DBA 9i Performance Tuning

1 – Performance Tuning Overview

- **There are 2 basic approaches to Performance Tuning:**

  1. For systems in design and development, Oracle recommends the ***Top Down Tuning Approach*** – Tune the system by this order: Data design, Application design, Memory allocation, I/O and physical structure, Contention & O/S (Operating System)
  2. For systems in production, Oracle recommends the use of ***Performance Tuning Principals*** – Tune the System in this order:

  a) Define the problem
  b) Examine host system and gather Oracle statistics
  c) Use the statistics gathered to identify the problems and suggest ways to correct the problem
  d) Implement changes needed
  e) Determine whether the objectives have been met. If not, repeat steps 4 and 5.

  Common Problems causing performance problems are poorly written SQL statements, inefficient SQL execution plans, SGA not sized correctly, excessive file I/O, and waits for database resources.
  Two tuning guidelines are: **Add More** – add resources to system such as CPU, memory, disks etc. and **Make Bigger** - resize memory structures, allocate space on disks, etc.

2 – Sources of Tuning Information

- **Oracle** supplies several sources for gathering tuning information:

  1) Alert Log – the Oracle alert log gives a quick indication whether problems exist in the database. Usually, it will indicate problems like table, Rollback Segment and Temporary segments extend problems, MAXEXTENTS limit reached, Checkpoint not complete, Snapshot too old and redo log sequence changes. The alert log contains Oracle internal errors (ORA-600) and backup and recovery information. The alert log resides in the BACKGROUND_DUMP_DEST directory
  2) Background, Event and User trace files – the Oracle background processes (PMON, SMON, DBW0, LGWR, CKPT and ARC0) will produce trace files in case of error. They reside in the BACKGROUND_DUMP_DEST directory. Event trace files come from settings trace on specific database events using the ***EVENT=*** parameter in the init.ora file. The event trace files are placed in the BACKGROUND_DUMP_DEST.
  User trace files come from placing specific sessions under trace. These is done at instance level by setting the SQL_TRACE=TRUE parameter in the init.ora file and at session level by using ALTER SESSION SET SQL_TRACE=TRUE or by executing the SYS.DBMS_SYSTEM.SET_SQL_TRACE_IN_SESSION procedure. The user trace files reside in the USER_DUMP_DEST directory and can be interpreted using ***tkprof*** utility
  3) Performance Tuning Views – There are approximately 255 V$ views, based on the X$ tables, which reside mainly in memory. Some of the V$ views are:
  V$SGASTAT – shows information about the System Global Area Components
  V$EVENT_NAME – shows a list of database events. There are approximately 200 wait events
  V$SYSTEM_EVENT – shows wait event for all sessions
  V$SESSION_ EVENT – shows wait event for each session
  V$SESSION_WAIT = shows current wait events in each session
  V$STATNAME – shows name of statistics (gathered in V$SYSSTAT & V$SESSTAT)
  V$SYSSTAT – shows overall system statistics for all sessions (since instance startup)
  V$SESSTAT – shows statistics per session
  V$WAITSTAT – shows statistics related to block contention
  4) DBA Views – There are approximately 170 DBA views, based on oracle base tables. These views provide statistics and information to help the DBA perform the tuning operations:
  DBA_TABLES – show table storage, row and block information
  DBA_INDEXES – show index storage, row and block information
  INDEX_STATS = show index depth and dispersion information
  DBA_DATA_FILES – show datafile location, name and size information
  DBA_SEGMENTS – show general information about any space consuming segment in the database

DBA_HISTOGRAMS – show table and index histogram definition information

5) Oracle-Supplied Tuning Utilities – Oracle supplies several tuning utilities:

UTLBSTAT.SQL/UTLESTAT.SQL – capture information between two points in time, compute the activity and produce a report. In order to rum UTLBSTAT/ESTAT, execute the UTLBSTAT.SQL first (stand for beginning). This script will create some tables to store the data in. Wait a period of time (generally, the duration should be at least 15 minutes), and then run the UTLESTAT.SQL. The script will create some tables and populate them with data. The UTLESTAT.SQL script will product a report called REPORT.TXT.

STATSPACK – is and improved version of the UTLBSTAT/ESTAT. The difference between the two is that UTLBSTAT/ESTAT measures the performance only between 2 points in time, where STATSPACK keeps the information for each time it was executed. In order to run STATSPACK, simply execute the $ORACLE_HOME/rdbms/admin/spcreate.sql script, which creates the STATSPACK user called PERFSTAT, its tables and packages (must be connected with SYSDBA privileges). Next, collect statistics using the STATSPACK.SNAP procedure. For each snap, a unique id is created. In order to compare performance between snaps, execute the $ORACLE_HOME/rdbms/admin/spreport.sql script. The script enables the DBA to view statistics between any 2 point in time. In order to automate procedures, the DBA can run the $ORACLE_HOME/rdbms/admin/spauto.sql script, which will create a job that executes the snap procedure.

UTLLOCKT.SQL – show lock wait-for information

CATPARR.SQL – show Parallel-Server specific views for performance queries (replace by catclust.sql in Oracle 9i)

DBMSPOOL.SQL – show information about the shared pool

UTLCHAIN.SQL – show chaining and migration information

UTLXPLAN.SQL – create the PLAN_TABLE for SQL Statement Tuning

6) Graphical Performance Tuning Tools – Oracle provides several performance tuning tools:

OEM (Oracle Enterprise Manager) – includes several tools that help the DBA to monitor, and manage the database graphically. OEM provides some tools like *Instance Manager* (for starting and stopping the instance and manage oracle instances), *Schema Manager* (create and manage database objects), *Security Manager* (create and manage oracle users, privileges and roles), *Storage Manager* (create and manage tablespaces and datafiles), *Replication Manager* (manage oracle replication and snapshots) and *Workspace Manager* (allow changes to be made to data in database).

Oracle Diagnostic Pack – is made of several tools designed to help identify, diagnose and repair problems in the database: *Capacity Planner* (estimate future system requirements based on current workload), *Performance Manager* (present real-time performance information), *TopSessions* (monitor user session activities), *Trace Data Viewer* (Tool for viewing trace files), *Lock Monitor* (monitor locking information for connected sessions), *Top SQL* (identify top SQL statements that are being executed and their resource consumption) & *Performance Overview* (Summary screen for overall performance)

Oracle Tuning Pack – designed to assist with database performance tuning issues. The Tuning pack is made up of *Oracle Expert* (Wizard-based database tuning tool), *SQL Analyze* (analyze and rewrite SQL statements to improve their performance), *Index Tuning Wizard* (identify index usage and performance), *Outline Management* (manage stored outlines), *Reorg Wizard* (assist with table and index reorganization) & *Tablespace Map* (show extents for each segment graphically).

3 – SQL Application Tuning and Design

- **There are several commonly used tools** for SQL application tuning. One of them is ***tkprof*** (trace kernel profile).

  TKPROF: is used to format trace files, generated by user sessions. Tkprof has several options like ***EXPLAIN*** – generate explain plan for each statement using the PLAN_TABLE, ***TABLE*** – store the explain plan is specified table, ***SYS*** – include SQL statements issued by user SYS, ***SORT*** – determine the order of the output, ***RECORD*** – specify the destination file name for SQL Statements, ***INSERT*** – create a SQL script, which will create the TKPROF_TABLE table and insert values into it, ***AGGREGATE*** – whether to gather statistics from several issuers or independently, ***WAITS*** – display wait statistics for executed

SQL statements.
Tkprof sorting options include sort in one of three phases:
PARSE: PRSCNT (parse count), PRSCPU (parse CPU time), PRSELA (parse elapsed time), PRSDSK (number of disk reads during parse), PRSMIS (number of misses during parse), PRSCU – number of data buffers found in SGA during parse & PRSQRY – number of rollback buffers read from the SGA during parse.
EXECUTE: EXECNT (number of executions), EXECPU (CPU time for each execution), EXEELA (execution elapsed time), EXEDSK (number of disk reads during execute), EXEMIS (number of misses during execute), EXEROW – number of rows processed, EXECU – number of data buffers found in SGA during execute & EXEQRY – number of rollback buffers read from the SGA during execute.
FETCH: FCHCNT (number of fetch), FCHCPU (CPU time for each fetch), FCHELA (Fetch elapsed time), FCHDSK (number of disk reads during Fetch), FCHROW – number of rows processed, FCHCU – number of data buffers found in SGA during fetch & FCHQRY – number of rollback buffers read from the SGA during fetch.
TKPROF output description include ***Count*** – the number of times the parse, execute or fetch phase occurred, ***CPU*** – total number of seconds the CPU spent processing all parse, execute or fetch phase calls for executed statement, ***Elapsed*** - total number of seconds spent processing all parse, execute or fetch phase calls for executed statement, ***Disk*** – total number of data block reads from disk during parse, execute or fetch calls for executed statement, ***Query*** – total number of rollback blocks read from SGA during parse, execute or fetch phase for executed statement, ***Current*** – total number of data blocks read from SGA during parse, execute or fetch phase for executed statement & ***Rows*** – total number of rows affected by the EXECUTE phase for DELETE, INSERT and UPDATE statements or by the FETCH phase for SELECT statements.
Generating Explain Plans – once a poorly performing SQL has been identified, you can use the EXPLAIN PLAN FOR command to generate explain plan for the statement. In order to create the PLAN_TABLE, simply run the $ORACLE_HOME/rdbms/admin/utlxplan.sql script. Next, use the EXPLAIN PLAN FOR statement and select data from PLAN_TABLE to see the statement’s execution plan. Oracle provides built-in script to query the PLAN_TABLE (utlxpls.sql & utlxplp.sql (includes parallel query options)).
Interpreting Explain Plans Output:
INDEX UNIQUE SCAN – table was searched using unique index.
TABLE ACCESS BY INDEX ROWID – table was searched using index by rowid.
TABLE ACCESS FULL – Full table scan occurred.
INDEX RANGE SCAN - table range search using an index (SQL had a '>', '<' or between operators).
NESTED LOOPS – results from first query are compared to second query.
The AUTOTRACE utility – the AUTOTRACE utility combines the elements from the tkprof and the EXPLAIN PLAN FOR utilities. The AUTOTRACE is set at the session level and requires some preparations in order to run. First, the current user must have the PLAN_TABLE in its schema; second, the connected user must have the PLUSTRACE role (created using the $ORACLE_HOME/sqlplus/admin/plustrce.sql script).
From now on, the user can activate the AUTOTRACE (using SET AUTOTRACE [option]) in 6 modes:
ON – display query results, execution plans and statistics
ON STAT[ISTICS] - display query results and statistics only
ON EXP[LAIN] - display query results and execution plans only
TRACE[ONLY] – display execution plans and statistics only
TRACE[ONLY] STAT[ISTICS] - display statistics only
OFF – turn off the AUTOTRACE
SQL Tuning Information in STATSPACK – in addition to TKPROF, EXPLAIN PLAN, and AUTOTRACE, output from the STATSPACK contain useful SQL statement tuning information. STATSPACK output file contains SQL order by gets, reads, executions and parse calls.
Rule-Based Optimization – the RBO (Rule-Based Optimizer), uses a set of predefined rules, to decide how to access data in tables. These rules include '*if an indexed column appears in a where clause, always use the index*'. RBO is not aware of table size and column cardinality (the variation of data in a column), thus making it less useful for small tables or columns that contain low cardinality.

Cost-Based Optimization – unlike the RBO, the CBO (Cost-Based Optimizer), considers many different execution plans and selects the best one. In previous versions of Oracle database, the CBO computed the cost primarily considering the logical I/O, whereas in Oracle 9i, the CBO considers memory, disk (for sorting operations) and CPU resources as well. When performing an EXPLAIN PLAN using the CBO, there are several columns that reflect the CBO decisions: *IO_COST* – the estimated cost in terms of I/O, *CPU_COST* - the estimated cost terms of CPU cycles & *TEMP_SPACE* – the estimated temporary space in bytes. The CBO relies on table and index statistics: table/index size, number of rows in table/index, number of database blocks used by table/index, average table row length, indexed column cardinality etc. In order to collect statistics use the ANALYZE TABLE/INDEX COMPUTE/ESTIMATE STATISTICS command. When using COMPUTE, the command gathers full table/index statistics. When using ESTIMATE, a SAMPLE or SIZE values must be given in rows or percent (default 1064 rows). The SIZE parameter indicates how many buckets to divide the column data cardinality.
Using the FOR clause in ANALYZE command guides the Oracle server how to collect statistics:
FOR TABLE – gather only table statistics (without column statistics)
FOR COLUMNS - gather column statistics only for specified columns
FOR ALL COLUMNS - gather column statistics only, for all columns
FOR ALL INDEXES – gather table's index statistics (without table statistics)
FOR ALL INDEXED COLUMNS - gather column statistics only for columns that are indexed
FOR ALL LOCAL INDEXES – gather column statistics on all local indexes of a partitioned table
Running the ANALYZE command creates ***histograms***. The CBO relies heavily on histograms when making choices for execution plan.
Oracle provides 2 more efficient ways to analyze table/index/schema/database:
DBMS_UTILITY – a package that contains several analyze procedures in instance, database, schema and partitioned object levels. Some procedures include ANALYZE_SCHEMA, ANALYZE_DATABASE etc…
DBMS_STATS – a package that contains numerous procedures and functions to analyze, store, import and export statistics in the database for all levels. Some procedures include GATHER_TABLE_STATS, EXPORT_SCHEMA_STATS, IMPORT_COLUMN_STATS, SET_INDEX_STATS etc…
In order to copy statistics from one database to another, follow these steps:
On the First Database
1. Create a stat table to hold the stats using DBMS_STATS.CREATE_STAT_TABLE
2. Populate new stat table with statistics using EXPORT_SCHEMA_STATS procedure
3. Export data in stat table using the exp utility.

On the Second Database
1. Create a stat table to hold the stats using DBMS_STATS.CREATE_STAT_TABLE
2. Import data into stat table using the imp utility
3. Populate schema statistics using the DBMS_STATS.IMPORT_SCHEMA_STATS procedure

The GATHER_SCHEMA_STATS procedure is useful for maintaining accurate statistics for the CBO. Using the GATHER option, you can specify 3 ways to gather statistics: *GATHER STALE* – gather statistics for tables that are monitored (ALTER TABLE … MONITORING), *GATHER EMPTY* – gather statistics for tables that have not been analyzed yet & *GATHER AUTO* – gather statistics based on application activity.
System statistics can be gathered using the GATHER_SYSTEM_STATS procedure (job_queue_processes value must be larger than 0).
Oracle Enterprise Manager, also gives the ability to gather statistics using the Tools➔Database Wizard➔Analyze.
Table and index statistics are stored in the DBA/ALL/USER_TABLES and DBA/ALL/USER_INDEXES.
The XXX_TABLES views contain some interesting columns such as NUM_ROWS (number of rows in table), BLOCKS (number of blocks below HWM[1]), EMPTY_BLOCKS (empty blocks above HWM), AVG_SPAGE (average available free space in table), CHAIN_CNT (chaining and migration information), AVG_ROW_LEN (average length in bytes used by row data), AVG_SPACE_FREELIST_BLOCKS (average length in bytes of the blocks

[1] HWM – High Water Mark

in table's free list), NUM_FREELIST_BLOCKS (number of blocks in table's free list), SAMPLE_SIZE (last analyze sample size) & LAST_ANALYZED (date of last analyze).
The XXX_INDEXES views contain some interesting columns such as BLEVEL (number of levels in index), LEAF_BLOCKS (number of leaf blocks in index), AVG_LEAF_BLOCK_PER_KEY (average number of leaf blocks used for each distinct key value in index), AVG_DATA_BLOCK_PER_KEY (average number of data blocks used for each distinct key value in index), CLUSTERING_FACTOR (how ordered the data is in the index's underlying table), NUM_ROWS, SAMPLE_SIZE & LAST_ANALYZED same as XXX_TABLES.
The value of CLUSTERING_FACTOR is used by the CBO to estimate logical I/O.
Additional views that store statistics are DBA_TAB_COL_STATISTICS, which holds column statistics like NUM_DISTINCT (number of distinct column values), LOW_VALUE & HIGH_VALUE, DENSITY (how dense the column data is, calculate by 1/NUM_DISTINCT), NUM_NULLS (number of NULL values in column), NUM_BUCKETS (number of 'slices' the data was divided to when analyzed), AVG_COL_LEN (average column length in bytes), USER_STATS (indicates statistics generated by user), GLOBAL_STATS (indicates statistics generated using partitioned data), SAMPLE_SIZE & LAST_ANALYZED.
Setting Optimizer Mode –the optimizer mode can be set at 3 levels:
Instance level – setting the OPTIMIZER_MODE parameter at the init.ora file to:
RULE – sets the RBO as current optimizer.
CHOOSE – CBO will be used only if statistics were gathered for the tables used in the query, if not the RBO will be used
FIRST_ROWS – like the CHOOSE option, only a variation of the CBO will be used that was designed to return the first rows fetched by a query as quickly as possible.
FIRST_ROWS_n – like FIRST_ROWS option. Specify number of first rows to be fetched (1,10,100,1000)
ALL_ROWS - like the CHOOSE option, only a variation of the CBO will be used that was designed to return all the rows fetched by a query as quickly as possible.
Session level – using the ALTER SESION SET OPTIMIZER_MODE = <option>
Statement level – by using hints in the SQL statements. There are several hints that can places in the statement: RULE, INDEX followed by the index name, REWRITE – force the optimizer to rewrite the query to make use of materialized view & PARALLEL – cause the execution in parallel mode.
All hints must be placed in this manner SELECT /*+ HINT */ …
The default optimizer mode is CHOOSE, but the statement level overrides the session level, which overrides the instance level.
Plan Stability – In order to improve SQL execution plan, Oracle 9i provides the ability to store the execution plan in a **stored outline**. A stored outline is a collection of hints that produce the required execution plan each time for a specific SQL statement. In order to use this feature, the CREATE_STORED_OUTLINES parameter must be set to TRUE in the init.ora file. Next, at instance or session level set the USE_STORED_OUTLINES=TRUE parameter. Now, create the outline for a specific SQL statement:

```
CREATE OR REPLACE OUTLINE EMP_MGR_OUTLINE
FOR CATEGORY EMP_QUERIES ON
SELECT LAST_NAME FROM EMPLOYEE
WHERE JOB_TITLE = 'MGR';
```

In order to activate the stored outline, simply use ALTER SESSION SET USE_STORED_OUTLINES=TRUE for all categories or ALTER SESSION SET USE_STORED_OUTLINES=category_name for a specific category.
Managing stored outlines can be done using Oracle's Outline Manager or using the OUTLN_PKG in the OUTLN schema. The OUTLN_PKG provides procedures like DROP_UNUSED, DROP_BY_CAT, UPDATE_BY_CAT etc…
It is possible to use the ALTER OUTLINE REBUILD/RENAME TO/CHANGE CATEGORY TO commands to manage outlines. Information about stored outlines is kept in the DBA_OUTLINES & DBA_OUTLINE_HINTS views.
Using the commands specified above, will cause the outline's behavior to change for all the users of the database. Private outlines are used to make changes to outlines in your current session. In order to create private outlines, the connected user must have an outline table in its schema. The outline table can be created using the DBMS_OUTLN_EDIT.CREATE_EDIT_TABLES procedure. The user must have the

CREATE ANY OUTLINE system privilege and the SELECT object privilege on any table participating in the outline also. Now the user can create a private outline using the CREATE PRIVATE OUTLINE …

Materialized Views – a materialized view, as opposed to a traditional view, which is stored in the data dictionary only, stored the actual physical results of the view's query. The materialized views are intended for data warehouses and DSS (Decision support systems). The optimizer recognizes that a materialized view is participating in the query, and dynamically adjusts the query to make use of the view by rewriting it.

