even when they were modified (delayed/lazy writing).

- However, all changes to the data files are logged in the redo log files.

  It is faster to write only the new/modified data to a sequential log file than to write all parts of the data files that are affected by the change. Sooner or later the data file must be written, but this can happen in the background when there is time. It is possible that the same block is changed several times before to is written to the disk.

Oracle Files: Redo Log (2)

- The redo log files 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`

- Since the redo log files are so important for recovery, one usually has two copies of every log file.

  Of course, they should be on different disks.

- The log files that are copies of each other are called a log file group.

  Oracle automatically writes the same information to all files in a log file group. In contrast, Oracle does not manage copies of data files.

Oracle Files: Redo Log (3)

- When the changes that are documented in the log file are reflected in the data files it can be overwritten with new changes.

  However, if one wants to be protected against loss of data files (e.g., because of a disk failure), one needs to keep all redo log files since the last backup of the data files. This is done by copying redo log files to an "archive destination" (a tape or a slower disk) before they are overwritten. If Oracle is put into "`ARCHIVELOG`" mode (this is not the default), it automatically ensures that the redo log files are archived before they are overwritten. In order to distinguish the main redo log files from their archived copies, they are called the "online log". More information will be given later (Backup&Recovery).

Oracle Files: Redo Log (4)

- 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.

  Every Oracle instance needs at least two log files.

Oracle Files: Redo Log (5)

- 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.

    It can be also be INVALID (file is inaccessible), STALE (file contens are incomplete), DELETED (file is no longer used).
  - MEMBER: File name of the log file.
- V$LOG contains information about the log file groups and their contents.

  Columns: GROUP#, THREAD#, SEQUENCE#, BYTES, MEMBERS, ARCHIVED, STATUS, FIRST_CHANGE#, FIRST_TIME.

Oracle Files: Parameters (1)

- When Oracle is started, it reads an initialization parameter file.

  Windows e.g.: `C:\Oracle\Admin\orcl\pfile\init.ora`

  UNIX e.g.: `/ora8/product/8.1.6/admin/ifidb/pfile/initifi.ora`

  Note that it might point to/include another file (`PFILE=...`).

- It contains the settings of important tuning parameters, as well as the location of the control files.

- Traditionally, the initialization parameter file was a standard ASCII file that could be viewed and modified with any text editor.

Oracle Files: Parameters (2)

- Beginning with Oracle 9i, "Server Parameter Files" are used that are binary files and can be changed only by Oracle.

  Traditional text files are still supported and it is possible to map in both directions with `CREATE SPFILE` and `CREATE PFILE`. Parameters are changed with `ALTER SYSTEM` (some also with `ALTER SESSION`). The advantage of server parameter files is that Oracle can automatically modify them for `ALTER SYSTEM` commands.

- Some parameters can be set only when the DBMS starts up, other parameters can be modified while the DBMS is running, and some parameters can be set separately for each user session.

Oracle Files: Parameters (3)

- V$PARAMETER: Settings of the initialization parameters that are in effect for the current session.

  Columns: NUM, NAME, TYPE, VALUE, ISDEFAULT, ISSES_MODIFIABLE (i.e. this parameter can be set separately for each session), ISSYS_MODIFIABLE (i.e. this parameter can be modified while the DBMS is running), ISMODIFIED, ISADJUSTED, DESCRIPTION, UPDATE_COMMENT. There is also a view V$PARAMTER2 that displays list-valued parameters differently (one row per list element), and V$SYSTEM_PARAMETER/...2 that contain the global values (inherited by each session when it starts).

- E.g. location of the control files:

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

- SQL*Plus has a command SHOW PARAMETER *X*.

Oracle Files: ALERT File (1)

- The alert file of the DB contains 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,

    For instance, adding files to the database.
  - errors.

    E.g., the archive log disk is full, therefore soon no more updates will be possible (when the online log files are used up).

Oracle Files: ALERT File (2)

- The DBA should carefully monitor the alert file.