Using Materialized Views – Several steps must be performed in order to use materialized view:

1. Determine the statement you wish to create a materialized view for (usually queries on large FACT tables with group by functions (MIN,MAX,SUM,COUNT…))
2. Determine the synchronization factor of the view with the underlying base tables:
   NEVER – Never synchronize the materialized view.
   COMPLETE – during a refresh, the materialized view is truncated and repopulated with data.
   FAST – during a refresh, the materialized view is populated only with data changed in base tables.
   FORCE – if an attempt to FAST refresh fails, use the COMPLETE method.
3. Determine the refresh rate:
   ON COMMIT – the materialized view will be refreshed when transactions are committed in base tables.
   By Time – using the START WITH and NEXT options during view creation, for specific times.
   ON DEMAND – manually refresh the materialized view.
4. Set the init.ora related parameters:

JOB_QUEUE_PROCESSES - number of background processes for executing jobs, must be larger than 0).
QUERY_REWRITE_ENABLE - allow optimizer to rewrite queries.
QUERY_REWRITE_INTEGRITY - determine the data consistency degree. Valid parameters are: *ENFORCED* – query rewrites will occur only when Oracle can guarantee data currency (default), *TRUSTED* – query rewrites will occur if relationship exist without data currency & *STALE_TOLERATED* – query rewrite will occur although materialized view's data and base table data are not current.
OPTIMIZER_MODE – must be set to one of the CBO options.
In order for a specific session to be able to user query rewrites, the connected user must have the GLOBAL QUERY REWRITE and/or QUERY REWRITE system privileges.
Create the materialized view using:

```
CREATE MATERIALIZED VIEW name TABLESPACE tbs
BUILD IMMEDIATE/DEFERRED/ON PREBUILT TABLE
ENABLE QUERY REWRITE
AS
SELECT …
```

BUILD IMMEDIATE causes Oracle to build a materialized view and populate it with table data.
BUILD DEFERRED causes Oracle to build materialized view structure. The materialized view will be populated with data when the first refresh occurs.
ON PREBUILD TABLE – causes Oracle to use a preexisting table, which has the same structure as the materialized view.

Managing Materialized Views – the DBMS_MVIEW package provides all operations on materialized views: REFRESH – refresh a specific materialized view, REFRESH_DEPENDENT – refresh all materialized views that uses a specific base table, REFRESH_ALL_MVIEWS – refresh all materialized views in schema.

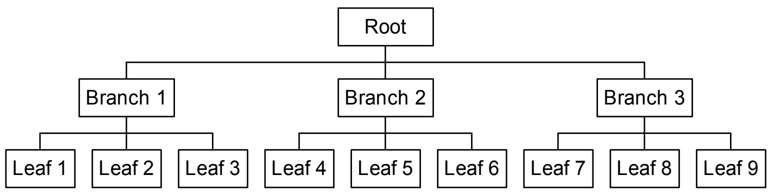
Disabling Materialized Views - materialized views can be disabled at instance, session and statement levels. Instance – set the QUERY_REWRITE_ENABLED=FALSE in init.ora by using ALTER SYSTEM statement, Session – set the QUERY_REWRITE_ENABLED=FALSE using the ALTER SESSION statement, Statement – use the NOREWRITE hint in the SQL statement.

Minimizing I/O using Indexes and Clusters:

Indexes – there are 6 different types of indexes in Oracle 9i: B-Tree, Compressed B-Tree, Bitmap, Function-Based, Reverse Key (RKI) and Index organized table (IOT).

B-Tree Indexes (balanced tree) are the most common type of index. B-Tree index stored the rowid and the index key value in a tree structure. When creating an index, a ROOT block is created, then BRANCH blocks are created and finally LEAF blocks. Each branch holds the range of data its leaf blocks hold, and each root holds the range of data its branches hold:

B-Tree Index



B-Tree indexes are most useful on columns that appear in the where clause (SELECT … WHERE EMPNO=1). The Oracle server, keeps the tree balanced by splitting index blocks, when new data is inserted to the table. Whenever a DML statement is performed on the index's table, index activity occurs, making the index to grow (add leaf and branches).

Index statistics are gathered using the ANALYZE INDEX statement. Available options are COMPUTE/ESTIMATE STATISTICS or VALIDATE STRUCTURE. When using the last option, Oracle populates the INDEX_STATS view with statistics related to analyzed index. The statistics contain number of leaf rows & blocks (LF_ROWS, LF_BLKS), number branch rows & blocks (BR_ROWS, BR_BLKS), number of deleted leaf rows (DEL_LF_ROWS), used space (USED_SPACE), number of distinct keys (DISTINCT_KEYS) etc…

Index reorganization is performed by dropping and recreating the index, building the index or coalescing it.

Compressed B-Tree Indexes are built on large tables, in a data warehouse environment. In this type of index, duplicate occurrences of the same value are eliminated, thus reducing the amount of storage space, the index requires. In a compressed B-Tree index, for each key value, a list of ROWIDs are kept:

Uncompressed B-Tree Index

Last Name	Associate ROWID
Smith	AAABSOAAEAAAABTAAB
Smith	AAABSOAAEAAAABTAAC
Smith	AAABSOAAEAAAABTAAD
Smith	AAABSOAAEAAAABTAAE

Compressed B-Tree Index

Last Name	Associate ROWID
Smith	AAABSOAAEAAAABTAAB, AAABSOAAEAAAABTAAC, AAABSOAAEAAAABTAAD, AAABSOAAEAAAABTAAE

Specifying the COMPRESS keyword when creating an index (CREATE INDEX … COMPRESS) will create a compressed B-Tree index. A regular B-Tree index can be rebuilt using the COMPRESS keyword to compress it.

Bitmap Indexes work on columns with low data cardinality (as opposed to B-Tree indexes). This type of index, creates a binary map of all index values, and store that map in the index blocks, this means that the index will require less space than B-Tree index. The Bitmap index is useful on large columns with low-DML activity like marital status (M/S) or gender (M/F). Bitmap Index structure contain a map of bits which indicate the value in the column, for example, for the GENDER column, the index block will hold the starting ROWID, the ending ROWID and the bit map:

Column Value	Starting ROWID	Ending ROWID	Bitmap
F	AAAD7fAAJAAAAM8AAA	AAAD7fAAJAAAAM8AAG	1101000
M	AAAD7fAAJAAAAM8AAA	AAAD7fAAJAAAAM8AAG	0010111

Bitmap indexes are very useful when created on columns with low cardinality, used with the AND & OR operator in the query condition:

SELECT ENAME FROM EMP WHERE DEPT = 10 OR GENDER = 'F';

Special notice to 4 init.ora parameters should be given when creating Bitmap indexes: SORT_AREA_SIZE (size in bytes of buffer used for sort operations), PGA_AGGREGATE_TARGET (memory size in bytes assigned to a bitmap index creation and bitmap merges following index range scan), CREATE_BITMAP_AREA_SIZE and BITMAP_MERGE_ARE_SIZE were deprecated in 9i and were replaced by PGA_AGGREGATE_TARGET.

Function-Based Indexes are indexes created on columns that a function is usually applied on. When using a function on an indexed column, the index is ignored, therefore a function-based index is very useful for these operations.

Example: UPPER function on ENAME column in EMP table – CREATE INDEX … on EMP(UPPER(ENAME));
or (units * unit_price) calculation in the SALES table: CREATE INDEX … on SALES(units * unit_price);

Reverse-Key Indexes are special types of B-Tree indexes and are very useful when created on columns contain sequential numbers. When using a regular B-Tree, the index will grow to have many branches and perhaps several levels, thus causing performance degradation, the RKI solve the problem by reversing the bytes of each column key and indexing the new data. This method distributes the data evenly in the index. Creating a RKI is done using the REVERSE keyword: CREATE INDEX … ON … REVERSE;

Index Organized Tables (IOT) – Using B-Tree, Bitmap and RKI indexes are used for tables that store data in an unordered fashion (*Heap Tables*). These indexes contain the location of the ROWID of required table row, thus allowing direct access to row data. In order to store data in a specific order, Oracle provides the IOT – instead of storing the ROWID pointing to the table row, the whole row is stored in the index itself. There are 2 benefits of using IOT:

1. table rows are indexes, access to table is done using its primary key, the row is returned quickly from IOT than heap tables. 2. There is less I/O when using the IOT.

In order to create an IOT, use the CREATE TABLE command:

CREATE TABLE …

ORGANIZATION INDEX TABLESPACE … (specify this is an IOT)

PCTTHRESHOLD … (specify % of block to hold in order to store row data, valid 0-50 (default 50))

INCLUDING … (specify which column to break a row when row length exceeds PCTTHRESHOLD)

OVERFLOW TABLESPACE … (specify the tablespace where the second part of the row will be stored)

MAPPING TABLE; (cause creation of a mapping table, needed when creating Bitmap index on IOT)

The *Mapping Table* maps the index's physical ROWIDs to logical ROWIDs in the IOT. IOT use logical ROWIDs to manage table access by index because physical ROWIDs are changed whenever data is added to or removed from the table.

In order to distinct the IOT from other indexes, query the USER_INDEXES view using the pct_direct_access column. Only IOT will have a non-NULL value for this column.

Index information can be obtained from several views such as DBA_INDEXES (column INDEX_TYPE, COPMRESSION & FUCNIDX_STATUS), DBA_SEGMENTS (column SEGMENT_TYPE) and DBA_TABLES (columns IOT_NAME & IOT_TYPE).

Identifying unused indexes is done by placing the index in monitoring state using the ALTER INDEX … MONITORING USAGE command. This action will populate the V$OBJECT_USAGE view that can be queries to identify object usage. To turn off monitoring use ALTER INDEX … NOMONITORING USAGE;

Partitions – partitions are subsets of data separated physically from one another. The CBO will benefit greatly from using partitions by skipping irrelevant partitions. There are four types of partitions: Range partitions, List partitions, Hash partitions and Composite partitions.

Range Partitions represent a partition data division by range of values (date for example). In order to create a range partitioned table use: CREATE TABLE … PARTITION BY RANGE (column) PARTITION P1 values … TABLESPACE …, PARTITION P2 …. The partition key can be compressed up to 16 columns. A table can have up to 65536 partitions. Gaps are now allowed in Range partitions (skip of date for example), all rows stored in a partition will have values less than, and not equal to the upper bound for that partition. The value specified by LESS_THAN clause must be literal (date, number). Range partitions cannot contain columns with LONG/LONG RAW data type. Specifying the ENABLE ROW MOVEMENT clause in the creation of partitions will enable the data to move across partitions.

List Partitions are similar to Range partitions except they are based on a set of specified values rather than a range of values. List partitions are created using the PARTITION BY LIST (column)

clause and each partition must specify its list of values: CREATE TABLE … PARTITION BY LIST (degree) (PARTITION P1 VALUES ('BS', 'BA', 'BBA'), PARTITION P2 VALUES ('MS', 'MA', 'MBA');
Hash partitions use a hashing algorithm to assign inserted records into partitions. This has the effect of maintaining a relatively even number of records in each partition, thus improving the performance of parallel operations like Parallel Query and Parallel DML. Hash partitions are created using the PARTITION BY HASH (column) PARTITIONS n clause, where n specifies the number of partitions. There are several rules regarding Hash partitions: The partition key should have high cardinality (column should contain unique values or very few duplicate values). Hash partitions work best when data is retrieved from via the unique key. Range lookups on hash partitioned tables derive no benefit from the partitioning, When they are properly indexed, hash partitioned tables improve the performance of joins between two or more partitioned tables. Updates that would cause a record to move across partition boundaries are not allowed. Local hash indexes can be built on each partition.
Composite Partitioning represents a combination of both range and hash partitioning. This type of partition is useful when Range partitioning is desired, but when the resulting number of values within each range would be uneven. Composite partitions are created using:
PARTITION BY RANGE (column 1) SUBPARTITION BY HASH (column 2) SUBPARTITIONS n.
Several guidelines related to composite partitioning should be considered:
The partitions are logical structures only; the table data is physically stored at the sub-partition level, Composite partitions are useful for historical, date-related queries at the partition level. Composite partitions are also useful for parallel operations (both query and DML) at the subpartition level, Partition-wise joins are also supported using composite local indexes, and Global local indexes are not supported .
<u>**Indexing Partitioned Tables**</u> - After a partitioned table has been created, it should be indexed. Proper indexing of partitioned tables will also improve the manageability of the indexes when performing routine index maintenance tasks. There are two methods of classifying partitioned indexes: 1) Local vs. global indexes - whether the index's partitioning structure matches that of the underlying, indexed table. 2) Prefixed vs. non-prefixed indexes - whether the index contains the partition key and where the partition key appears within the index structure.
Local Partition Indexes are said to be local when the number of partitions in the index match the underlying table's partitions on a one-to-one basis. Therefore, if a table contains four partitions, the local index on that table will also contain four partitions, each indexing one of the four table partitions. Several guidelines related to local partition indexes:
Local partitioned indexes can use any of the four partition types, Oracle automatically maintains the relationship between the table's partitions and the index's partitions, If a table partition is merged, split, or dropped, the associated index partition will be merged, split, or dropped, Any bitmapped index built on a partitioned table must be a local index .
Global Partition Indexes are said to be global when the number of partitions in the index do not match the underlying table's partitions on a one-to-one basis. For example, if a table contains four partitions, its global index may be comprised of only two partitions, each of which may encompass one or more of the table partitions. Several guidelines related to global partition indexes:
Although global indexes can be built on a range, list, hash, or composite partitioned table, the global partitioned index itself must be Range partitioned. The highest partition of a global index must be defined using the MAXVALUE parameter. Performing maintenance operations on partitioned tables can cause their associated global indexes to be placed into an invalid state. Indexes in an invalid state must be rebuilt before users can access the table. Creating a global partitioned index with the same number of partitions as its underlying table (i.e. simulating a local partitioned index) does not substitute for a local partitioned index. The indexes would not be considered the same by the CBO despite their similar structures.
<u>**Prefixed Partition Indexes**</u> are said to be prefixed whenever the left-most column of the index is the same as the underlying table's partition key column. For example, if a table were partitioned on the

specific column, a prefixed partitioned index would also use the same column as the first column in its index definition. Prefixed indexes can be either unique or non-unique.
Non-prefixed Partitioned Indexes are said to be non-prefixed when the left-most column of the index is not the same as the underlying table's partition key column. For example, if a table were partitioned on a specific column, a non-prefixed partitioned index would use some column other than the one specified as the first column in its index definition.

Combination of Partitioned Indexes:

	Local index	**Global index**
Prefixed index	Local, prefixed Partitioned index	Global, prefixed Partitioned index
Non-prefixed index	Local, non-prefixed Partitioned index	Not Allowed

Creating a Local, Prefixed Partition Index:

```
CREATE INDEX index_name ON table_name (column_name) LOCAL;
```

The above syntax would create a partition index with the same number of partitions as the underlying table whose leading column would be the same column that makes up the underlying table's partition key.

Creating a Local, Non-prefixed Partition Index:

```
CREATE INDEX index_name ON table_name (column_name) LOCAL;
```

The above syntax would create a partition index with the same number of partitions as the underlying table whose leading column would be a column different from that, which makes up the underlying table's partition key.

Creating a Global, Prefixed Partition Index:

```
CREATE INDEX index_name ON table_name (column 1) GLOBAL PARTITION BY RANGE (column 1)
(PARTITION P1 VALUES LESS THAN …, PARTITION P2 VALUES LESS THAN…);
```

The above syntax would create a n-partition index (according to number of partitions defined in the call). In addition to the above partitioned index types, traditional non-partitioned B-Tree indexes can also be built on partitioned tables. These indexes are referred to as global, prefixed non-partitioned indexes.

How the Partitioned Tables Affect the Optimizer - Once partitioned tables and indexes have been created, it is up to the cost-based optimizer to decide how to use them effectively when executing application queries. Because the Oracle9i CBO is very 'partition aware', it can eliminate partitions that will not be part of the query result. Partitioned tables and indexes also help the CBO develop effective execution plans by influencing the manner in which joins are performed between two or more partitioned tables. When performed in parallel using Oracle Parallel Query, there are two possible join methods that are considered by the CBO: *full partition-wise joins* and *partial partition-wise joins*. Partition-wise joins occur any time two tables are joined on their partition key columns. *Partition-wise joins* can be performed either serially or in parallel. Partial partition-wise joins occur any time two tables are joined on the partition key columns of one of the two tables. Partial *partition-wise joins* can only be performed in parallel. Each of these join types reduces the overall CPU and memory utilized to service a query, particularly on very large partitioned tables.
Partition information can be gathered with the help of these views: DBA_IND_PARTITIONS (details about index partitions), DBA_LOB_PARTITIONS (details about large object partitions), DBA_PART_COL_STATISTICS (columns statistics for partitioned tables), DBA_PART_HISTOGRAMS (histogram statistics for partitioned tables), DBA_PART_INDEXES (details about partitioned index), DBA_PART_KEY_COLUMNS (partition key columns for all partitioned tables and indexes), DBA_PART_LOBS (details about each partitioned large object), DBA_PART_TABLES (details about each partitioned table), DBA_TAB_PARTITIONS (details about each table's individual partitions).
For each DBA view of partitions, exists an exact view for the Sub Partition.

Index and Hash Clusters - A cluster is a group of one or more tables whose data is stored together in the same data blocks. In this way, queries that utilize these tables via a table join don't have to read two sets of data blocks to get their results; they only have to read one. There are two types of clusters available in Oracle9i: the Index cluster and the Hash cluster.

Index Clusters are used to store the data from one or more tables in the same physical Oracle blocks. Clustered tables should have these attributes: Always be queried together and only infrequently on their own, Have little or no DML activity performed on them after the initial load and have roughly equal numbers of child records for each parent key. A cluster is a segment stored in a tablespace. The cluster is accessed via an index that contains entries that point to the specific key values on which the tables are joined. In order to create a cluster, use CREATE CLUSTER cluster_name (column_name data_type) SIZE n STORAGE … TABLESPACE …; command. The parameter SIZE specifies how many cluster keys to have per Oracle block (db_block_size/SIZE).

Hash Clusters are used in place of a traditional index to quickly find rows stored in a table. Like cluster indexes. Hash cluster tables should have these attributes: Have little or no DML activity performed on them after the initial load, have a uniform distribution of values in the indexed column, have a predictable number of values in the indexed column and be queried with SQL statements that utilize equality matches against the indexed column in their WHERE clauses.

Rather than examine an index and then retrieve the rows from a table, a Hash cluster's data is stored so queries against the cluster can use a hashing algorithm to determine directly where a row is stored with no intervening index required.

OLTP vs. DSS Tuning Requirements

Tuning OLTP Systems

Online Transaction Processing (OLTP) systems tend to be accessed by large numbers of users doing short DML transactions. Users of OLTP systems are primarily concerned with throughput.

OLTP systems need enough B-Tree and Reverse Key indexes to meet performance goals but not so many as to slow down the performance of INSERT, UPDATE, and DELETE activity. Bitmap indexes are not a good choice for OLTP systems because of the locking issues they can cause. Table and index statistics should be gathered regularly if the CBO is used because data volumes tend to change quickly in OLTP systems. OLTP indexes should also be rebuilt frequently if the data in the tables they are indexing is frequently modified.

Tuning DSS Systems

Decision Support Systems (DSS) and data warehouses represent the other end of the tuning spectrum. These systems tend to have very little if any DML activity, except when data is mass loaded or purged at the end of a period. Users of these systems are concerned with response time, which is the time it takes to get the results from their queries. DSS makes heavy use of full table scans so the appropriate use of indexes and Hash clusters are important. Index-organized tables can also be important tuning options for large DSS systems. Bitmap indexes may be considered where the column data has low cardinality but is frequently used as the basis for queries. Thought should also be given to selecting the appropriate optimizer mode and gathering new statistics whenever data is loaded or purged. The use of histograms may also help improve DSS response time. Finally, consideration should be given to database block size, init.ora parameters related to sorting, and the possible use of the Oracle Parallel Query option. As with OLTP systems, database statistics should also be gathered following each data load if the CBO is used.

Tuning Hybrid Systems: OLTP and DSS

Some systems are a combination of both OLTP and DSS. These hybrid systems can present a significant challenge because the tuning options that help one type of system frequently hinder the other. However, through the careful use of indexing and resource management, some level of coexistence can usually be achieved. As the demands on each of these systems grows, you will probably ultimately have to split the two types of systems into two separate environments in order to meet the needs of both user communities.

4 – Tuning the Shared Pool

- **The Shared Pool** is the portion of the SGA that caches the recently issued SQL and PL/SQL statements. The Shared Pool is managed by a Least Recently Used (LRU) algorithm. Once the Shared Pool is full, this algorithm makes room for subsequent SQL statements by aging out the statements that have been least recently accessed. By caching these frequently used statements in memory, an application that issues the same SQL or PL/SQL statement benefits from the fact that the statement is already in memory, ready to be executed. This is very useful for the subsequent application calls as the user can skip some of the overhead that was incurred when the statement was originally issued.

  Benefits or Statement Caching – When a user executes a query, the Oracle server converts the query into a string of ASCII characters. The ASCII string is then passed through a hashing algorithm, which generates a hash value. Next, the Server Process checks to see if the hashed value is already exists in the shared pool. If is exists, the Server Process uses the cached version of the statement to execute it. If the hashed value does not exist in the shared pool the statement is *parsed* and then executed. The parse step must complete the following tasks:

  1. Check statement for syntax errors
  2. Perform object resolution (check names and structures of referenced objects in data dictionary)
  3. Gather statistics regarding the objects referenced in the query in the data dictionary
  4. Prepare and select an execution plan, check for stored outlines or materialized views
  5. Determine the security for the objects referenced in the query by examining the data dictionary
  6. Generate a compiled version of the statement (called P-Code)

  The parsing process is expensive and therefore must not be avoided by making sure that most SQL Statements find a parsed version of themselves in the shared pool. Finding a matching SQL statement in the Shared Pool is referred to as a **cache hit**. Not finding a matching statement and having to perform the parse operation is considered a **cache miss**. In order for a cache hit to occur, the two SQL statements must match exactly; the ASCII equivalents of the two statements must be identical for them to hash to the same value in the Shared Pool. **Maximizing cache hits and minimizing cache misses is the goal of all Shared Pool tuning**. As of Oracle9i, a hashed value is also assigned to the execution plan for each cached SQL statement.

  Components of the Shared Pool – the shared pool is made of three components:

  Library Cache – All SQL and PL/SQL statements are cached in the library cache. The statements can be procedures, functions, triggers, anonymous PL/SQL blocks or java classes. The cached statement contains several components: statement text, the hashed value, the P-Code, statistics and execution plan. SQL-Related Dynamic Performance Views: V$SQL - SQL statement text and statistics for all cached SQL statements including I/O, memory usage, and execution frequency, V$SQLAREA - information for SQL statements that are cached in memory, parsed, and ready for execution, V$SQLTEXT - The complete text of the cached SQL statements along with a classification by command type and V$SQL_PLAN - Execution plan information for each cached SQL statement. The V$SESSION COMMAND column, displays the types of SQL a user is issuing: 2-Insert, 3-Select, 6-Update, 7-Delete, 26-Lock table, 44-Commit, 45-Rollback and 47-PL/SQL Execute. The V$DB_OBJECT_CACHE displays the types of database objects that are being referenced by the application’s SQL statements. The EXECUTIONS column displays how often the application SQL has referenced the database object.

  Data Dictionary Cache - data dictionary cache stored the structure of the tables, columns and data types referenced in the statement. It also stores the issuing user’s privileges on the objects involved. This memory area is also managed using an LRU mechanism. When data dictionary information is kept in memory, subsequent application users who issue similar, but not identical, statements as previous users, benefit from the fact that the data dictionary information associated with the tables in their statement may be in memory—even if the actual statement is not.

  User Global Area - The UGA is only present in the Shared Pool if the Shared Server option is being used. In the shared server architecture, the User Global Area is used to cache application user session information. In a dedicated server environment, session information is maintained in the application user’s private Process Global Area (PGA).

Measuring the Performance of the Shared Pool - The primary indicator of the performance of the Shared Pool is the cache-hit ratio. High cache-hit ratios indicate users are frequently finding the SQL and PL/SQL statements they are issuing already in memory. Hit ratios can be calculated for both the Library Cache and the Data Dictionary Cache. Oracle recommends tuning the Library Cache first, before attempting to tune the Database Buffer Cache.

Measuring Library Cache Performance – The library cache performance is measured by calculating the hit ratio. There are 4 places to get library cache hit ratio: V$LIBRARYCACHE view, UTLBSTAT/ESTAT, STATSPACK and Oracle Performance Manager GUI tool.

V$LIBRARYCACHE view, displays information about cache hit ratio. The GETHITRATIO column shows cache hit ratio related to the parse phase, the PINHITRATIO column shows cache hit ratio related to execution phase. Other useful columns for Library Cache tuning are INVALIDATION, which display the number of times a cached SQL statement was marked as invalid and therefore forced to parse Cached statements are marked invalid whenever the objects they reference are modified and RELOADS, which shows the number of times that an statement had to be re-parsed because the Library Cache had aged out or invalidated. The NAMESPACE column shows the source of the cached object (BODY, CLUSTER, INDEX, JAVA DATA, JAVA RESOURCE, JAVA SOURCE, OBJECT, SQL AREA, TABLE/PROCEDURE, TRIGGER).

GETHITRATIO - Oracle uses the term get to refer to a type of lock, called a Parse Lock, that is taken out on an object during the parse phase for the statement that references that object. Each time a statement is parsed, the value for GETS in the V$LIBRARYCACHE view is incremented by 1.

The GETHIT column stores the number of times a statement found its parsed copy in memory.

PINHITRATIO - PINS, like GETS, are also related to locking. However, PINS are related to locks that occur at execution time. These locks are the short-term locks used when accessing an object. Therefore, each library cache GET also requires an associated PIN, in either Shared or Exclusive mode, before accessing the statement’s referenced objects. Each time a statement is executed, the value for PINS is incremented by 1. The PINHITRATIO column stored the number of times a statement found the associated parsed SQL Library Cache.

Measuring Data Dictionary Cache Performance - Like the Library Cache, the measure of the effectiveness of the Data Dictionary Cache is expressed in terms of a hit ratio. This Dictionary Cache hit ratio shows how frequently the application finds the data dictionary information it needs in memory, instead of having to read it from disk. This hit-ratio information is contained in a dynamic performance view called V$ROWCACHE. Querying GETS and GETMISSES columns in V$ROWCACHE, can be used to calculate the Data Dictionary Cache hit ratio. The output from STATSPACK and REPORT.TXT also contain statistics related to the Data Dictionary Cache hit ratio.

Improving Shared Pool Performance - The objective of all these methods is to increase Shared Pool performance by improving Library Cache and Data Dictionary Cache hit ratios. These techniques fall into five categories: Make it bigger, Make room for large PL/SQL statements, Keep important PL/SQL code in memory, Encourage code reuse and Tune Library Cache-specific init.ora parameters.

Make it Bigger - The simplest way to improve the performance of the Library and Data Dictionary Caches is to increase the size of the Shared Pool. Because the Oracle Server dynamically manages the relative sizes of the Library and Data Dictionary Caches, making the Shared Pool larger lessens the likelihood that cached information will be moved out of either cache by the LRU mechanism. This has the effect of improving both the Library Cache and Data Dictionary Cache hit ratios.

The shared pool size is determined by the SHARED_POOL_SIZE init.ora parameter (default 64M for 64-bit operating systems and 16M for 32-bit operating systems). If java is installed in the Oracle server, the shared pool must be at least 50M in size (it is possible to configure the java pool for this purpose by setting the JAVA_POOL_SIZE parameter in the init.ora parameter file). Shared pool size can be increased dynamically using the ALTER SYSTEM SET SHARED_POOL_SIZE command (increase size allowed until SGA_MAX_SIZE is reached).

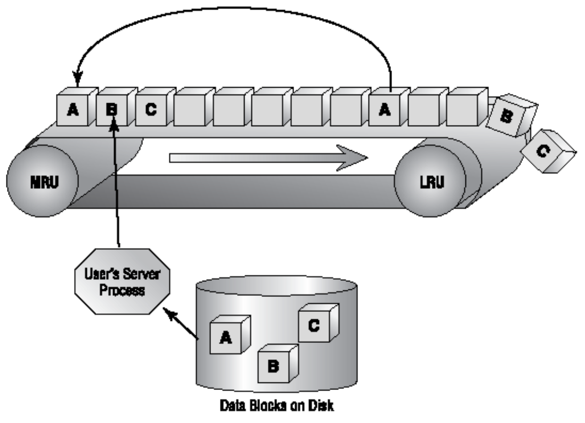
Make room for large PL/SQL statements - If an application makes a call to a large PL/SQL package or trigger, several other cached SQL statements may be moved out of memory by the LRU mechanism when this large package is loaded into the Library Cache. This has the effect of reducing the Library

Cache hit ratio if these statements are subsequently re-read into memory later. To avoid this problem, Oracle gives you the ability to set aside a portion of the Library Cache for use by large PL/SQL packages. This area of the Shared Pool is called the Shared Pool Reserved Area. The init.ora parameter SHARED_POOL_RESERVED_SIZE can be used to set aside a portion of the Shared Pool for exclusive use by large PL/SQL packages and triggers. The value of SHARED_POOL_RESERVED_SIZE is specified in bytes and can be set to any value up to 50 percent of the value specified by SHARED_POOL_SIZE. By default, SHARED_POOL_RESERVEDSIZE will be 5 percent of the size of the Shared Pool. Oracle recommends setting SHARED_POOL_RESERVED_SIZE to 10 percent of the SHARED_POOL_SIZE. A way to determine the optimal size of your reserve pool is to monitor the V$DB_OBJECT_CACHE dynamic performance view. The V$SHARED_POOL_RESERVED view can be used to monitor the use of the Shared Pool Reserved Area and help determine if it is properly sized. If you have over-allocated memory for the reserved area, you should notice that the REQUEST_MISSES column are consistently zero or static, FREE_SPACE column shoes more than 50 percent of the total size allocated to the reserved area. The REQUEST_FAILURES column indicates that the reserved area is too small if Non-zero or steadily increasing values appear. Oracle recommends that you aim to have REQUEST_MISSES and REQUEST_FAILURES near zero in V$SHARED_POOL_RESERVED when using the Shared Pool Reserved Area.
The ABORTED_REQUEST_THRESHOLD procedure in the DBMS_SHARED_POOL package is used to specify how much of the Library Cache’s memory can be flushed from the Shared Pool’s LRU list when a large PL/SQL object is trying to find space for itself in memory.
Keep Important PL/SQL Code in Memory - Applications that make heavy use of PL/SQL packages and triggers or Oracle sequences can improve their Shared Pool hit ratios by permanently caching these frequently used PL/SQL objects in memory until the instance is shutdown. This process is known as pinning and is accomplished by using the DBMS_SHARED_POOL package. Pinned packages are stored in the Shared Pool Reserved Area. ALTER SYSTEM FLUSH SHARED_POOL does not flush pinned objects. However, pinned objects will be removed from memory at the next instance shutdown.
DBMS_SHARED_POOL package is created by running the $ORACLE_HOME/rdbms/admin/dbmspool.sql script. By using the KEEP procedure, the object specified as the parameter for the procedure is pinned in the shared pool. The V$DB_OBJECT_CACHE view contains the KEPT column which indicates the pinned objects.
What to Pin – The most used objects such as triggers, packages, procedures, etc…
When to Pin - Right after instance startup. This is accomplished by manually executing SQL script after instance startup, or automatically by an AFTER STARTUP ON DATABASE trigger.
Encourage Code Reuse – Adopt coding standards in order to increase shared pool performance or use bind variables.
Tune Library Cache–specific init.ora Parameters - In addition to SHARED_POOL_SIZE, there are three init.ora parameters that directly affect the performance on the Library Cache:
OPEN_CURSORS - The parameter limits the number of cursors a user’s session can open (default 50). Increasing this value will allow each user to open more cursors and minimize re-parsing previously executed SQL statements, thus improving the Library Cache hit ratio.
CURSOR_SPACE_FOR_TIME - When set to TRUE, shared SQL areas are pinned in the Shared Pool (default FALSE). This prevents the LRU from removing a shared SQL area from memory unless all cursors that reference that shared SQL area are closed. This can improve the Library Cache hit ratio and reduce SQL execution time. Set to TRUE only if you have enough server memory to make the Shared Pool large enough to hold all the potential pinned SQL areas.
SESSION_CACHED_CURSORS - the parameter specified how many of the cursors associated with SQL statements, which have been issued several times, should be cached in the Library Cache (default 0).
CURSOR_SHARING - The parameter allows you to change the Shared Pool’s default behavior when parsing and caching SQL statements. Values for CURSOR_SHARING Parameter:
FORCE - Allows two SQL statements, which differ only by a literal value, to share parsed code cached in the Shared Pool.
SIMILAR - Allows two SQL statements, which differ only by a literal value, to share parsed code cached in the Shared Pool.

EXACT Two SQL statements must match exactly in order to share the parsed code cached in the Shared Pool (default).

5 - Tuning the Database Buffer Cache

- **The Database Buffer Cache** or Buffer Cache is the portion of the SGA that caches copies of the most recently used data blocks. Each buffer in the Buffer Cache holds the contents of, one database block. The blocks cached in the Buffer Cache may belong to any of the following segment types: Tables, Indexes, Clusters, LOB segments, LOB indexes, Rollback segments and Temporary segments.
  The usage of these buffers in the Database Buffer Cache is managed by a combination of mechanisms:
  LRU list - When a SQL statement is issued, the data associated with that statement will be copied from disk into the Buffer Cache in the SGA. Each Server Process is responsible for copying this data from the datafiles into the buffers in the Buffer Cache. The Database Buffer Cache is managed by a Least Recently Used (LRU) algorithm. Once the Buffer Cache's buffers are full, the LRU algorithm makes room for subsequent requests for new buffers by aging out the buffers that have been least recently accessed .This allows the Oracle Server to keep the most recently requested data buffers in the Buffer Cache while the less commonly used data buffers are flushed. By caching the data buffers in this manner, Statements which need the same data buffers as a previous SQL Statement, benefits from the fact that the buffers are already in memory and therefore do not need to be read from disk.



When a request is made for data, the user's Server Process copies the blocks (A, B, C) from disk into buffers at the beginning MRU. These buffers stay on the LRU List but move towards the LRU end as additional data blocks are read into memory. If a buffer (A) is accessed again during the time it is on the LRU List, the buffer is moved back to the beginning of the LRU List (back to the MRU). If buffers are not accessed again before they reach the end of the LRU List, the buffers (B and C) are marked as free and will subsequently be overwritten by another block being read from disk.