  Windows, e.g.: `C:\Oracle\Admin\orcl\Bdump\orclALRT.log`
  UNIX, e.g.: `/ora8/product/8.1.6/admin/ifidb/bdump/alert_ifi.log`

- Some DBAs always have a window open that shows the last lines of the alert file.

  Of course, the Oracle Enterprise Manager also has a window that shows the current status of the database. One can also specify that when certain events happen, an email or SMS is automatically sent.

- In addition, each Oracle process has a trace file.

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

Inhalt

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" or "Shared Global Area").
- This server part is called an Oracle instance.

  Normally, an instance is synonymous to database. But with "Oracle real application clusters" it is also possible that several instances (using different CPUs) access the same database. Of course, it is possible to have several Oracle instances running on the same machine (managing different databases).

Oracle Architecture (2)

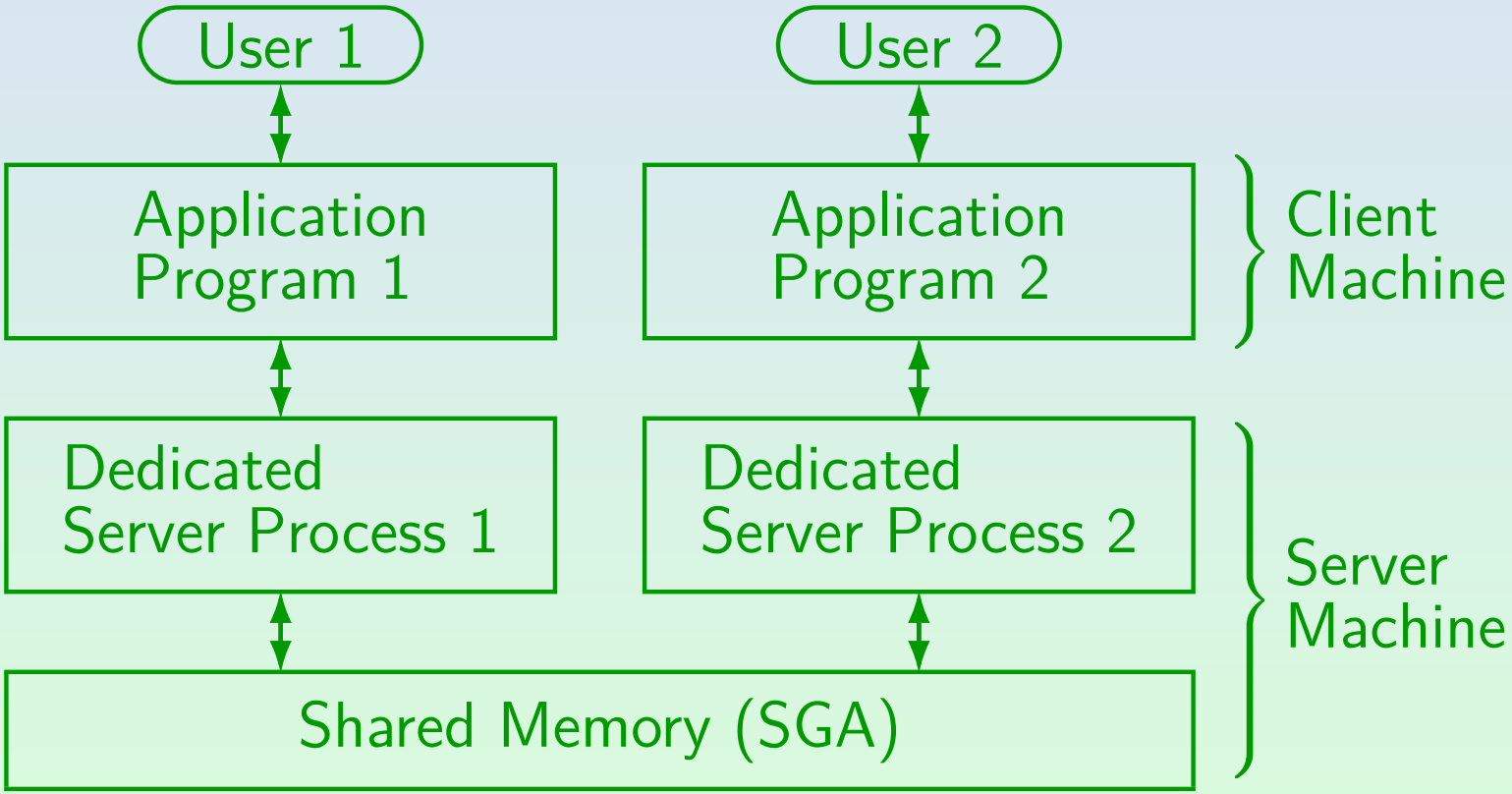
- Oracle supports two architectural variants:
  - Dedicated server architecture: One server process per client (classical/old architecture).