The behavior of the LRU List is slightly different when a table is accessed during a full table scan. During an FTS, the table buffers are placed immediately at the least recently used end of the LRU List. While this has the effect of immediately causing these blocks to be flushed from the cache, it also prevents an FTS on a large table from pushing all other buffers out of the cache.
The buffers that the LRU list maintains can be in one of four states:
Free - Buffer is not currently in use.
Pinned - Buffer is currently in use by a Server Process.
Clean - A buffer that was released from a pin and has been marked for immediate reuse.
Dirty - Buffer is not in use, but contains committed data that has not yet been written to disk by Database Writer.
The mechanism for managing these dirty buffers is called the Dirty List or Write List. Using a checkpoint queue, this list keeps track of all the blocks that have been modified using INSERT, DELETE or UPDATE statements, but have not yet been written to disk. Dirty buffers are written to disk by the Database Writer (DBW0). Each Server Process also makes use of the Dirty List while carrying out its Buffer Cache-related activities.
User Server Process – When the Server Process does not find the data it needs in the Buffer Cache, it must read the data from disk. Before the data can be read from disk, however, a free buffer must be

found to hold the copy of the data block in memory. When searching for a free buffer to hold the block, the Server Process makes use of both the LRU List and the Dirty List:
While searching the LRU List for a free block, the Server Process moves any dirty blocks it finds on the LRU List to the Dirty List. As buffers are added to the Dirty List, it grows longer and longer. When it hits a predetermined threshold length, DBW0 writes the dirty buffers to disk. DBW0 also write dirty buffers to disk when a Server Process has examined too many buffers without successfully finding a free buffer. In this case, DBW0 will write dirty buffers directly from the LRU List (as opposed to moving them to the Dirty List first, as above) to disk. When a Server Process needs a buffer and finds that buffer in memory, the buffer may contain uncommitted data or data that has changed since the time the user's transaction began. Since uncommitted data is not displayed to user, the Server Process uses a buffer that contains the *before image* of the data to provide a read consistent view of the database. This *before-image* is stored in a rollback segment whose blocks are also cached in the Buffer Cache. The Database Writer background process also directly assists in the management of the LRU and Dirty Lists.
Database Writer - Several database events cause Database Writer to write the dirty buffers to disk: Dirty List threshold is reached, LRU List is searched too long without finding a free buffer, Every three seconds, At Checkpoint, At Database Shutdown (Unless a SHUTDOWN ABORT is used), At Tablespace Offline Temporary and At Drop Segment (index or table).
Measuring the Performance of the Database Buffer Cache - Like the Shared Pool, one indicator of the performance of the Database Buffer Cache is the cache hit ratio. Cache hits occur whenever a SQL statement finds user finds a data buffer needed, in memory. Cache misses occur when the user does not find the requested data in memory, causing the data to be read from disk.
Buffer Cache hit ratio information can be found at:
V$SYSSTAT – contains statistics regarding overall system performance, gathered since instance startup. Contains these columns: STATISTIC# - The identifier of the performance statistic, NAME - The name of the performance statistic, CLASS - The category the statistic falls into (1=User, 2=Redo, 4=Enqueue, 8=Cache, 16=Operating System, 32=Real Application Cluster, 64=SQL, 128=Debug) and VALUE - The value currently associated with this statistic.
There are only four statistics associated with performance of the Database Buffer Cache:
Physical Reads - number of data blocks (i.e., tables, indexes, and rollback segments) read from disk into the Buffer Cache since instance startup.
Physical Reads Direct - number of reads that bypassed the Buffer Cache, because the data blocks were read directly from disk instead (i.e.: Parallel Query).
Physical Reads Direct (LOB) - number of reads that bypassed the Buffer Cache, because the data blocks were associated with a Large Object (LOB) datatype.
Session Logical Reads - number of times a request for a data block was satisfied by using a buffer cached in the Database Buffer cache. For read consistency, some of these buffers may have contained data from rollback segments.
STATSPACK output - The STATSPACK utility output, contains a calculation for the Database Buffer Cache hit ratio under the Instance Efficiency Percentages section, in the Buffer Hit category.
UTLBSTAT.SQL/UTLESTAT.SQL output - The REPORT.TXT contains a section that shows the statistics needed to calculate the Database Buffer Cache hit ratio. These statistics include the Physical Reads, Physical Reads Direct, Physical Reads Direct (LOB) and Session Logical.
Non-Hit Ratio Performance Measures - there are non-hit ratio measures of Buffer Cache effectiveness:
Free Buffer Inspected - number of Buffer Cache buffers inspected by the Server Processes before finding a free buffer. A closely related statistic is *dirty buffer inspected*, which represents the total number of dirty buffers a user process found while trying to find a free buffer.
Free Buffer Waits - number of waits experienced by the Server Processes during Free Buffer Inspected activity. These waits occur whenever the Server Process had to wait for Database Writer to write a dirty buffer to disk.

Buffer Busy Waits - number of times the Server Processes waited for a free buffer to become available. These waits occur whenever a buffer requested by a Server Processes, is already in memory, but is in use by another process. These waits can occur for rollback segment buffers as well as data and index buffers.
High or steadily increasing values for any of these statistics, indicate that Server Processes are spending too much time searching for and waiting for access to free buffers in the Database Buffer Cache. V$SYSSTAT view contains statistics on the Free Buffer Inspected statistic and the V$SYSTEM_EVENT view contains statistics on the Free Buffer Waits and Buffer Busy Waits.
Improving Buffer Cache Performance - The objective of these methods is to increase Database Buffer Cache performance by improving its hit ratio. These techniques fall into five categories:

- **Make it bigger** – The easiest way to improve Database Buffer Cache performance is to increase its size. The larger the Database Buffer Cache, the less likely cached buffers are to be moved out of the cache by the LRU List. The longer buffers are stored in the Database Buffer Cache, the higher the hit ratio will be. Increasing the size of the Buffer Cache will also lower the number of waits reported by the free buffer inspected, buffer busy waits, and free buffer waits system statistics.
  In Oracle9i, Database Buffer Cache size is determined by several init.ora parameters:
  DB_BLOCK_SIZE - Defines the primary block size for the database.
  DB_CACHE_SIZE - Determines the size of the Default Buffer Pool (default 48M).
  DB_KEEP_CACHE_SIZE - Determines the size of the Keep Buffer Cache (default 0KB).
  DB_RECYCLE_CACHE_SIZE - Determines the size of the Recycle Buffer Cache (default 0KB).
  DB_nK_CACHE_SIZE - Specifies the size of the Buffer Cache for segments with nKB block size. Valid values are 2,4,8,16,32.
  In order to improve performance, the Buffer Cache can be divided into up to three different areas called the Default, Keep, and Recycle. By default, only the Default Pool is configured, as both the Recycle and Keep Pool are assigned zero bytes.
  The size of the Database Buffer Cache and its three component pools can all be changed dynamically using the ALTER SYSTEM command. Three rules must be kept in mind:
  1) The size specified must be a multiple of the granule size
  2) The total size of the Buffer Cache, Shared Pool, and Redo Log Buffer cannot exceed the value specified by SGA_MAX_SIZE
  3) The Default Pool cannot be set to a size of zero.
  Oracle9i ***Buffer Cache Advisory*** displays the performance changes that might occur if the Buffer Cache were made larger (or smaller) than its existing size.
  Using the Buffer Cache Advisory feature requires some initial configuration.
  Configuring the Buffer Cache Advisory Feature - You must set the init.ora parameter DB_CACHE_ADVICE = ON in order for the Buffer Cache Advisory feature to gather statistics about how changes to the Buffer Cache size might affect performance. Setting this parameter to ON causes Oracle9i to allocate memory to the Buffer Cache Advisory feature and causes the Buffer Cache Advisory feature to start gathering statistics about the Buffer Cache’s performance.
  Other possible values for the DB_CACHE_ADVICE parameter are: OFF - Turns off the Buffer Cache Advisory feature and releases any memory or CPU resources allocated to it. READY - Pre-allocates memory to the Buffer Cache Advisory process, but does not actually start it. Therefore, no CPU is consumed and no statistics are gathered until the DB_CACHE_ADVICE parameter is set to ON.
  The V$DB_CACHE_ADVICE view contains information gathered by the Buffer Cache Advisory:
  ID - identifier for the Buffer Pool being referenced. Can be a value from 1 to 8, NAME - name of the Buffer Pool being referenced, BLOCK_SIZE - block size for the buffers in this Buffer Pool, shown in bytes, ADVICE_STATUS - status of the Buffer Cache Advisory feature (i.e. OFF, READY, ON), SIZE_FOR_ESTIMATE - cache size estimate used when predicting the number of physicals reads, expressed in MB, BUFFERS_FOR_ESTIMATE - cache size estimate used when predicting the number of physicals reads, expressed in buffers, ESTD_PHYSICAL_READ_FACTOR - ratio comparing the estimated

number of physical reads to the actual number of reads that occurred against the current cache, NULL if no physical reads occurred, ESTD_PHYSICAL_READS - estimated number of physical reads that would have occurred if the cache size specified by SIZE_FOR_ESTIMATE and BUFFER_FOR_ESTIMATE had actually been used for the DB_CACHE_SIZE.

- **Use multiple Buffer Pools** – By default, all database segments compete for use of the same Database Buffer Cache buffers in the Default Pool. This can lead to a situation where some infrequently accessed tables push more-frequently-used data buffers out of memory. To avoid this, Oracle provides you with the ability to divide the Database Buffer Cache into three separate areas called Buffer Pools. Segments are then explicitly assigned to use the appropriate Buffer Pool as determined by the DBA: **Keep Pool** - Used to cache segments that you rarely, if ever, want to leave the Database Buffer Cache. The size of this pool is designated by the init.ora parameter DB_KEEP_CACHE_SIZE. The use of the Keep Pool is optional (default 0 byte). **Recycle Pool** - Used to cache segments that you rarely want to retain in the Database Buffer Cache. The size of a Recycle Pool is designated by the init.ora parameter DB_RECYCLE_CACHE_SIZE. The use of a Recycle Pool is also optional (default 0 bytes). **Default Pool** - The size of this pool is designated by the DB_CACHE_ SIZE init.ora parameter. The Default Pool is required (default 48Mb). This parameter cannot be set to zero.

  Determining Which Segments to Cache - Four views, V$BH, DBA_OBJECTS, V$CACHE, and DBA_USERS can be used for this purpose. The V$BH and DBA_OBJECTS views contain useful information that can help you identify which segments are currently cached in the Buffer Cache. V$CACHE and DBA_USERS can give additional information about segments that might make good candidates for caching in the Keep or Recycle Pools.

  Determining the Size of Each Pool - After determining which segments you wish to cache, you need to determine how large each pool should be. Making this determination is easy if the segments to be cached have been analyzed. The BLOCKS column of the DBA_TABLES and DBA_INDEXES data dictionary views can be used to determine how many Database Buffer Cache buffers would be needed to cache an entire segment or portion of that segment.

  A**ssigning Segments to Pools** – Assigning segments to pools is done using the ALTER TABLE table_name STORAGE (BUFFER_POOL KEEP/RECYCLE).

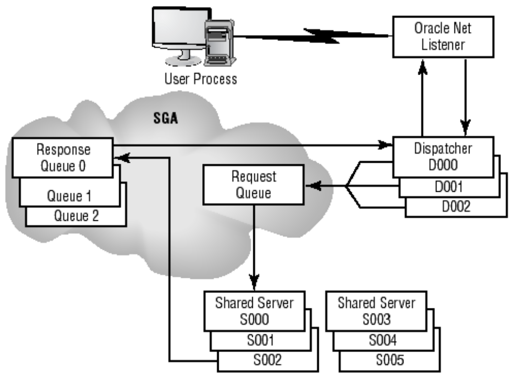
  Monitoring the Performance of Multiple Buffer Pools – The V$BUFFER_POOL view contains information about the configuration of the multiple Buffer Pools themselves. The V$BUFFER_POOL_STATISTICS view contains several columns that contain information that is useful for calculating hit ratios for each of the individual Buffer Pools (DB_BLOCK_GETS - number of requests for segment data that were satisfied by using cached segment buffers, CONSISTENT_GETS - umber of requests for segment data that were satisfied by using cached rollback blocks for read consistency, PHYSICAL_READS – number of requests for segment data that required that the data be read from disk into the Buffer Cache)
- **Cache tables in memory** – Each Buffer Pool is managed by an LRU List. As was noted earlier, tables that are accessed via a full table scan (FTS) place their blocks immediately at the least recently used end of the LRU List. If table is accessed again via FTS, the blocks are re-read from disk to memory. One way to manage this problem, particularly with small tables, is to make use of cached tables . Cached table buffers are placed at the most recently used end of the LRU List just as if they had not been full table scanned. This has the effect of keeping these buffers in memory longer while still accessing them in the most efficient manner. Cached tables can be implemented in three ways: at table creation (CREATE TABLE ... STORAGE ... CACHE;), by altering the table after creation (ALTER TABLE table_name CACHE;) or by using a hint in SQL statement (SELECT /*+ CACHE */ … from …). Displaying Cache Table Information - You can use the CACHE column in the DBA_TABLES view to determine which tables are cached.
- **Bypass the Buffer Cache** – By bypassing the Buffer Cache, buffers that are already stored there are not moved down or off the LRU List during processing. These two types of transactions can be

configured to bypass the Database Buffer Cache: Sort Direct Writes and Parallel DML (involves doing bulk inserts, updates, and deletes in parallel)

- **Use indexes appropriately** – Ensure that unnecessary full table scans are avoided through the appropriate use of indexes. The fewer full table scans that occur, the higher the Database Buffer Cache hit ratio will be. One is to build indexes on the foreign key columns of tables that reference a primary key column in another table. This improve the effectiveness of multi-table joins and minimize Buffer Cache intensive FTS sort-and-merge joins between the two tables.

6 - Tuning Other SGA Areas

- **Shared Server Concepts** - Shared Server processes are created on the Oracle server machine for serving multiple users requests. As opposed to dedicated server mode, in which each user session is assigned a dedicated Server Process.
  The components of the Shared Server architecture are:
  User Process – a connection to the Oracle server machine.
  Oracle Net Listener - The Listener listens for incoming client requests for data or DML activity. When a request is detected, the listener assigns the request to the least busy Dispatcher Process.
  Dispatcher Process - Dispatchers are Oracle background processes that run on the Oracle server machine and accept incoming requests from User Processes. Up to Five dispatchers can run at one time.
  Request Queue - The queue, which the Dispatcher places requests received from User Processes. There is only one request queue. This queue is stored within the Oracle SGA.
  Shared Server Process - Shared Server processes are Oracle background processes that run on the Oracle server machine, interacting with the SGA on behalf of the User Processes. The maximum number of Shared Servers is OS specific.
  Response Queue - The queue, which the Shared Server processes place the results of their database activity. The Dispatcher processes then return these results to the User Process that initiated the request. Each dispatcher has one response queue. These queues are stored within the Oracle SGA.



  Implementing the Shared Server option generally only makes sense when the number of concurrent application users exceeds 200 or more users, depending on the Oracle server's memory and CPU resources. Since application users will be sharing Server, it is important that the application SQL perform short transactions. The application users should be utilizing the application in such a manner that occasional pauses occur in their activities (for example order entry systems).
  Configuring Shared Servers - Several init.ora Parameters need to be set:
  DISPATCHERS - specify the number of Dispatchers to spawn at instance startup and the Oracle Net protocol assigned to each Dispatcher. Valid values are 0 to 5.
  MAX_DISPATCHERS - specify the maximum number of Dispatcher processes allowed against the instance (default 5, maximum value is 5 or the value for DISPATCHERS, whichever is greater).
  SHARED_SERVERS - specify the number of Shared Server processes to spawn at instance startup. When set to a value of 0, the Shared Server option is disabled (minimum value 1).
  MAX_SHARED_SERVERS - specify the maximum number of Shared Server processes allowed against the instance (default 20 or 2 × value of SHARED_SERVERS).

CIRCUITS - specify the number of virtual circuits for handling incoming and outgoing network connections.
PROCESSES - specify the maximum number of OS processes that can access the instance.
DISPATCHERS and SHARED_SERVERS parameters are used to specify the number of Dispatchers and Shared Server process to spawn at instance startup. While Dispatcher processes must be explicitly started by the DBA using the ALTER SYSTEM command, Shared Server processes can be dynamically started and stopped by the PMON background process based on the demands placed on those resources by the connected application users.
Measuring Shared Server Performance – Several view contain Shared Server Information:
V$SHARED_SERVER view contains detailed statistics about the Shared Server processes, including idle and busy times for each Shared Server process.
V$QUEUE view contains information about contention for Shared Server Request and Response queues.
V$SHARED_SERVER_MONITOR view contains statistics regarding the Shared Server processes, including the Shared Servers that have been dynamically started and terminated by PMON since instance startup.
V$DISPATCHER view contains detailed statistics about the Shared Server Dispatcher processes, including idle and busy times for each Dispatcher process.
V$DISPATCHER_RATE view contains historical and real-time statistics regarding Dispatcher activity.
V$CIRCUIT view contains statistics about the path, or circuit, a User Process has taken through a Dispatcher, Request Queue, Shared Server, Response Queue, and back to the User Process again.
Monitoring Shared Server Process Performance – can be obtained through monitoring the rate the available server processes are servicing database requests. This ***busy ratio*** can be calculated using the V$SHARED_SERVER view (NAME - Shared Server process name, REQUESTS - Total number of requests that the Shared Server has serviced during the time it was running, BUSY - Total amount of time (in 100ths of a second) that the Shared Server was busy during the time it was running, IDLE - Total amount of time (in 100ths of a second) that the Shared Server was idle during the time it was running).
When User Processes make a database request, their requests are initially placed in the Request Queue by the Dispatcher process. If there are too few Shared Server processes, these requests may experience a delay while waiting to be serviced. These waits for access to a Shared Server process can be monitored using the V$QUEUE view (TYPE - queue type (DISPATCHER, COMMON), TOTALQ - number of items placed in the queue, WAIT - total time spent waiting for access to a Shared Server process, in 100ths of second).
Monitoring Dispatcher Performance - The performance of the Dispatcher processes can also be monitored using a "busy ratio". This ratio can be calculated using the V$DISPATCHER view using the following columns: NETWORK - protocol used by the Dispatcher (network address), STATUS - current status of the Dispatcher (WAIT (idle), SEND (sending a message), RECEIVE (receiving a message), CONNECT (establishing connection), DISCONNECT (disconnecting a session), BREAK (performing a break), TERMINATE (terminating a connection), ACCEPT (accepting connections), REFUSE (refusing connection)), OWNED - number of virtual circuits owned by this Dispatcher, BUSY - total time (in 100ths of second) that the Dispatcher was busy, IDLE Total time (in 100ths of second) that the Dispatcher was idle.
Another indication of Shared Server performance is the amount of time that User Processes are waiting to have their requests accepted by the Dispatchers. The V$QUEUE and V$DISPATCHER dynamic performance views can be used to calculate the average wait.
The waits indicated by the V$QUEUE and V$DISPATCHER views are a sign of Dispatcher contention. Additional evidence that contention for Dispatchers is occurring in the Shared Server environment can be determined by querying the V$DISPATCHER_RATE (NAME - Dispatcher name, CUR_IN_CONNECT_RATE - current Dispatcher service request rate, MAX_IN_CONNECT_RATE - maximum Dispatcher service request rate).
The V$SHARED_SERVER_MONITOR view gives an overview of the cumulative activity of the Shared Server environment. This view contains five columns:
MAXIMUM_CONNECTIONS - maximum number of virtual circuits used by Shared Servers since instance startup. MAXIMUM_SESSIONS - maximum number of Shared Server sessions that have been utilized since

instance startup. SERVERS_STARTED - number of additional Shared Servers, which were automatically started since instance startup (beyond the number of Shared Servers specified by the SHARED_SERVERS init.ora parameter). SERVERS_TERMINATED - Total number of Shared Servers that were automatically shut down by the Shared Server option since the instance was started. SERVERS_HIGHWATER - maximum number of Shared Servers running since the instance was started (both those that were started explicitly in the init.ora and those started implicitly by PMON).

Improving Shared Server Performance - Performance problems with the Shared Server architecture are usually related to one of the following areas: SGA components are not adequately sized for the Shared Server environment, Too few Shared Servers running to adequately service user requests, Too few Dispatchers are running to adequately service user requests.

Increase the Size of Related SGA Components – In shared server environment, the user session and cursor state information (e.g., bind variable values and session settings) resides inside the Shared Pool in the SGA under the Shared Server configuration, Thus forcing the DBA to increase the Shared Pool size.

Increasing the Number of Shared Servers - Whenever Shared Servers are unable to service the incoming requests, the PMON background process will dynamically start additional Shared Server processes, up to the limit specified by the MAX_SHARED_SERVERS value in init.ora. You can also explicitly add additional Shared Server processes either dynamically or manually:

<u>Dynamically Adding Additional Shared Servers</u> - by using the ALTER SYSTEM SET shared_servers = n;

<u>Manually Adding Additional Shared Servers</u> – by increasing the value for SHARED_SERVERS in the init.ora (requires instance restart).