    The process is started when the client connects to Oracle and terminated when it logs off. Problem: The process is idle most of the time, but still binds resources (memory).
  - Multithreaded server architecture (MTS): There is a pool of server processes and a dispatcher which sends client requests to one of the servers.

    This is advantageous when a large number of concurrent clients must be served.

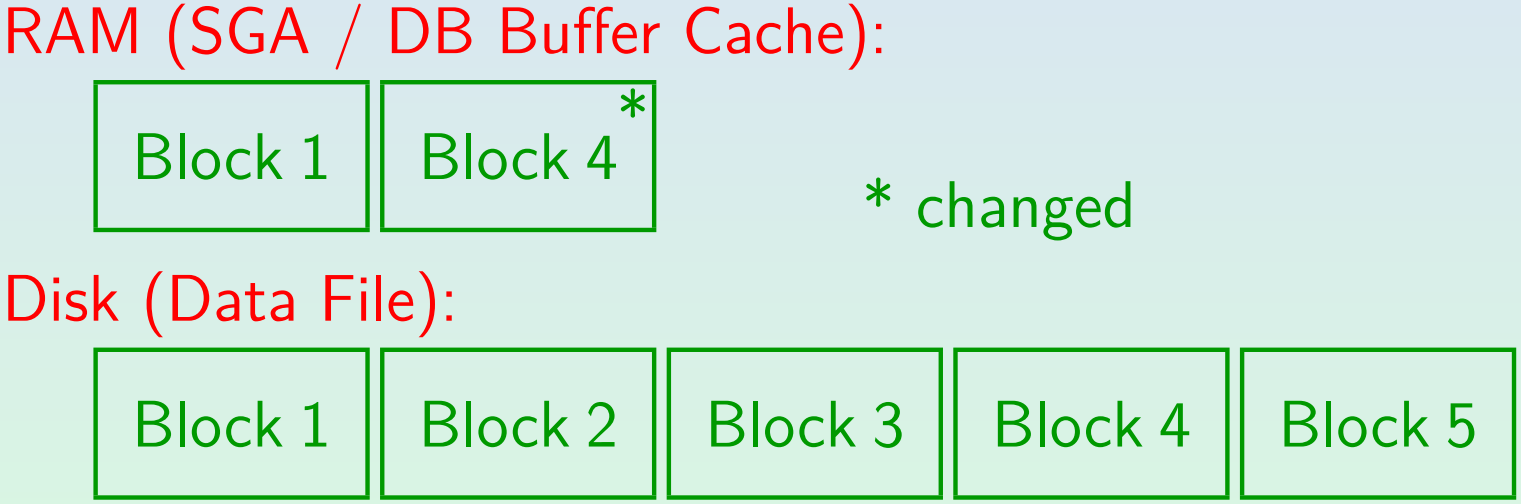
Oracle Architecture (3)

Dedicated Server Architecture:



Oracle Architecture (4)

- Part of the SGA is the DB 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 smaller (and volatile).

Oracle Architecture (5)

- 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, of course.
- If not, the server process allocates a free buffer 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 in Chapter 3.

Oracle Architecture (6)

- Even if the server process changes the block in the buffer, it does not write the block back to the disk.
- The "DB writer" background processes (DBW0, DBW1, ...) save changed blocks from the DB buffer cache 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.
- Oracle uses a set of 5 or more background processes (besides the server processes).

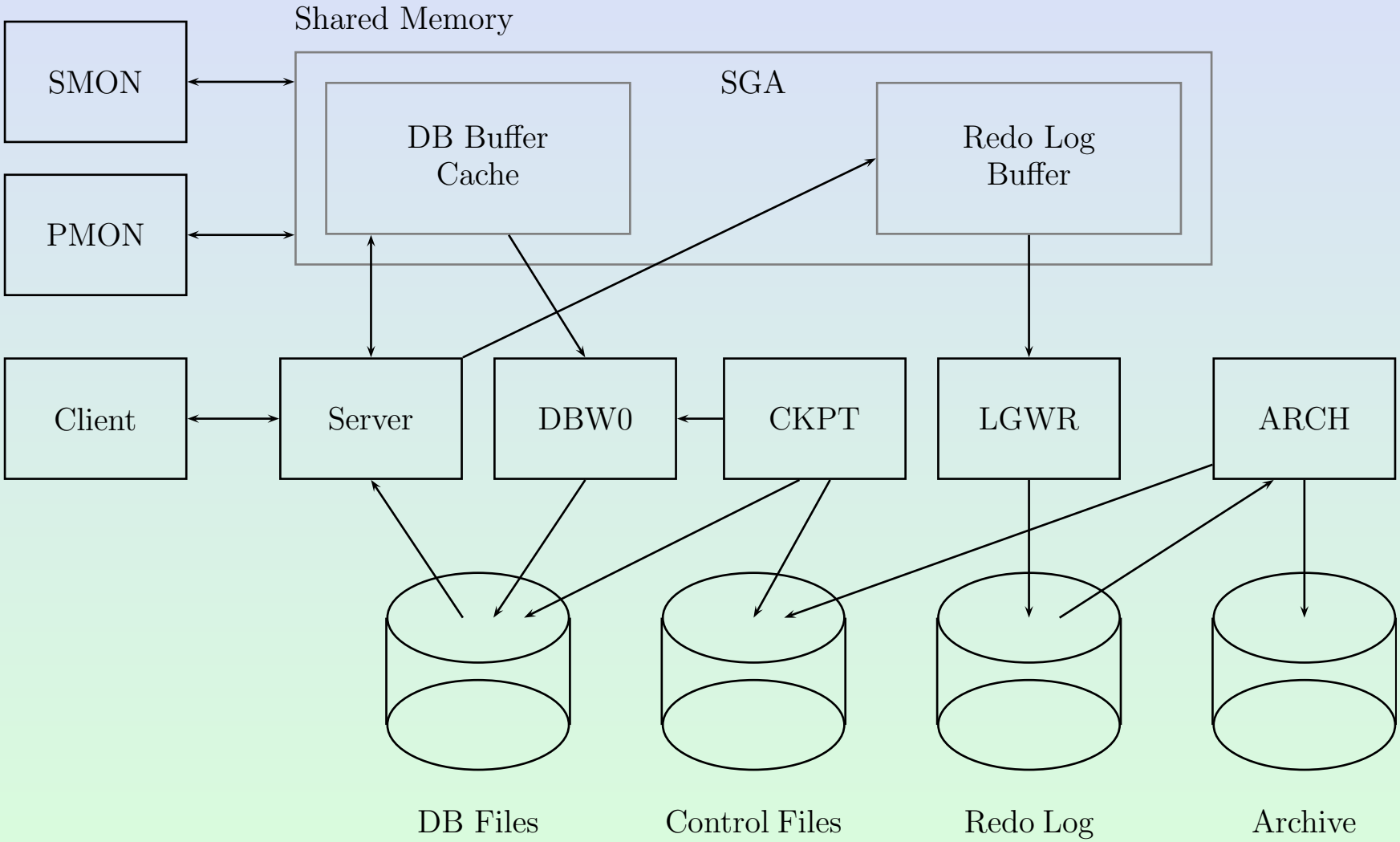
Oracle Architecture (7)

- 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 (8)



Oracle Architecture (9)

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 (10)

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 (11)

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 (12)

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 (13)

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.
  - the "row cache" (for data dictionary entries).