Increasing the Number of Dispatchers - Dispatcher processes are not dynamically started. Additional Dispatchers can be added dynamically or manually:

<u>Dynamically Adding Additional Dispatchers</u> - by using ALTER SYSTEM SET dispatchers = 'protocol, n'; (protocol – the network protocol (i.e. TCP), n – number of dispatchers).

<u>Manually Adding Additional Dispatchers</u> - by increasing the value for DISPATCHERS in the init.ora (requires instance restart).

<u>Large Pool Concepts</u>

The Large Pool is an optional SGA structure, which can be used to process requests for optional features like Recovery Manager and Parallel Query.

Configuring the Large Pool - The LARGE_POOL_SIZE parameter defines the size of the Large Pool (default 0 unless PARALLEL_AUTOMATIC_TUNING parameter is set to TRUE, in which case the size of the Large Pool is set automatically). Once configured, the Large Pool’s memory area can be used to cache data related to: I/O slave processes for Database Writer, Backup and restore operations for Recovery Manager, Shared Server session data, Messaging information for the Parallel Query option.

When configuring the Large Pool manually, the minimum value allowed for LARGE_POOL_SIZE is 600K.

Measuring the Performance of the Large Pool - V$SGASTAT view displays how much space is allocated to the Large Pool (using POOL column).

Improving the Performance of the Large Pool - Large Pool size can be increases by sizing the value for LARGE_POOL_SIZE in the init.ora. The range of values for LARGE_POOL_SIZE is 600K to 2GB or more depending on operating system. The value of LARGE_POOL_SIZE cannot be changed dynamically using the ALTER SYSTEM command.

<u>Java Pool Concepts</u>

Oracle9i allows you to dedicate a portion of the SGA, called the Java Pool, as the location where session-specific Java code and application variables reside during program execution. Configuring the java pool correctly is critical to the successful performance of any Java-based Oracle application.

Configuring the Oracle Java Environment - The primary parameter is JAVA_POOL_SIZE, which is used to set the size of the SGA memory structure where most Java-related session data is cached during execution. SHARED_POOL_SIZE - Shared Pool memory is used by the JVM when Java classes are loaded and compiled and when Java resources in the database are accessed. JAVA_POOL_SIZE - All other Java-related session data is cached in the Java Pool memory structure (default 20M; valid values 1M-1G).

JAVA_SOFT_SESSIONSPACE_LIMIT - When memory is allocated to a Java process, the amount of memory requested is compared to this limit. If the request exceeds this limit, a message is written to a user trace file in the USER_DUMP_ DEST (default 0; maximum value 4GB). JAVA_MAX_SESSIONSPACE_SIZE - When memory is allocated to a Java process, the amount of memory requested is compared to this limit. If the request exceeds this limit, an out-of memory error (ORA-29554) occurs (default 0; maximum 4GB)
Measuring the Performance of the Java Pool - monitor java pool using V$SGASTAT (POOL column), STATSPACK output (performance of the Java Pool - java free memory).
Improving the Performance of the Java Pool - you can increase the size of the Java Pool by increasing the value for JAVA_POOL_SIZE in init.ora. The range of values for JAVA_POOL_SIZE is 1M to 1GB. The size of the Java Pool cannot be changed dynamically.

<u>7 - Tuning Redo Mechanisms</u>

- Oracle's redo mechanisms record the changes made to data so committed transactions can be '*redone*' in the event of a server failure or user error. Oracle's redo mechanisms consist of five components:
  Redo Log Buffer – A portion of the SGA, which records the information needed to redo transactions in the event of media failure or user error. These transactions may be DML statements as INSERT, UPDATE or DELETE, or DDL statements like CREATE, ALTER or DROP. Redo information is copied into the Redo Log Buffer by each user's Server Process.
  Log Writer (LGWR) – A background process, which is responsible for writing the contents on the Redo Log Buffer to the Online Redo Logs. Each instance has only one Log Writer.
  Database Checkpoints - A checkpoint event represents the moment in time when the database is in a consistent state. Checkpoints are important because, following instance failure, only those transactions that occurred after the last checkpoint have to be recovered during instance recovery.
  Online Redo Logs – A background process, which writes the contents of the Redo Log Buffer to physical files called Redo Logs. Every database must have a minimum of at least two Redo Log files. When LGWR fills the current Redo Log with redo information, LGWR switches to the next Redo Log group before writing the next batch of redo information.
  Archived Redo Logs - After LGWR has written to all the available Online Redo Logs, LGWR will start over by writing to the first Redo Log group again. If the data in this Redo Log is not preserved somehow, the redo information contained in the log will be lost, limiting your ability to perform a complete database recovery. However, a database operating in Archive Log Mode will not reuse an Online Redo Log until the Archiver (ARC0) background process has copied the contents of the log to the archive destination.
  <u>**Tuning the Redo Log Buffer**</u> – The Redo Log Buffer's management mechanism can be thought of as funnel, where transaction redo information enters at the top of the funnel and is then occasionally emptied out the bottom of the funnel by the LGWR background process. To keep up with the volume of incoming Redo Log Buffer entries, LGWR is prompted to write the contents of the Redo Log Buffer to disk whenever any of the following events occur: a COMMIT command is issued, every three seconds, the Redo Log Buffer is 1/3 full, Redo Log Buffer reaches 1MB and Whenever a database checkpoint occurs.
  The size of the Redo Log Buffer is determined by the LOG_BUFFER parameter.
  <u>**Measuring the Performance of the Redo Log Buffer**</u> - Performance is measured by the of the number and length of waits Server Processes experience when trying to place entries in the Redo Log Buffer. These waits can be viewed in the V$SYSSTAT and V$SESSION_WAIT views, STATSPACK output and UTLBSTAT/ESTAT output (REPORT.TXT).
  Using V$SYSSTAT to Measure Redo Log Buffer Performance – V$SYSSTAT contains 3 relevant statistics:
  redo buffer allocation retries - refers to the number of times a Server Process had to wait and then retry placing their entries in the Redo Log Buffer because LGWR had not yet written the current entries to the Online Redo Log.
  redo entries - reports the number of entries that have been placed into the Redo Log Buffer by the user Server Processes since instance startup.
  redo log space requests - measures how often LGWR is waiting for a Redo Log switch to occur when

moving from the current Online Redo Log to the next.
During a Redo Log switch, LGWR cannot empty the contents of the Redo Log Buffer. This may cause user Server Processes to experience a wait when trying to access the Redo Log Buffer. This wait generates a retry request. Therefore, high or increasing values for redo log space requests indicate that your Redo Logs may be too small. This can also indicate a problem with I/O contention.
Using V$SESSION_WAIT to Measure Redo Log Buffer Performance - V$SESSION_WAIT shows how long, and for which events, individual user sessions have waited. STATE column in V$SESSION_WAIT valid values: *WAITING* - The session is waiting at that moment, *WAITED UNKNOWN TIME* - Duration of the last wait is undetermined, *WAITED SHORT TIME* - The last wait lasted less than 1/100th of a second and *WAITED KNOWN TIME* - The value in the WAIT_TIME column is the actual wait time.
Using STATSPACK Output to Measure Redo Log Buffer Performance - Redo Log Buffer performance information appears in two different sections of the STATSPACK output file:
Instance Efficiency Percentages - indicates the Redo Log Buffer performance in terms of a ratio called the *Redo NoWait%* (percentage of time that user Server Processes did not experience a wait when attempting to place an entry in the Redo Log).
Instance Activity Stats - -contains the same statistical information found in the V$SYSSTAT dynamic performance view.
Using REPORT.TXT Output to Measure Redo Log Buffer Performance - contains a section that shows the same statistics related to Redo Log Buffer performance that are found in V$SYSSTAT and STATSPACK output.
Improving Redo Log Buffer Performance - The objective of Redo Log Buffer tuning is to make sure that user Server Processes have access to, and can place entries in, the Redo Log Buffer without experiencing a wait. These techniques fall into two categories:
Make It Bigger - The larger the Redo Log Buffer is, the less likely user Server Processes are to experience a wait when trying to place redo entries into the buffer. The size of the Redo Log Buffer is specified in bytes using LOG_BUFFER parameter (default 512KB, or 128KB × the number of CPUs whichever is greater). The range of values is 64K to an OS specific maximum. An acceptable tuning practice is to continue increasing the size of the Redo Log Buffer until the Redo Log Buffer Retry Ratio shows no further improvement or the value for the statistic log buffer space in V$SESSION_WAIT ceases to diminish.
Reduce redo generation - This technique is implemented using one of the following methods:
UNRECOVERABLE - this keyword is used when creating a table using the CREATE TABLE AS SELECT. Tables created in this manner do not generate any redo information for the inserts generated by the CREATE statement’s sub-query. However, any subsequent DML on the table will generate entries in the Redo Log Buffer. By default, all tables created using the CREATE TABLE AS SELECT are recoverable.
NOLOGGING - Like UNRECOVERABLE, the NOLOGGING option also allows you to specify, which tables should skip generating redo entries for certain types of DML. However, unlike UNRECOVERABLE, NOLOGGING is an attribute of the table that stays in effect until you disable it. You can specify the NOLOGGING attribute at either table creation, or after creation using the ALTER TABLE statement. Once the NOLOGGING attribute is set on a table, redo entry generation will be suppressed for all subsequent DML on the table only when that DML is of the following types: Direct Path loads using SQL*Loader or Direct load inserts using the /*+ APPEND */ hint. In addition to the CREATE TABLE and ALTER TABLE, the following commands can also be used with the NOLOGGING: CREATE TABLE AS SELECT, CREATE INDEX, ALTER INDEX REBUILD and CREATE TABLESPACE.
Tuning Checkpoints - A checkpoint event represents the moment in time when the database is in a consistent state. Checkpoints are important because, if instance failure occurs, only transactions that occurred after the last checkpoint have to be recovered.
There are two types of checkpoints: incremental and full.
When an *incremental checkpoint* occurs, the following actions take place:
The CKPT updates the control file headers immediately with then SCN and the Redo Log sequence.
When a *full checkpoint* event occurs, the following actions occur in the database:

DBW0 writes all buffers in the Buffer Cache containing committed transactions to disk.
LGWR writes all the contents of the Redo Log Buffer to the Online Redo Log files.
The CKPT updates the control file headers.
Database checkpoints occur whenever the instance is shutdown (except ABORT), the Online Redo Log switches from the current log to the next, the DBA issues the ALTER SYSTEM CHECKPOINT command, when a tablespace is placed into hot backup mode using the ALTER TABLESPACE … BEGIN BACKUP command or when a tablespace is taken offline. (This checkpoint is a special form of the complete checkpoint referred to as a full tablespace checkpoint. During this type of checkpoint, only the dirty buffers belonging to the tablespace in hot backup mode are written to disk) and when the value specified by the init.ora parameter FAST_START_MTTR_TARGET is exceeded.
Measuring the Performance of Checkpoints - It is important to monitor checkpoint activity because too many checkpoints causes unnecessary I/O and too few checkpoints exposes the database to longer instance recovery times. Checkpoint performance information can be gathered from V$SYSTEM_EVENT and V$SYSSTAT views, STATSPACK, REPORT.TXT, the Alert log and the OEM Performance Manager.
Using V$SYSTEM EVENT to Measure Checkpoint Performance - Occasionally, checkpoint events are started, but do not complete successfully because a second checkpoint request occurs very soon after the first. You can detect checkpoints that are started but not completed by querying the *checkpoint incomplete* statistic in V$SYSTEM_EVENT. This view reports the number of waits that have occurred since instance startup for a variety of events and contains these columns:
EVENT - name of the event associated with the wait, TOTAL_WAITS - total number of times a wait occurred for this event & AVERAGE_WAIT - The average time, in 100ths of a second, spent waiting for this event.
Two events found in the V$SYSTEM_EVENT view, are indicators of checkpoint performance:
Checkpoint Completed - This event shows how often waits occurred for the checkpoint to complete its activities. High or steadily increasing values for this event indicate that checkpoints need to be tuned.
Log File Switch (Checkpoint Incomplete) - This event shows how often the Online Redo Log switched from one log to the next, before the checkpoint from the previous log switch had time to complete. When this occurs, the in-progress checkpoint is abandoned and a new checkpoint is begun. (Because incomplete checkpoints cause excess I/O that do not provide any recovery benefits, checkpoint activity should be tuned).
Another indicator can be found in the V$SYSSTAT view. Two statistics, *background checkpoints started* and *background checkpoints completed*, can be used to determine whether all the checkpoints that were started, actually completed.
Using STATSPACK and REPORT.TXT to Measure Checkpoint Performance - The output in both files, show the background checkpoints started and background checkpoints completed events.
Using the Alert Log to Measure Checkpoint Performance - The Alert log records the Redo Logs switches and shows if they are switching too fast and not allowing enough time for a checkpoint that has been started to complete normally. In this case the 'Checkpoint not complete' message will appear.
Using Performance Manager to Measure Checkpoint Performance - The Performance Manager component of OEM can also monitor the performance of checkpoint activity. The Average Dirty Queue Length option of the Performance Manager I/O feature indicates how often checkpoint activity is occurring.
Improving Checkpoint Performance - The techniques for tuning database checkpoint activity fall into two categories:
Make it bigger - increase the size of the Redo Logs. Since checkpoints occur at every log switch increasing the redo logs size will reduce the number of checkpoints. Since Redo Logs cannot be altered to a larger size, the only way to increase their size is to add new logs with a larger size, and then drop the original, smaller logs.
Adjust checkpoint-related init.ora parameters - Checkpoint has two purposes: assure that all buffers in the Database Buffer Cache that contain committed transactions are written to disk and limit instance recovery time by recording that fact in the headers of the datafiles and control files.

Using FAST_START_MTTR_TARGET, you can specify a mean time (in seconds) to recover the instance following an instance failure (Valid values are 0-3,600 seconds). Oracle will perform additional checkpoints, beyond the ones performed at a log switch, in order to ensure that the checkpoints are happening frequently enough to meet the recovery target. If FAST_START_IO_TARGET and LOG_CHECKPOINT_INTERVAL parameter are used, the FAST_START_MTTR_TARGET parameter is ignored.
V$INSTANCE_RECOVERY view helps monitor the FAST_START_MTTR_TARGET effectiveness. The view contains these columns: TARGET_MTTR - the target Mean Time to Recover and ESTIMATED_MTTR - the estimated mean time to recover the instance if it were to fail at that moment.
Similar information can be retrieved from STATSPACK output under Instance Recovery Stats section.
Tuning Online Redo Log Files - Tuning Redo Log performance is critical to ensure not only optimal performance, but also optimal recovery.
Measuring the Performance of Redo Logs - V$SYSTEM_EVENT view and OS utilities can be useful when monitoring Redo Log performance.
Using V$SYSTEM_EVENT to Measure Redo Log Performance – The view shows statistics on two related events: *log file switch completion* - this event indicates the amount of time that LGWR waited for a log switch to complete. *log file parallel write* – this event indicates how long it took for LGWR to write the redo entries from the Redo Log Buffer to the Online Redo Logs.
High or increasing values for both events can indicate Redo Logs contention.
Using OS Utilities to Measure Redo Log Performance - OS utilities often help monitor I/O activity on disk devices. The Unix utilities ***sar*** and ***iostat*** are both useful for monitoring disk I/O on the devices where Redo Logs are located.
Improving Redo Log Performance - is done through applying two rules:
Minimizing Redo Log Contention - separate redo logs from other database files (like Datafiles, Control Files, and Archive Logs) and **Maximizing Redo Log Throughput** - place redo logs on the fastest devices available. Placing the Redo Logs on fast devices will allow LGWR to perform its writes as quickly as possible.
Tuning Archiving Operations - a primary bottleneck for the Redo Log Buffer performance is the frequency and efficiency with which the archive background process (ARC0) copies the contents of the Redo Log files to the archive destination when the database is operating in archive log mode.
If LGWR needs to write to a Redo Log that is currently being archived by ARC0, LGWR will wait until ARC0 finishes copying the Redo Log’s contents to the archive destination .
To reduce the likelihood of this occurrence, LGWR will automatically start additional archive background processes (ARC1, ARC2, etc.) when demands on the system warrant them. However, two areas related to the archiving process can also cause performance problems:
The archive destination fills with archived logs, causing database processing to halt until additional space is made available.
The ARC0 background process does not keep up with the Redo Log switching activity, causing a wait to occur when the Redo Logs wrap before ARC0 has completed archiving the contents of the log. These events can be monitored using the V$ARCHIVE_DEST, V$ARCHIVE_PROCESSES, and V$SYSTEM_EVENT views.
LOG_ARCHIVE_DEST or LOG_ARCHIVE_DEST_n (n in 1-10) parameters specify the location of the archived Redo Log. When the archive destination becomes full, the database processing halts. The database will remain halted until space is made available in the archive location or archiving is moved to another location using ALTER SYSTEM ARCHIVE LOG ALL TO '*location*'.
ARC0 Processes Causing Waits at Log Switch - If the Redo Logs are filling and switching too frequently, LGWR may wrap around and try to write to a Redo Log that has not yet been archived by ARC0. The LGWR will hang for a moment until the Redo Log has been archived and becomes available. To prevent this, LGWR automatically starts new Archive processes. The DBA can also start additional Archiver processes at instance startup by setting the LOG_ARCHIVE_MAX_PROCESSES parameter to a value between 2 and 10 (1 is the default). V$ARCHIVE_PROCESSES view shows the status of each Archiver process and whether it is currently busy or idle.

Improving the Performance of Archiving -

Add More - Every Oracle database must have at least two Redo Log groups. By adding additional Redo Log groups to your database, you decrease the likelihood that LGWR will wait for archiving to end.

Make it Bigger - In addition, increasing the redo logs size can also cut down on the frequency of log switches. Oracle recommends that a log switch take place approximately every 20 to 30 minutes.

Several init.ora parameters ensure the database will no halt due to filled archive location:

LOG_ARCHIVE_DUPLEX_DEST - By setting this parameter, ARC0 is instructed to write archived Redo Logs to both locations. When used in conjunction with LOG_ARCHIVE_MIN_SUCCEED_DEST, ARC0 can continue to archive Redo Log files even if one of the two locations is full.

LOG_ARCHIVE_DEST_n - By setting this parameter, ARC0 is instructed to write archived Redo Logs to multiple locations. These locations can be local or remote.

LOG_ARCHIVE_MIN_SUCCEED_DEST - When used with LOG_ARCHIVE_DUPLEX_DEST and LOG_ARCHIVE_DEST_n, this parameter specifies the number of locations to which ARC0 must be able to successfully write archive log files before an error is raised (default 1, valid values are 1 or 2 for LOG_ARCHIVE_DUPLEX_DEST, or between 1-5 when used with LOG_ARCHIVE_DEST_n).

LOG_ARCHIVE_DEST_STATE_n - is specified for each corresponding LOG_ARCHIVE_DEST_n parameter and its valid values are ENABLE or DEFER.

Create Additional ARC0 Processes - LGWR starts additional Archiver processes the current number does not meet the instance's archiving needs. Additional Archiver processes are started by using the LOG_ARCHIVE_MAX_PROCESSES parameter in the init.ora. The number of Archiver processes to start is somewhat dependent upon the number of archive destinations you have specified and the speed of the devices that are behind those locations (default 1).

The V$ARCHIVE_PROCESSES view shows the number and activity of multiple Archiver processes and contain these columns: PROCESS - Identifies which of the 10 Archiver processes the statistics are associated with. STATUS - Archiver process status. Valid values are STOPPED, SCHEDULED, STARTING, ACTIVE, STOPPING, TERMINATED. LOG_SEQUENCE - The Redo Log sequence number that is currently being archived. STAT - current state of the Archiver process (IDLE or BUSY).

8 - Tuning Disk I/O

- Nearly every action that occurs in the database will result in some type of I/O activity. That I/O activity can either be logical (in memory) or physical (on disk). All of the following activities can be the source of disk I/Os: Database Writer (DBW0) writing data buffers from the Database Buffer Cache to the database's Datafiles. DBW0 writing data to rollback segment blocks to maintain read consistency. Server Processes reading data blocks into the Database Buffer Cache. Log Writer (LGWR) writing transaction recovery information from the Redo Log Buffer to the online redo log. Archiver (ARC0) reading the contents of Redo Logs and writing those contents to the archive destination. Application user activity temporarily writing large sort requests to disk.

  The goals when tuning physical I/O are generally these: Minimize physical I/O by properly sizing the SGA and perform any remaining physical I/O as fast as possible when it is required.

  Tuning Tablespace and Datafile I/O - Every database segment is stored within a logical structure called a Tablespace. Every database has at least one tablespace, SYSTEM, which is used to store the Oracle data dictionary tables and indexes. Several tablespaces will be created later for application data and index data. Temporary tablespace will be created also and will be used for sort operations. Undo tablespace is required also for the use of undo segments.

  Each tablespace is comprised of one or more physical files called Datafiles. The actual I/O occurs against the Datafiles, therefore, the number and location of the physical Datafiles are an important area of tuning consideration. In particular, try to minimize disk contention by placing Datafiles for the various tablespaces on different disk drives, volume groups, or disk controllers in order to maximize I/O performance.

  Measuring Datafile I/O - can be done using the V$FILESTAT and V$DATAFILE views, the output from STATSPACK, REPORT.TXT and the output from the OEM Performance Manager GUI tool.

Using V$FILESTAT, V$DATAFILE, and V$TEMPFILE to Measure Datafile I/O - these views can be used to monitor the performance of the read and write activity against the individual Datafiles and tablespaces in the database. *V$FILESTAT* view contains these columns: FILE# - The Datafile's internal identifier, PHYRDS   number of physical reads, PHYWRTS - number of physical writes, AVGIOTIM - average time, in milliseconds, spent performing I/O, MINIOTIM - minimum time, in milliseconds, spent performing I/O, MAXIOWTM - maximum time, in milliseconds, spent writing to that Datafile, MAXIORTM - maximum time, in milliseconds, spent reading from that Datafile.
V$DATAFILE view contains these columns: FILE# - The Datafile's internal identifier, NAME - the fully qualified path and name of the Datafile. *V$TEMPFILE* view contains these columns: FILE# - The Datafile's internal identifier, NAME - the fully qualified path and name of the Datafile.
Using STATSPACK and REPORT.TXT to Measure Datafile I/O – The STATSPACK report contains tablespace I/O statistics under the *Tablespace IO Stats* section. The REPORT.TXT reports the sum of IO operations over tablespaces.
Using Performance Manager to Measure Datafile I/O - The Performance Manager component of the Oracle Enterprise Manager Diagnostics Pack includes several graphical representations of Datafile I/O performance.
Improving Datafile I/O - Once statistics about Datafile I/O have been gathered, there are several techniques to enhance the performance of each disk I/O related to Datafiles:
Minimizing Non-Oracle I/O - Do not place non-Oracle files on the same disk drives or logical volumes as the Datafiles. Placing non-Oracle files on the same disk as the Datafiles may cause contention for those disk resources.
Using Locally Managed Tablespaces - Locally Managed Tablespace (LMT) uses a bitmap stored in the header of each of the tablespace's Datafiles instead of using Free Lists in the data dictionary to manage the allocation of space within the tablespace. This allows LMTs to allocate and de-allocate space from the tablespace more quickly, without having to access the data dictionary in the SYSTEM tablespace.
Balancing Datafile I/O - Allocate storage for segments to the appropriate tablespaces. Excessive I/O on the SYSTEM tablespace Datafiles can indicate that non-data dictionary segments may be stored in the SYSTEM tablespace.
The separation of temporary segment and rollback segment tablespaces from the SYSTEM tablespace is important for both tuning and management purposes, as is separating application tables from their associated indexes. This technique helps improve performance on busy OLTP systems when tables and their associated indexes are having their blocks read while the blocks are also having rows inserted into them. Segregating segments by functional area or size is also important. Redo Logs and Control Files should be separated from Datafiles too, because their I/O characteristics are different:
Control Files - The Database Writer and Checkpoint background processes write to the Control Files. The Archiver background process reads from the Control Files during a database recovery. Since Control Files I/Os are brief, they can be placed almost anywhere without impacting performance.
Datafiles - The DBW0 process writes to Datafiles. The Server Processes reads Datafiles. Separating System, temporary, and rollback segment Datafiles from application table and index Datafiles will help enhance performance.
Redo Logs and Archived Redo Logs - Redo Logs are written to in a sequential fashion by the LGWR process. Redo Logs are also read by the ARC0 process during archiving. Archived Redo Logs are written to by the ARC0 at a log switch. Datafiles should be separated from Redo Logs not only for recovery purposes, but also because Datafile I/O is generally random whereas Redo Log I/O is sequential. Redo Logs and the archived Redo Logs should not be placed on the same device.
Background and User Trace Files - Background and user trace files are written to the directories specified by BACKGROUND_DUMP_DEST and USER_DUMP_DEST parameters. Trace files can be generated by any of the Oracle background processes and by user Server Processes. Since these I/Os tend to be very short, these files haves a negligible impact on performance.

Performing Datafile I/O Quickly to Improve Performance - Performing Datafile I/O quickly is achieved in three ways:
Placing high I/O Datafiles on separate disk drives and controllers: I/O performance can be improved by ensuring that several devices are used to store several Datafiles and that these devices are attached to several separate disk controllers.
Datafile Striping - When a Datafile is striped, it is stored across several devices, not just one. This increases I/O performance because multiple sets of disk drive heads are brought into use when a read or write of the Datafile is required. The easiest way to stripe a Datafile is to store the Datafile on a RAID device (Redundant Array of Independent Disks, consists of several physical disks that can be managed and accessed as if they were one or more physical devices). Datafiles can also be manually striped across devices in the absence of a RAID array. Manual striping is accomplished by creating a tablespace made up of several Datafiles, where each Datafile is placed on a separate physical device. Next, a segment is created. In order to strip the segment's extents across the datafiles, you can use ALTER TABLE table_name ALLOCATE EXTENT (DATAFILE 'file_name' SIZE nK/M).
Tuning DB_FILE_MULTIBLOCK_READ_COUNT – This parameter, determines the maximum number of database blocks that are read in one I/O operation by a Server Process whenever a full table scan is performed (default 8). The maximum value for this parameter varies by OS. By increasing this parameter, more blocks are accessed with each I/O, thereby cutting down on the total I/Os required to scan an entire table. V$SYSSTAT view holds the table scans (long tables) statistic, which shoes the number of Full Table Scans that occurred since instance startup. Another view useful for monitoring full table scan operations is the V$SESSION_LONGOPS view, which shows activity associated with selected long-running operations like snapshot refreshes, recovery operations, and parallel query jobs.
<u>**Tuning DBW0 Performance**</u> - DBW0 is responsible for writing buffers from the Database Buffer Cache to the database Datafiles. DBW0 performs this write activity at database checkpoints and when Server Processes are searching free buffers in the Database Buffer Cache. Tuning Database Writer's I/O activity is an important aspect of tuning the database's overall disk I/O.
Measuring DBW0 I/O - The V$SYSTEM_EVENT and V$SYSSTAT views, STATSPACK output and REPORT.TXT can be used to determine whether DBW0 is experiencing any difficulty while performing write requests.
Using V$SYSTEM_EVENT to Measure DBW0 Performance – Several events indicate DBW0 I/O performance:
buffer busy waits - indicates that waits are being experienced for buffers in the Database Buffer Cache, due to inefficient writing of dirty buffers by DBW0.
db file parallel write - indicates DBW0 may be experiencing waits when writing many blocks in parallel, due to a slow device on which the Datafiles reside, or the fact that DBW0 cannot keep up with the write requests it is being asked to perform.
free buffer waits - indicate that Server Processes have been experiencing waits when moving dirty buffers to the Dirty List while searching the LRU for a free buffer.
write complete waits – indicates that user sessions have been experiencing waits for buffers to be written from the Database Buffer Cache by DBW0.
Using V$SYSSTAT to Measure Database Writer Performance - V$SYSSTAT view is also a good source for measuring the performance of DBW0:
redo log space requests - indicates that a wait occurred for a redo log to become available following a log switch. Since log switch is followed by a checkpoint, both DBW0 and LGWR have to write buffers from the Database Buffer Cache and Redo Log Buffer respectively, before LGWR can start writing to the next redo log. If DBW0 is not writing fast enough, redo log space requests may result.
DBWR buffers scanned – indicates the total number of buffers in the Database Buffer Cache that were examined in order to find dirty buffers to write. Since DBW0 performs this action, DBW0 may perform writes ineffectively if it is busy examining the LRU List for dirty buffers when it is signaled to write.
DBWR lru scans – indicates the total number of buffers examined in the LRU dirty list.

Using STATSPACK and REPORT.TXT to Measure Database Writer Performance - STATSPACK output and REPORT.TXT contain wait event information related to Database Writer in the System Activity Stats and System wide wait event for background processes respectively.

Improving DBW0 I/O - Two init.ora parameters are used to tune the performance of DBW0's activities:
DBWR_IO_SLAVES - specifies the number of Database Writer slaves to start at startup (default 0).
The naming convention for the DBW0 slave processes on Unix is: ora_i101_PROD, ora_i102_PROD…
Database Writer slave processes are similar to the DBW0 process itself, except they can only perform write operations. The purpose of these slaves is to simulate asynchronous I/O on systems that only support synchronous I/O. After configuring the I/O slaves, DBW0 will coordinate assigning I/O requests to each of the slave processes. If all available slave processes are busy when an I/O request is made, then DBW0 will spawn additional processes—up to the limit specified by DBWR_IO_SLAVES parameter. If no I/O slaves are available when a request is made, a wait will result. Any time Database Writer spawns I/O slave processes, other background process that perform disk I/O (i.e., LGWR, ARC0 and RMAN) will also have I/O slaves created to support their I/O activities.

Configure and use multiple DBW processors - While DBW0 slaves can help improve I/O performance, they are not able to perform all the functions of DBW0 (like manage Dirty and LRU Lists). You can start additional, Database Writer processes using the DB_WRITER_PROCESSES parameter (default 1, maximum 10). Multiple Database Writer processes generally have better throughput than Database Writer I/O slaves. If the Buffer Cache wait events are strictly related to DBW0 I/O activity, then starting I/O slaves is appropriate. If the Buffer cache wait events are occurring for activities related to internal Buffer Cache management (i.e., free buffer waits events), then starting multiple Database Writer processes to handle those structures would be more suitable.

Tuning Segment I/O - Oracle segments (e.g., tables and indexes) store their data in tablespaces, which are made up of one or more of physical Datafiles. Each Datafile is in turn made up of individual database blocks. These blocks store the actual data for each segment and represent the smallest unit of I/O that can be performed against a Datafile. When a segment is created, it is allocated a chunk of contiguous blocks, called an extent.

Understanding Oracle Blocks and Extents - In Oracle9i, there are two block sizes to consider:
The first is the Primary Block Size - is set at database creation and is specified in bytes by the DB_BLOCK_SIZE parameter. The only way to change the primary block size is to re-create the database.
The second is the local block size associated with an individual tablespace during creation using the BLOCKSIZE keyword. If BLOCKSIZE is omitted at tablespace creation, the tablespace will use the primary block size.
An extent is a collection of contiguous Oracle blocks. When a segment is created, it will be assigned at least one extent called the initial extent. When a segment is dropped, its extents are released back to the tablespace.

Each Oracle block is divided into three sections:
Block header area - store header information about the contents of that block. Header information includes the transaction slots specified by the INITRANS parameter at table creation, a directory of the rows that are contained within the block, and other general header information needed to manage the contents of the block. This block header information generally consumes between 50 to 200 bytes of the block's total size.
Reserved space - using PCTFREE, you can specify how much space is reserved in each block for updates. This value is specified as a percentage of the overall size of the block. Once a block is filled with data to the level of PCTFREE, the block will no longer accept new inserts, leaving the remaining space for update operations. The process of removing a block from the list of available blocks is performed by the table's Free List. Whenever a Server Process wants to insert a new row into a segment, it searches the Free List to find the block ID of a block that is available to accept the insert. If the subsequent insert should cause the block to fill to above the PCTFREE value, the block is taken off the Free List. A block stays off of the Free List until enough data is deleted so that the block's available space falls below that specified by PCTUSED. The default values for

PCTFREE and PCTUSED are 10 percent and 40 percent respectively.
Free space - The remaining space in the segment block is free space that is used to store the row data for the segment. The number of rows that will fit into each block is dependent upon the size of the block and the average row length of the data stored in that segment.
Improving Segment I/O - The goal is to minimize the number of blocks that must be accessed in order to retrieve requested data. Key areas related to improving segment I/O include:
The cost associated with dynamic extent allocation - When all the available extents assigned to a segment are full, the next insert operation will cause the segment to acquire a new extent. On traditional dictionary-managed tablespaces, this dynamic allocation of segment extents incurs undesirable I/O overhead due to queries that Oracle must perform against the data dictionary. One way to avoid this issue is to use locally managed tablespaces. Another way to avoid dynamic extent allocation is to identify tables and indexes that are close to needing an additional extent, and then assigning them additional extents manually using ALTER TABLE table_name ALLOCATE EXTENT.
The performance impact of extent sizing - Larger extent sizes offer slightly better performance than smaller extents because they are less likely to dynamically extend and can also have all their locations identified from a single block (called the extent map) stored in the header of the segment's first extent. Large extents also perform better during full table scan operations because fewer I/Os are required to read the extents (when DB_FILE_MULTIBLOCK_READ_COUNT is set properly). The disadvantages of large extents sizes are the potential for wasted space within tablespaces and the possibility that there may not be a large enough set of contiguous Oracle blocks available when an extent is required.
The performance impact of block sizing - The appropriate block size for your system will depend on your application, OS specifications, and available hardware. Generally, OLTP systems use smaller block sizes for these reasons: Small blocks provide better performance for random-access nature. Small blocks reduce block contention, since each block contains fewer rows. Small blocks are better for storing the small rows (that are common in OLTP systems). However, small block sizes add to Database Buffer Cache overhead because more blocks must generally be accessed, since each block stores fewer rows. Conversely, DSS systems use larger block sizes for these reasons: Large blocks pack more data and index entries into each block. Large blocks favor the sequential I/O common in most DSS systems. However, larger block sizes also increase the likelihood of block contention and require larger Database Buffer Cache sizes to accommodate all the buffers required to achieve acceptable Database Buffer Cache hit ratios.
How row chaining and migration affect performance - *Row Chaining* occurs when a row that is inserted into a table exceeds the size of the database block, causing the row to spill over into two or more blocks. Row chaining is bad for performance because multiple blocks must be read to return a single row. The only way to fix a chained row is to either decrease the size of the insert or increase the Oracle block size. *Row migration* occurs when a previously inserted row is updated with a value larger than the space available in the block specified by PCTFREE causing the Oracle Server to move (or migrates) the row to a new block. When migration occurs, a pointer is left at the original location, which points to the row's new location in the new block. Row migration is bad for performance because Oracle must perform at least two I/Os (one on the original block, and one on the block referenced by the row pointer) in order to return a single row. Row migration can be minimized by setting PCTFREE to an appropriate value. There are two techniques for determining whether row chaining and/or migration are occurring in your database: examining the CHAIN_CNT column in DBA_TABLES and the presence of the *table fetch continued row* statistic in V$SYSSTAT. This statistic is also found in the STATSPACK and REPORT.TXT under Instance Activity Stats.
The role of the High Water Mark during full table scans - As a segment uses the database blocks allocated to its extents, the Oracle Server keeps track of the highest block ID that has ever been used to store segment data. This block ID is called the High Water Mark (HWM). The HWM is significant because a Server Process reads all the segment blocks up to the HWM when performing a full table scan. Since the HWM does not move when rows are deleted from a segment, many empty blocks may end up

being scanned during a full table scan. If the segment is static, the space above the HWM will be wasted. After using the ANALYZE command, the EMPTY_BLOCKS column in DBA_TABLES will show the number of blocks that a table has above its HWM. This unused space can be released using the ALTER TABLE table_name DEALLOCATE UNUSED command or using the DBMS_SPACE.UNUSED_SPACE procedure.

Tuning Sort I/O - Sorting occurs whenever data must be placed in a specified order. A sort can take place in one of two locations: in memory or on disk. Sorts in memory are the least expensive in terms of performance. Sorts to disk are the most expensive because of the extra overhead of the disk I/Os. The primary tuning goal with regard to sorting is to minimize sort activity. The types of SQL statements that can cause database sorts are: ORDER BY, GROUP BY, SELECT DISTINCT, UNION, INTERSECT, MINUS, ANALYZE, CREATE INDEX and Joins between tables on non-indexed columns.

The amount of memory reserved for sorts in each Server Process is determined by 4 parameters:

SORT_AREA_SIZE - specify how much memory is reserved for each Server Process should to perform in-memory sort operations. The default value for SORT_AREA_SIZE is OS-dependent. The minimum size is equivalent to six Oracle blocks. The maximum size is OS-dependent. The SORT_AREA_SIZE parameter can be set at instance level (in init.ora or by issuing the ALTER SYSTEM SET SORT_AREA_SIZE=n DEFERRED command) or at session level (by using the ALTER SESSION SET SORT_AREA_SIZE=n command).

SORT_AREA_RETAINED_SIZE - specify how much memory each Server Process reduces its memory for the final fetch. The default value is equal to SORT_AREA_SIZE. The minimum size is the equivalent of two Oracle blocks. The maximum size is limited to the value of SORT_AREA_SIZE.

The parameter can be set in init.ora, by using the ALTER SYSTEM SET SORT_AREA_RETAINED_SIZE=n DEFERRED command, or by using the ALTER SESSION SET SORT_AREA_RETAINED_SIZE=n command.

PGA_AGGREGRATE_TARGET - this parameter can be used to establish an upper boundary on the maximum amount of memory that all user processes can consume while performing database activities, including sorting (default 0). Valid values range from 10MB to 4000GB.