    It seems that caching single rows is more efficient for the data dictionary than caching entire blocks.
  - the library cache.

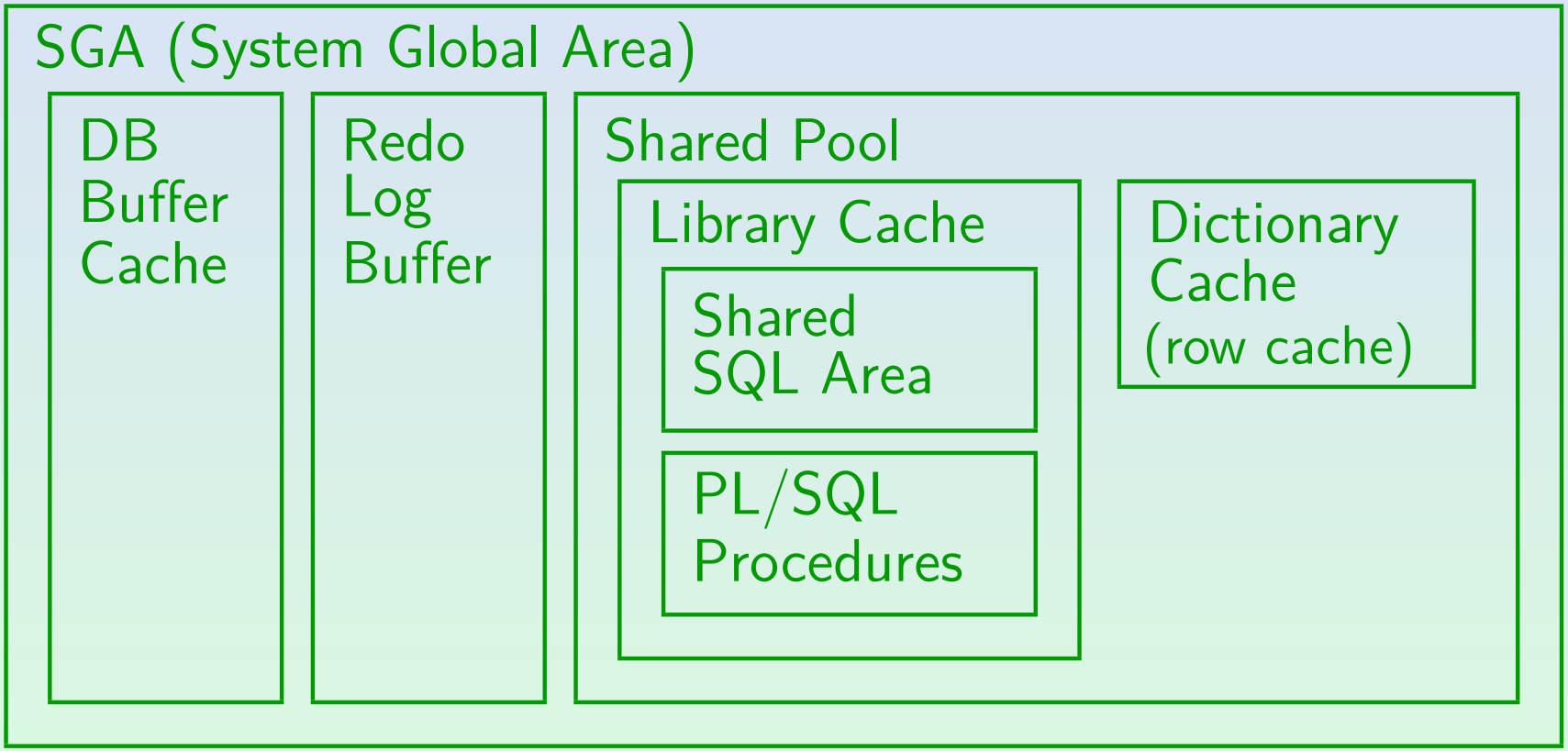
Oracle Architecture (14)

Memory Structures, continued:

- The library cache contains e.g.
  - the Shared SQL Area (here recently executed SQL statements together with the query evaluation plans are stored).