WORKAREA_SIZE_POLICY - used to determine if the overall amount of memory, assigned to all user processes, is managed explicitly or implicitly. When set to the default value of MANUAL, the size of each user's sort area will be equivalent to the value of SORT_AREA_SIZE for all users. When set to a value of AUTO, Oracle will automatically manage the overall memory allocations so that they do not exceed the target specified by PGA_AGGREGATE_TARGET.

Measuring Sort I/O - Sort activity can be monitored using the V$SYSSTAT and V$SORT_SEGMENT views, using the output from STATSPACK and REPORT.TXT, and using the output from the OEM Performance Manager.

Using V$SYSSTAT to Measure Sort Activity - The V$SYSSTAT dynamic performance view has two statistics, sorts (memory) and sorts (disk), that can be used to monitor sort user activity.

Using STATSPACK Output and REPORT.TXT to Measure Sort Activity - STATSPACK utility shows similar sort statistics. These statistics can be found in several areas of the STATSPACK report (under Instance Efficiency Percentages). REPORT.TXT also contains sort activity information.

Using OEM Performance Manager to Measure Sort Activity - The Performance Manager includes several graphical representations of sort performance.

Improving Sort I/O - Sort activity can cause excessive I/O when performed in disk instead of memory. There are several possible methods of improving sort performance, including:

Avoiding SQL statements that cause sorts - minimize the number of sorts being performed by application code, ad-hoc queries, and DDL activities:

SQL Statement Syntax - use of the UNION ALL operator instead of the UNION operator. Avoid using the INTERSECT, MINUS, and DISTINCT keywords.

Use Indexes - Indexing columns that are referenced by ORDER BY and GROUP BY clauses in application SQL statements can minimize unnecessary sorting.

Index Creation Overhead - eliminate the sort that normally occurs during index creation by using the NOSORT option of the CREATE INDEX command.

Statistics Calculation - Overhead Sorts can occur whenever table and index statistics are gathered. Consider using the ESTIMATE option instead COMPUTE of when gathering table and index statistics to

minimize the overhead associated with this process. Gather statistics for only columns that are relevant to the application SQL by using the ANALYZE ... FOR COLUMNS command.
Make It Bigger - minimize the number of sorts that are done to disk by increasing the value of SORT_AREA_SIZE. While the amount of memory specified by SORT_AREA_SIZE is not allocated to a session until they initiate a sort, the server's available memory must be sufficient to accommodate the user's sort area while the sort is being processed. If SORT_AREA_SIZE is set to a large value and many users are sorting simultaneously, the demands placed on the server's memory may impact performance until the memory is released when the sorts are complete. Decreasing the size of SORT_AREA_RETAINED_SIZE when SORT_AREA_SIZE is increased will help minimize the problem of excessive memory usage related to sorting.
Making proper use of temporary tablespaces - When a Server Process writes a sort chunk to disk, it writes the data to the user's temporary tablespace. This tablespace, although it is referred to as the user's temporary tablespace, can be either permanent (contain permanent segments like tables and indexes, as well as multiple temporary sort segments owned by each Server Process) or temporary (contain only a single temporary segment, that is shared by all users performing sorts to disk). Dynamic management of individual sort segments is expensive both in terms of I/O and recursive data dictionary calls. The sort segments in the temporary tablespace are not dropped when the user's sort completes. Instead, the first sort operation following instance startup creates a sort segment that remains in the temporary tablespace for reuse by subsequent users who also perform sorts to disk. This sort segment will remain in the temporary tablespace until instance shutdown.
Improving the reads related to sort I/O – 2 views allow monitoring on sort segments:
V$SORT_SEGMENT - The view allows you to monitor the size and growth of the sort segment that resides in the temporary tablespace. The sort segment will grow dynamically as users place demands on it.
V$SORT_USAGE - The view allows you to see which individual users are causing large sorts to disk.
Tuning Rollback Segment I/O - rollback segments play a critical role in every database DML transaction because they store the before-image of changed data.
The before-image data stored in the rollback segment is used for three important purposes:
It can be used to restore the original state of the data by issuing a ROLLBACK command.
It provides a read-consistent view of the changed data to other users who access the same data prior a COMMIT command is issued.
It is used during instance recovery to undo uncommitted transactions that were in progress just prior to an instance failure.
Rollback segments are made up of extents, which are in turn comprised of contiguous Oracle blocks. Within each rollback segment, Oracle uses the extents in a circular fashion until the rollback segment is full. Once the rollback segment is full, no new transactions will be assigned to it until some of the rollback segment space is released by using COMMIT or ROLLBACK commands. A single rollback segment can store before-images for several different transactions. However, a transaction writes its before-image information to only one rollback segment. Once a transaction is assigned to a rollback segment, the transaction never switches to a different rollback segment. If the before-image of a transaction grows to fill that extent, the transaction will wrap into the adjacent extent. Unless you ask for a specific rollback segment using the SET TRANSACTION USE ROLLBACK SEGMENT command, the Oracle Server assigns transactions to rollback segments. The total number of transactions a rollback segment can handle is dependent on the Oracle block size.
The goals of rollback-segment tuning usually involve the following: Make sure database users always find a rollback segment to store their transaction before-images without experiencing a wait.
Make sure that database users always get the read-consistent view.
Make sure database rollback segments do not cause unnecessary I/O.
Measuring Rollback Segment I/O - There are four areas that you should monitor when trying to tune the performance of rollback segments:
Rollback segments header contention - each rollback segment uses a transaction table stored in its header block to track the transactions that use it. The header block is generally cached in the

Database Buffer Cache so that all users can access it when trying to store their transaction before-images. On a busy OLTP system, users may experience a wait for access to these rollback segment header blocks, thereby causing their transaction performance to decline. '*undo segment tx slot*' statistic in V$SYSTEM_EVENT, '*undo header*' and '*system undo header*' classes in V$WAITSTAT and V$ROLLSTAT view (columns USN (undo segment number), GETS (number of times a Server Process succeeded in accessing the rollback segment header) and WAITS (number of times a Server Process needed to access the rollback segment header and experienced a wait)) indicate rollback segment header block contention. STATSPACK and REPORT.TXT also show rollback segment header block contention information at Rollback Segments Stats and buffer busy wait statistic on the rollback segment undo header respectively.

Rollback segment extent contention - indicate waits occurring for access to the blocks within the individual extents of each rollback segment. V$WAITSTAT 'undo block' and 'system undo block' classes display information about RBS extent contention. V$SYSSTAT 'consistent gets' statistic indicates the number of times rollback segment extent blocks were accessed in the Database Buffer Cache.

Rollback segments extent wrapping - When a transaction’s before-image exceeds the size of the extent to which it has been allocated, the transaction will wrap into the next extent if it is available. This dynamic wrapping incurs a small I/O cost and should be avoided if possible.
V$ROLLSTAT WRAPS column shows how often transactions have wrapped from one extent to another since instance startup. STATSPACK and REPORT.TXT also show rollback segment extent wrapping information using Wraps column.

Rollback segments dynamic extent allocation - when a transaction’s before-image exceeds the size of the extent, but cannot wrap to the next extent because there are still active transactions in that extent, the rollback segment will add a new extent and wrap into that extent instead. This dynamic extent allocation incurs an I/O cost that should be avoided if possible. 'undo segment extension' event in V$SYSTEM_EVENT records how long user Server Processes had to wait for rollback segments to add extents to handle transaction. V$ROLLSTAT view contains the EXTENDS column, which indicates how often the rollback segment was forced to add extents to support database transaction activity. STATSPACK show rollback segment dynamic extent using the EXTENDS column. OEM Performance Manager includes several graphical representations of undo segment performance (like Undo Segment Hit Ratios and undo wait statistics).

<u>**Improving Rollback Segment I/O**</u> - undo segment tuning goals are to eliminate contention for rollback segments, try to minimize rollback segment extending and wrapping, avoid running out of space in undo segments, and always have rollback data needed for constructing read consistent images for application users. In order to achieve these objectives, consider these four tuning categories:

Add more rollback segments - add more rollback segments to the database and create them in a new tablespace, separated from the existing rollback segments.

Make the existing rollback segments bigger - the optimal size of rollback segments varies with the type of system (i.e. OLTP vs. DSS) and the types of transactions being performed in the database. INSERT (Low Cost) UPDATE (Medium Cost) and DELETE (High Cost). By joining the V$SESSION and V$TRANSACTION views you can see how much space each session is using in the database rollback segments. Query V$ROLLSTAT view to determine how much rollback segment space the transaction needs. V$ROLLSTAT's WRITES column, shows how many bytes of before-image data have been written to the rollback segment.

Explicitly manage rollback segments for large transactions - Very large transactions, like batch processing runs, require large rollback segments. In these cases, it is best to create one or two large rollback segments and dedicate them to this purpose.

Minimize the need for rollback space - try to minimize the number and size of entries that are written to the rollback segments by performing frequent commits to minimize large rollback entries, using the COMMIT=Y option when performing database imports, forgoing the use of the CONSISTENT option when using the database EXPORT utility, and setting an appropriate COMMIT value when using the SQL*Loader utility.

Use automatic undo management features - Oracle9i offers a new feature, Automatic Undo Management (AUM). Automatic Undo Management is designed to minimize undo segment performance problems by dynamically managing the size and number of undo segments. With AUM, dedicated tablespaces, called Undo Tablespaces, are created to hold before-image data. The number and size of these undo segments is automatically managed by Oracle based on the demands of the system.

Configuring Automatic Undo Management – set UNDO_MANAGEMENT parameter to AUTO (default MANUAL). Set the UNDO_TABLESPACE parameter to the name of the tablespace where the AUM undo segments are to be stored (default value - the first undo tablespace found during database startup). If no undo tablespace exists, the SYSTEM rollback segment will be used to store undo data. Set the UNDO_RETENTION parameter to specify how long to retain undo information after the transaction committed in seconds. Additional parameter is UNDO_SUPPRESS_ERRORS, which suppress errors generated from commands that are appropriate in RBU.

Monitoring the Performance of System-Managed Undo – the DBA_TABLESPACES (CONTENTS = UNDO) and V$UNDOSTAT (columns BEGIN_TIME - begin time of undo statistics monitoring, END_TIME - end time of undo statistics monitoring, UNDOTSN - undo tablespace ID, UNDOBLKS - number of undo blocks used, TXNCOUNT - total number of transactions executed, MAXQUERYLEN - time (in seconds) that the longest query took to execute, UNXPBLKREUCNT - number of undo blocks that were needed to maintain read consistency for another transaction) views are used to monitor system-managed undo tablespaces.

9 - Tuning Contention

- **Contention for Oracle resources** occurs any time an Oracle process tries to access an Oracle structure, but is unable to gain access to the structure because it is already in use by another process. Latches, Free Lists, and locking are all common sources of contention.

  Latch Contention - Latches are used to protect access to Oracle's memory structures. A latch is a specialized type of lock that is used to serialize access to a particular memory structure or serialize the execution of kernel code. Each latch protects a different structure or mechanism as indicated by the name of the latch. Only one process at a time may access a latch; processes are allowed to access a latch only when the latch is not already in use by another process. In this manner, Oracle makes sure that no two processes are accessing the same data structure simultaneously. If a process needs a latch that is busy when the process requests it, the process will experience a wait. This wait behavior varies with the type of latch being accessed:

  If the latch is a **Willing-to-Wait** latch, the process requesting the latch will wait for a short period and then request the latch again, perhaps waiting several more times, until it successfully attains the requested latch.

  If the latch is an **immediate** latch, the process requesting the latch continues to carry out other processing directives instead of waiting for the latch to become available.

  The V$LATCH view is used to monitor the activity of both Willing-to-Wait and Immediate latches:

  NAME - name of the latch.

  GETS - number of times a Willing-to-Wait latch was acquired without waiting.

  MISSES - number of times a Willing-to-Wait latch was not acquired and a wait resulted.

  SLEEPS - number of times a process had to wait before obtaining a Willing-to-Wait latch.

  IMMEDIATE_GETS - number of times an immediate latch was acquired without waiting.

  IMMEDIATE_MISSES - number of times an immediate latch was not acquired and a retry resulted.

  Latch behavior differs on single and multiple CPU servers. On a single CPU server, a process requesting an in-use latch will release the CPU and sleep before trying the latch again. On multiple CPU servers, a process requesting an in-use latch will "spin" on the CPU a specific number of times before releasing the CPU and trying again. The number of spins the process will use is OS specific.

  Measuring Latch Contention - latch contention information can be obtained from V$LATCH, output from STATSPACK and REPORT.TXT and the OEM Performance Manager. V$SYSTEM_EVENT 'latch free' event indicates latch contention.

Once latch contention has been identified, you must determine which latch is experiencing the contention:
Shared Pool Latch - used to protect access to the Shared Pool’s memory structures. Frequent waits for access to this latch indicate Shared Pool need tuning.
Library Cache Latch - Like the Shared Pool latch, frequent waits for the Library Cache latch also indicates a poorly tuned Shared Pool.
Cache Buffers LRU Chain Latch - used to manage the blocks on the LRU List in the Database Buffer Cache. This latch is used when Database Writer writes dirty buffers to disk and when a user’s Server Process searches the LRU list for a free buffer during a disk read. Frequent waits for the Cache Buffer LRU Chain latch can be caused by two possible sources: Inefficient application SQL that results in excessive full table scans or inefficient execution plans. Database Writer is unable to keep up with write requests.
Cache Buffers Chains Latch - accessed by user Server Processes when they are attempting to locate a data buffer that is cached in the Database Buffer Cache. Waits for this latch indicate that some cached blocks are probably being repeatedly searched for in the Buffer Cache. OLTP with large block sizes have a tendency to experience Cache Buffers Chains latch waits more that systems with smaller block sizes.
Redo Allocation Latch - used to manage the space allocation in the Redo Log Buffer. Contention can occur for this latch if many users are trying to place redo entries in the Redo Log Buffer at the same time. Waits for the Redo Allocation latch can be minimized using Redo Log Buffer tuning.
Redo Copy latches - are accessed by user Server Processes when they are copying their redo information into Redo Log Buffer. Wait activity for this latch can be minimized using the Redo Log Buffer tuning.
STATSPACK utility output includes two sources of information on latch wait activity:
“Top 5 Wait Events” and Latch Activity section. The STATSPACK output uses a *get miss ratio* shows how often a requested latch was not available when it was requested. The *Pct Get Miss* column indicates how often Willing-to-Wait latches were inaccessible when they were requested. The *Pct NoWait Miss* column indicates how often Immediate latches were not available when they were requested.
The REPORT.TXT file shows latch contention under the Latch Statistics section. The REPORT.TXT uses a *hit ratio* to indicate latch performance. This ratio shows how frequently a requested latch was available when it was requested. The SGA component related to any latch whose value in the HIT_RATIO column is less than 1 would be a candidate for possible tuning.
The Performance Manager component of the Diagnostics Pack includes graphical representations of wait events, some of which can be related to latches.
Tuning Latch Contention - DBAs do not tune latches. In Oracle9i, all init.ora parameters related to latch activity have been deprecated. Instead, DBAs uses evidence of latch contention as an indicator of possible areas for tuning improvement in the database’s other structures, such as the SGA.
Free List Contention - If your application has many users performing frequent inserts, the Server Process may experience waits when trying to access the Free List for a frequently inserted table. These waits are called Free List contention. The tuning goal with regard to Free Lists is to minimize this type of contention by making sure that all processes can access a segment’s Free List without experiencing a wait.
Measuring Free List Contention - Free List contention can be detected by querying V$WAITSTAT, V$SYSTEM_EVENT, V$SESSION_WAIT and the DBA_SEGMENTS view.
The V$SYSTEM_EVENT view shows statistics regarding wait events that have occurred in the database since instance startup. Occurrences of the *buffer busy wait* event indicate that Free List contention may exist in the database.
The V$WAITSTAT view contains statistics about contention for individual segment blocks. '*free list*' and '*segment header*' statistics, indicate that Free List contention is occurring in the database.
The V$SESSION_WAIT view, which contains statistics related to the waits experienced by individual sessions, can be joined to the DBA_SEGMENTS view, which contains information about each segment in

the database, to determine which segments are experiencing the Free List contention identified in the previous section.

Tuning Free List Contention - There are two options for reducing contention:

Adding additional Free Lists to the segment - A segment can have more than one Free List. However, by default, only one Free List is assigned to a segment at creation. Segment free lists can be altered using ALTER TABLE table_name STORAGE (FREELISTS n); where n is a number.

Moving the segment to a tablespace that uses automatic segment-space management - Eliminate Free Lists by moving the segment to tablespaces with the automatic segment-space management, This feature utilize bitmaps in the tablespace's datafile headers, instead of Free Lists, to manage the free block allocations for each segment in that tablespace.

Creating tablespace with automatic segment-space management is done using:

CREATE TABLESPACE tbs_name … EXTENT MANAGEMENT LOCAL SEGMENT SPACE MANAGEMENT AUTO;

Lock Contention - Oracle's locking mechanisms are similar to the latching mechanisms, but locks are used to protect access to data. Locks are also less restrictive than latches. In some cases, several users can share a lock on a segment. This is not possible with latches, which are never shared between processes. Additionally, lock requests can be queued up in the order they are requested and then applied accordingly. This queuing mechanism is referred to as an **enqueue**. The enqueue keeps track of users who are waiting for locks, which lock mode they need, and in what order they asked for their locks. Lock contention can occur any time two users try to lock the same resource at the same time. Lock contention usually arises when you have many users performing DML on a relatively small number of tables. When two users try modifying the same row in the same table, at the same time, lock contention results. In general, locks are used to preserve data consistency. This means that the data a user is changing stays consistent within their session, even if other users are also changing it. Oracle's automatic locking processes lock data at the lowest possible level so as not to needlessly restrict access to application data. Since this type of locking model allows many users to access data at the same time, application users achieve a high degree of data concurrency. Once taken out, a lock is maintained until the locking user issues either a COMMIT or a ROLLBACK command. Because of this, locks that long in duration or restrictive in nature can affect performance for other users who need to access the locked data. In most cases, this locking is done at the row level.

Using Oracle's default locking mechanism, multiple users can do the following:

Change different rows in the same table with no locking issues.

Change the same row in the same table with enqueues determining who will have access to the row and when, and with System Change Numbers (SCN) deciding whose change will be the final one.

Oracle uses **two lock types** to perform its locking operations: a DML (data lock) and a DDL (dictionary lock). Oracle also uses two different locking modes: **exclusive** - is the most restrictive, locks a resource until the transaction holding it is complete. No other user can modify the resource while it is locked in exclusive mode, **share lock -** is the least restrictive, locks the resource, but allows other users to also obtain additional share locks on the same resource.

DML or data locks - are denoted by **TM** and are used to lock tables when users are performing INSERT, UPDATE, and DELETE commands. Data locks can be either at table or row level. Every user who performs DML on a table actually gets two locks on the table: a share lock at the table level and an exclusive lock at the row level. These two locks are implicit (Oracle performs the locking actions). Explicit locks can also be taken out when performing DML commands.