    This is a cache for query evaluation plans: If the same SQL statement (e.g., from an application program) is executed again and again (possibly with different parameter values), the (relatively expensive) query optimization does not have to be repeated.
  - Stored procedures/packages in compiled form.

Oracle Architecture (15)



Oracle Architecture (16)

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, ...)
  - 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.

Oracle Architecture (17)

Remark about Multithreaded Server:

- In the multithreaded server configuration, the private SQL areas are allocated in the SGA (in the shared pool).

  That means the size of the SGA must be increased when changing from the dedicated server configuration to the multithreaded server configuartion.

Oracle Architecture (18)

Related Information in the Data Dictionary:

- V$PROCESS: List of the Oracle processes.
- V$BGPROCESS: Description of background processes.
- V$BUFFER_POOL: Size of DB buffer cache.

  Oracle can have different "buffer pools" with different replacement strategies. "BUFFERS" is the number of buffer frames. The buffer pools can be segmented into multiple sets for multiprocessor systems. Buffering is explained in more detail in the next chapter.

Oracle Architecture (19)

Related Information in the Data Dictionary, continued:

- V$RESOURCE_LIMIT: Sizes of some arrays in the SGA.

  E.g. the SGA contains 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.

  E.g. it contains the size of the DB buffer pool in bytes.

- V$SGASTAT: Detailed information about the size of memory structures, listing components of the shared pool individually.

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, query evaluation plans, etc.
- DB_FILE_MULTIBLOCK_READ_COUNT: Number of blocks that are read in one OS call during full table scans.
- There are more than 200 such parameters.

Inhalt

Controlling Oracle (1)

- The DB server can be running (i.e. executing queries and updates) or not running (shut down).

  There are also several intermediate/restricted states, which are necessary for DB creation or recovery, or certain administrative operations.

- One of the tasks of the DBA is to control the availability of the database.

- For adminitrative operations (such as DB startup), the DBA should log into Oracle as follows:

```
UNIX> sqlplus /nolog
SQL> CONNECT SYS AS SYSDBA
```

Controlling Oracle (2)

- "`/nolog`" means that no connection to a database is opened (e.g. when the database is not yet started).

  This might not be necessary, since when one logs in "`AS SYSDBA`", one gets only a warning when the database is not yet started.

- "`AS SYSDBA`" gives special administrative rights, e.g. the right to startup the database or shut it down.

  "`SYSDBA`" is a system privilege in Oracle, but it is can also be viewed as a special type of connection to the database. In other words, it is a privilege that must be explicitly activated. While `SYS` can only log in `AS SYSDBA`, other users who were granted the `SYSDBA` right can choose whether they log in `AS SYSDBA` or as a normal user. There is also a weaker right called `SYSOPER`, which permits to start up or shut down the database, but does not permit to view all data in the database.

Controlling Oracle (3)

- As long as the DBMS does not run, the passwords for SYS etc. stored in the DB 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 start/stop the DB.
  - 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 (4)

- The password file is e.g. stored in (OS dependent):

  ```
  C:\orawin95\database\pwdorcl.ora
  $ORACLE_HOME/dbs/orapw$ORACLE_SID
  ```

- The program "orapwd" creates the password file:

  ```
  orapwd FILE=orapworcl PASSWORD=nina ENTRIES=5
  ```

- PASSWORD is the initial password for SYS.
- ENTRIES is the maximal number of users with SYSDBA or SYSOPER rights (i.e. with passwords in this file).

  The file has a fixed size. Whenever a user is granted SYSDBA or SYSOPER, an entry in the password file is created.

Controlling Oracle (5)

- If one forgot the password: Delete or rename the password file and recreate it.

  The DB must be restarted. Afterwords one can log in `AS SYSDBA` and change the password in the DB (the two `SYS` passwords do not agree).

- A password file is used if the initialization parameter `REMOTE_LOGIN_PASSWORD_FILE` is set to `EXCLUSIVE`.