DDL or dictionary locks - are denoted by **TX** and are used to lock tables when users are creating, altering, or dropping tables. This type of lock is always at the table level and is designed to prevent two users from modifying a table's structure simultaneously.

Comparison of the Oracle DML Lock Modes

Kind of Lock	Lock Mode	Command	Description
Implicit	Row Exclusive (RX)	INSERT, UPDATE, DELETE	Other users can still perform DML on any other row in the table.
Implicit	Table Row Share (RS)	SELECT … FOR UPDATE	Other users can still perform DML on the rows in the table that were not returned by the SELECT statement
Implicit	Share (S)	UPDATE and DELETE on parent tables with Foreign Key to child tables	Users can still perform DML on any other row in either parent or child table as long as an index exists on the child table's Foreign Key column
Implicit	Share Row Exclusive (SRX)	DELETE on parent tables with Foreign Key to child tables	Users can still perform DML on any other row in either parent or child table as long as an index exists on the child table's Foreign Key column*
Explicit	Exclusive (X)	LOCK TABLE … IN EXCLUSIVE MODE	Other users can only query the table until locking transaction is committed or rolled back

* In versions prior to 9i, Oracle will take out a more restrictive lock on the child table whenever appropriate indexes on the Foreign Key columns of a child table are not present.

Comparison of the Oracle DDL Lock Modes

Kind of Lock	Lock Mode	Command	Description
Implicit	Exclusive (X)	CREATE, DROP, ALTER	Prevents other users from issuing DML or SELECT statements against the referenced table until DDL operation is complete
Implicit	Shared (S)	CREATE PROCEDURE, AUDIT	Prevents other users from altering or dropping the referenced table until after the DDL operation is complete
Implicit	Breakable Parse	-	Used by statements cached in the Shared Pool; never prevents any other types of DML, DDL, or SELECT by any user

The Special Case of Deadlocks - A deadlock error occurs whenever one transaction is holding a lock for a first row and waiting for lock on second row and the second transaction is holding a lock on the second row and waiting for lock on the first row. Oracle automatically resolves deadlocks by rolling back the blocking statement of the session that detects the lock, thus releasing one of the locks involved in the deadlock.

Measuring Lock Contention - When locking occur, contention can be identified using the V$LOCK, V$LOCKED_OBJECT, DBA_WAITERS and DBA_BLOCKERS views and the OEM Performance Manager GUI.

V$LOCK contains data regarding the locks that are being held in the database at the time a query is issued against the view. The view contains the session id (SID), lock type (TYPE), lock mode (LMODE) and locked object unique identifier (ID1) columns.

V$LOCKED_OBJECT lists all the locks currently held by every user on the system and includes blocking information showing which user is performing the locking transaction that is causing other users to experience a wait. The view contains the undo segment Number (XIDUSN), undo segment slot (XIDSLOT), locked object unique identifier (OBJECT_ID), session id (SESSION_ID), Oracle user connected (ORACLE_USERNAME), Operating System user (OS_USER_NAME) and the lock mode (LOCKED_MODE) columns.

DBA_WAITERS view contains information about user sessions that are waiting for locks to be released by other user sessions. The view contains the session id currently waiting to obtain a lock (WAITING_SESSION), the session id currently holding the lock (HOLDING SESSION), lock type by the holding session (LOCK_TYPE), lock mode held by the holding session (MODE_HELD),lock mode requested by the waiting session (MODE_REQUESTED), internal lock identifier for the first lock (usually Share) held by the holding session (LOCK_ID1) and internal lock identifier for the second lock (usually Row Exclusive) held by the holding session (LOCK_ID2).

DBA_BLOCKERS contains only one column (HOLDING_SESSION), which displays the session id of the user

sessions that are blocking the lock requests of other application users.
Oracle Performance Manager includes several graphical representations of lock activity.
Tuning Lock Contention - Lock contention is usually only a problem when many users perform DML on a relatively small number of tables, causing the users to wait other user to commit or roll back their transaction. Resolving the contention is done using one of these methods:
Change the application code - Lock contention problems arise from two situations:
Too many long transactions and explicitly coding restrictive lock levels.
If long-running transactions that do not commit regularly, lock contention is greatly increased.
Design application to include logical commit points so that transactions do not hold unnecessarily long locks. In addition, do not use explicit locks in your application code.
Contact Blocking Users - User suspending their activities for long periods, lead to lock contention. Try to contact the user to get him to commit or rollback their work. Another way you can prevent this problem, is to disconnect users who are idle for a specified period using Profiles.
Use SQL command – Once locking session has been detected, it can be killed using ALTER SYSTEM KILL SESSION command.

10 - Operating System Tuning

- **Three primary server resources** impact the performance of Oracle databases: Memory, Disk I/O and CPU and should be tuned in that order.
  Tuning Server Memory - SGA and background processes are created in the server's main memory during instance startup. This memory area is shared by all processes on the server. Every operating system loads its essential executables into memory when the server is booted. These executables, referred to as the ***OS kernel***, are used to manage the operating system's essential memory and I/O functions.
  On Unix machines, some Kernel Parameters are tunable such as SHMMAX & SHMMIN (maximum & minimum size, of a shared memory segment), MAXFILES (soft limit on the number of files a single process can utilize) and NPROC (maximum number of processes that can run simultaneously on the server).
  Numerous programs are loaded into server's memory on boot, such as OS-level services (print services, logical volume managers, etc…), Application/Web Servers and Software Agents (OEM's SNMP agents).
  In general, it is bad practice to use your database server to run application software since this will negatively impact the memory resources available to Oracle.
  Every server has two types of memory available: Physical and Virtual.
  Physical memory - the amount of memory in the server's physical memory chips. This memory is divided up into smaller pieces called pages. Allocation of processes and data to these pages is managed by the operating system page table mechanism. If the physical memory pages are full, a server's OS may have to temporarily remove pages or processes from memory in order to make room for other requested pages or processes. This process is referred to as paging or swapping.

Paging	**Swapping**
An individual memory page is temporarily removed from memory and written to disk in order to make room for another requested page	An entire process is removed from memory and written to disk in order to make room for another requested process or page

  When paging or swapping occurs, the second type of memory, **Virtual Memory**, is used to store the on-disk copy of the page or process that was removed from physical memory. The primary goal of OS tuning is to maximize the frequency with which requested memory pages are already cached in memory when requested so that they do not need to be read from disk. On Unix machines, the ***ipcs***, ***ps***, ***vmstat*** and ***sar*** executables are used to monitor Paging and Swapping.
  There are several techniques available for tuning the server memory such as locking the SGA and using Intimate Shared Memory:
  SGA Locking – Setting LOCK_SGA parameter to TRUE, will prevent the OS from paging or swapping any portion of the SGA by locking the entire SGA in physical memory (default FALSE). The LOCK_SGA parameter is not available on Windows 2000 servers.

Intimate Shared Memory - Database servers running the Sun Solaris operating system can also make use of Intimate Shared Memory (ISM) to help tune OS paging and swapping activities. Enabling ISM allows multiple OS processes to share access to the OS page tables that contain entries for shared memory areas and, at the same time, locks the SGA into physical memory.

Tuning Server CPUs - The server's CPU ultimately performs all the processing that occurs on a server. If a server has multiple CPUs, then the processing tasks are shared among the available CPUs as assigned by the server's operating system.

Common Server Architectures:

Uniprocessor - Servers with a single CPU and memory area. I/O, bus, and disk resources are used exclusively by this server.

Symmetric Multiprocessor (SMP) - Servers with two or more CPUs, but one memory area. I/O, bus, and disk resources are used exclusively by this server.

Massively Parallel Processor (MPP) - Two or more servers connected together. Each server has its CPU, memory area, I/O bus, disk drives, and a copy of the OS.

Non-Uniform Memory Access (NUMA) - Two or more SMP systems connected together. Each server has its own CPU, but the memory areas for each server is shared as one large memory area across all servers. A single copy of the OS is run across all servers.

Oracle is also a very CPU-aware product. If new CPUs are added to a database server, Oracle will dynamically change the default settings for several CPU-related parameters.

CPU-related init.ora Parameters: CPU_COUNT - number of CPUs. PARALLEL_THREADS_PER_CPU - default degree of parallelism when using parallel query/DML. FAST_START_PARALLEL_ROLLBACK - number of parallel rollback processes (in instance recovery), valid values HIGH, LOW, FALSE, derived from the number of CPUs. LOG_BUFFER - maximum size is 512K or 128K × the number of CPUs (whichever is higher). PARALLEL_MAX_SERVERS - number of CPUs is one factor determining this parameter.

Additional CPUs most dramatically affect the performance of Oracle's parallel execution features such as Parallel Query, Parallel DML, Parallel ANALYZE, and Parallel Index Creation.

Parallel Query - allows a single query to spawn multiple query slaves, which work on a portion of the query before the individual results are combined into a final result set. Parallel Query's CPU usage can be controlled through the use of the Resource Manager feature discussed later in this chapter

Parallel DML - Some DML activities can be performed in parallel using CREATE TABLE AS SELECT statements and the /*+ PARALLEL */ SQL hint.

Parallel ANALYZE - Table and index statistics can be gathered in parallel using DBMS_STATS package.

Parallel Index Creation - Indexes created on large tables, can be created in parallel using the PARALLEL keyword in the CREATE INDEX command. Using the PARALLEL keyword start multiple processes that work together to create the index more quickly.

Tuning Processes and Threads - On Unix systems, each Oracle-related process runs as a separate and distinct process. Each process consumes its own memory and CPU resources. On Windows systems, each Oracle-related process runs as a separate thread within oracle.exe. A thread is an independent sequence of instructions that executes within a single OS process. The process can contain multiple threads.

Resource Manager - In Oracle versions prior to Oracle8i, resource consumption management was done through the use of *profiles*. Oracle8i introduced a new feature, ***Resource Manager***, which was designed to improve the allocation and management of server resources needed by application users. Using the Resource Manager, it is possible to create resource groups and assign them specific resource limits. Resource Manager allows the DBA to limit the amount of CPU that an individual application user can consume and the number of slave processes that an application user can spawn when performing Parallel Query operations. Resource Manager can also be used to control resource allocations such as a user's maximum amount of undo segment usage and number of sessions against the database, thus ensuring higher-priority resource groups to obtain sufficient CPU, memory, undo and session resources.

The Oracle9i Resource Manager uses three components to achieve the goal of effective resource management: *resource consumer groups*, *resource plans*, and *resource plan directives*:

Resource consumer group - A group of users who have similar needs for database resources. A user can be a member of several resource groups, but only one group can be active at a time.

Resource plan - A collection of resource plan directives that are used to determine how resources are allocated to users.

Resource plan directive - Specifies how many resources are allocated to each resource plan.

Resource Manager Resource - Resources that can be controlled through the use of Resource Manager include these:

1. The amount of CPU allocated to each member of the resource consumer group
2. Parallel Queries degree of parallelism allowed for a member of the resource consumer group
3. The amount of undo segment space a member of a resource group is allowed to consume
4. The total number of active, concurrent sessions that a resource consumer group is allowed to have
5. The maximum expected time of a database action taken by a member of the resource consumer group

Managing CPU Resources - The CPU resources are allocated using the ***Emphasis method***. The resources associated with Parallel Query are assigned using the ***Absolute method***. Both methods use a relative scale, consisting of values from 1 (highest priority) to 8 (lowest priority) to determine what priority should be assigned to a particular user's request for resources.

Emphasis Method CPU Resources Management - The Emphasis method uses percentages to assign CPU resources to each of the eight priority levels. The percentage assigned to a resource consumer group at a given level determines the maximum amount of CPU that users can consume at that level. If excess CPU resources remain after all users at that level have been serviced, then the remaining CPU resources will be made available to users at the next level, and so on.

Absolute Method Parallel Query Resources Management - The Parallel Query (PQ) resource that is controlled by Resource Manager is the degree of parallelism. Degree of parallelism refers to the number of query slave processes that an individual session is allowed to start when processing its query. The more query slaves started, the faster the query will be processed. However, this comes at the expense of increased CPU utilization and disk I/O. Resource manager uses the ***Absolute method*** to control Parallel Query resources. This means that the maximum degree of parallelism is a specific (i.e., absolute) value.

Managing Undo Resources - Oracle9i introduces a new Plan Directive called the **UNDO_PLAN**, which controls the amount of undo segment space a user is allowed to consume when executing a large DML transaction. The limits placed on undo segment usage are implemented in the form of a quota for the entire resource group. If the quota on undo segment space is exceeded, additional DML cannot be performed by the user, or any other member of the user's resource group, until another member of the resource group releases undo resources.

Managing Workload Resources - The Active Session Pool, allows you to limit the number of active concurrent sessions for a particular resource group. Once the members of the resource group reach the number of allowed active concurrent sessions, any subsequent requests for active sessions will be queued by Resource Manager instead of being processed immediately. Any queued sessions will be executed after one or more of the existing sessions completes or becomes inactive. There is one queue per resource consumer group. Queued sessions are allocated resources on a FIFO basis.

Configuring Resource Management:

Granting Resource Manager Privileges – Grant the ADMINISTER_RESOURCE_MANAGER privilege to users who are going to manage Resource Groups, Plans, and Directives using DBMS_RESOURCE_MANAGER_PRIVS.
This package requires three arguments: GRANTEE_NAME, PRIVILEGE_NAME, and ADMIN_OPTION.
GRANTEE_NAME - name of the Oracle user being granted the privilege. PRIVILEGE_NAME - is the name of the privilege being granted. ADMIN_OPTION - indicates whether the user receiving the privilege can pass that privilege along to other users.

Creating the Resource Manager Objects - Setting up Resource Manager requires the following steps:

1. Creation of a pending area - Whenever a new resource consumer group, plan, or directive is

created, it is temporarily stored in the pending area until it is validated and written to the database. This gives the DBA the opportunity to confirm that the definitions of each consumer group, plan, and directive are correct before implementing it. The pending area is created using the DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA procedure.
2. Creation of one or more resource consumer groups - A resource consumer group is used to define a group of application users who have similar resource requirements. By default, every application user belongs to at least one RCG, which is called the DEFAULT_CONSUMER_GROUP. In addition, several other RCGs are constructed at database creation: **SYS_GROUP** - has the highest priority for resource access. SYS and SYSTEM are assigned to this RCG. **LOW_GROUP** – has the lowest priority for database resources. Every user has access to this RCG. **DEFAULT_CONSUMER_GROUP** - Every user who is assigned to this RCG by default. **OTHER_GROUPS** - The group to which all users belong when they are not members of the specific resource plan that is currently active in the instance. Creating RCG is done through DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP procedure.
3. Creation of one or more resource plans - Resource plans are used to organize plan directives. A group of plan directives can be assigned to a resource plan, which can in turn be assigned to one or more resource groups. Only one resource plan can be active in the instance at a time. Creating Resource Plans is done using the DBMS_RESOURCE_MANAGER.CREATE_PLAN procedure. Three default resource plans, called SYSTEM_PLAN, INTERNAL_PLAN, and INTERNAL_QUIESCE, are created at database creation.
4. Creation of one or more resource plan directives - A plan directive is used to link a resource consumer group to a resource plan. The plan directive is where the appropriate allocation of the resources controlled by Resource Manager is specified (e.g., CPU, degree of parallelism). Plan directives are created using the DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE procedure.
5. Validation of the resource consumer groups, plans, and directives - Once a resource consumer group has been defined and assigned a resource plan and directive, the entire package must be validated before being written to the database. Verification is performed using the VALIDATE_PENDING_AREA procedure of the DBMS_RESOURCE_MANAGER package.
6. Saving the resource consumer groups, plans, and directives to the database - Once the pending resource consumer groups, plans, and directives have been validated, they must be committed to the database before they can be assigned to database users. This commit is performed using the DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA procedure.
<u>**Assigning Resources to Users**</u> – You can assign a resource consumer group to a database user by either granting the RCG directly to an individual user, or by granting the RCG to a database role using the DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SWITCH_CONSUMER_GROUP procedure. Since a user can be a member of several RCGs at one time, it is preferred to specify a default RCG that will be active for the user when they initially connect to the database. (assigned using the SET_INITIAL_CONSUMER_GROUP procedure in DBMS_RESOURCE_MANAGER package).
Once all the resource management groups, plans, and directives are in place and have been assigned to users, the Resource Management feature must be enabled for the directives to take effect. If a user is active for a specified period of time, Resource Manager can be configured to automatically switch that user's session to a secondary resource group. This feature is managed by specifying three resource plan directive parameters:
SWITCH_TIME - used to specify the duration, in seconds (default 1,000,000), that a session must be active before Resource Manager switches the session to the group specified by SWITCH_GROUP parameter (default value NULL).
SWITCH_GROUP - If set to TRUE (default FALSE), Resource Manager will use the estimated execution time to decide whether to assign the session to the SWITCH_GROUP before execution even begins, without waiting for the execution time to exceed the value specified by SWITCH_TIME and SWITCH_ESTIMATE.
<u>**Setting Instance Resource Objectives**</u> - Any of the defined resource plans can be activated for the instance. However, only one resource plan can be active at a time. The active resource plan for the instance can be defined using the RESOURCE_MANAGER_PLAN parameter in init.ora, or by dynamically issuing the ALTER SYSTEM SET RESOURCE_MANAGER_PLAN command. If this parameter is not set, then the

features of Resource Manager are disabled.
Oracle also gives you the ability to dynamically change the active RCG for an individual connected user by using the DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_USER procedure.
Changing active RCG is possible at session level also using the SWITCH_CONSUMER_GROUP_FOR_SESS procedure in DBMS_RESOURCE package. This procedure accepts the SID and SERIAL# parameters as an input.
Resource Manager Dynamic Performance Views - The three views that contain information related to Resource Manager are:
V$SESSION - The RESOURCE_CONSUMER_GROUP column displays the current RCG for each session.
V$RSRC_CONSUMER_GROUP - contains details about the resource allocations that have been made to the active resource consumer groups (CPU time, CPU waits etc…)
V$RSRC_PLAN – The NAME column displays the names of all the currently active resource plans.
Other Resource Manager related views are:
DBA_RSRC_CONSUMER_GROUPS - contains information on each resource consumer group in the database.
DBA_RSRC_CONSUMER_GROUPS_PRIVS - shows which users or roles in the database have been granted to each resource consumer group.
DBA_RSRC_PLANS - shows all the resource plans that have been created in the database.
DBA_RSRC_PLAN_DIRECTIVES - displays the specific resource allocations that were assigned to each resource plan.
DBA_RSRC_MANAGER_SYSTEM_PRIVS - contains information about which users have been granted the DMINISTER_RESOURCE_MANAGER privilege.
DBA_USERS - The INITIAL_RSRC_CONSUMER_GROUP column indicates the resource consumer group that has been assigned to a user as their default.
Resource Manager OEM Tools - The Instance section under the Database section of the OEM Console has GUI tools that provide information on resource consumer groups and resource plans.