  It is `NONE` by default which means OS authentication.

- On Windows, a DBA 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.

Controlling Oracle (6)

- All users who connect `AS SYSDBA` are mapped to `SYS` when they access the DB.

  It might be a surprise that one's own tables are not available when one works in this mode. Users who work `AS SYSOPER` are mapped to `PUBLIC`.

- The DBA usually works while logged into the server machine.

  Of course, he/she can use `ssh` to log into the server from somewhere else. It is possible to do administration remotely (with SQL*Plus running on the client), but normally the network connection is not very secure. Also, unless one uses the new server parameter files, a copy of the initialization parameter file must be available on the client.

Starting Oracle (1)

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

    The parameter file is read, the SGA is allocated, the background processes are started. In this state a new DB 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 datafiles and log files are open, and the database is available for normal operations.

Starting Oracle (2)

- The commands for starting Oracle in one of the above 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.
- `STARTUP RESTRICT` opens the database, but allows only users with the `RESTRICTED SESSION` privilege to connect (e.g. only DBAs).

Starting Oracle (3)

- One can explicitly specify the parameter file and/or the DB name:

```
STARTUP OPEN ifi PFILE=initifi.ora
```

  The default `PFILE` is `$ORACLE_HOME/dbs/init$ORACLE_SID.ora` on UNIX, and `%ORACLE_HOME%\database\initORCL.ora` on Windows. However, in starting in Oracle 9i, the default is to use a server parameter file. If one uses a traditional text parameter file, one must specify `PFILE=...`.

- A database in mounted state can be made available for users with

```
ALTER DATABASE OPEN
```

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 are logged in) are listed in `V$SESSION`. Columns are, e.g.:
  - `SADDR`: Memory address of session data in DBMS.
  - `SID`: Session identifier.
  - `SERIAL#`: Serial number of the session.

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

Killing Sessions (2)

- Before the DBA shuts down the system or kills a session, he/she might check whether transactions are currently running.

  A transaction is started at the first `INSERT`/`UPDATE`/`DELETE` and ends with `ROLLBACK` or `COMMIT`. I.e. if the session should be killed, changes are rolled back (a user will have to enter data again).

- `V$TRANSACTION` lists the currently active transactions. Attributes are, e.g.,:
  - `SES_ADDR`: Memory address of the session data.
  - `START_TIME`: Time when the transaction started.

Killing Sessions (3)

- Exercise: Write a query to list the users who have currently active transactions.
- V$TRANSACTION_ENQUEUE lists the locks hold by transactions.

  One attribute is the SID of the session that holds the lock. CTIME is the time since the transaction holds the lock (in seconds). BLOCK is 1 if another transaction waits for the lock. V$LOCK lists all locks and lock requests (including system locks: The list is quite long).

- The DBA can kill a session with the command:

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

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

References

- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems, 3rd Ed. Chapter 17: "Database System Architectures and the System Catalog", Chapter 10: "Examples of Relational Database Management Systems: Oracle and Microsoft Access"
- Michael J. Corey, Michael Abbey, Daniel J. Dechichio, Ian Abramson: Oracle8 Tuning. Osborne/ORACLE Press, 1998, ISBN 0-07-882390-0, 608 pages, ca. $44.99.
- Jason S. Couchman: Oracle8i Certified Professional: DBA Certification Exam Guide with CDROM. Osborne/ORACLE Press, ISBN 0-07-213060-1, ca. 1257 pages, ca. $99.99.
- Mark Gurry, Peter Corrigan: Oracle Performance Tuning, 2nd Edition (with disk). O'Reilly & Asociates, December 1996, ISBN 1565922379, 964 pages.
- Oracle 8i Concepts, Release 2 (8.1.6), Oracle Corporation, 1999, Part No. A76965-01.
- Oracle 8i Administrator's Guide, Release 2 (8.1.6), Oracle Corporation, 1999, Part No. A76956-01.
- Oracle 8i Designing and Tuning for Performance, Release 2 (8.1.6), Oracle Corporation, 1999, Part No. A76992-01.