Oracle Database 10*g*: SQL Tuning Workshop

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Course Overview

Objectives

After completing this lesson, you should be able to do the following:

- Describe course objectives
- Describe course schedule

Course Objectives

Proactive Tuning:

- Describe the basic steps in processing SQL statements
- Describe the causes of performance problems
- Understand where SQL tuning fits in an overall tuning methodology
- Influence the physical data model so as to avoid performance problems
- Understand query optimizer behavior
- Influence the optimizer behavior

Course Objectives

Reactive Tuning:

- **Use the diagnostic tools to gather information about SQL statement processing**
- **Describe Automatic SQL Tuning**
- **Describe alternative methods of accessing data**

Course Schedule

Day	Lesson
1	1. Oracle Database Architecture
	2. Following a tuning methodology
	3. Designing and developing for performance
	4. Introducing the optimizer
	5. Optimizer Operations
	6. Execution Plans
2	7. Generating Execution Plans
	8. Application Tracing
	Workshop 1

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Course Schedule

Day	Lesson
2	9. Identifying High load SQL
	10. Automatic SQL Tuning
	Workshop 2
3	11. Using Indexes
	12. Different Types of Indexes
	Workshop 3 and 4
	13. Using Hints
	Workshop 5
	14. Matrialized Views
	Workshop 6 and Optional Workshop 7

Summary

In this lesson, you should have learned to:

- Describe course objectives
- Describe course schedule

1

Oracle Database Architecture: Overview

Objectives

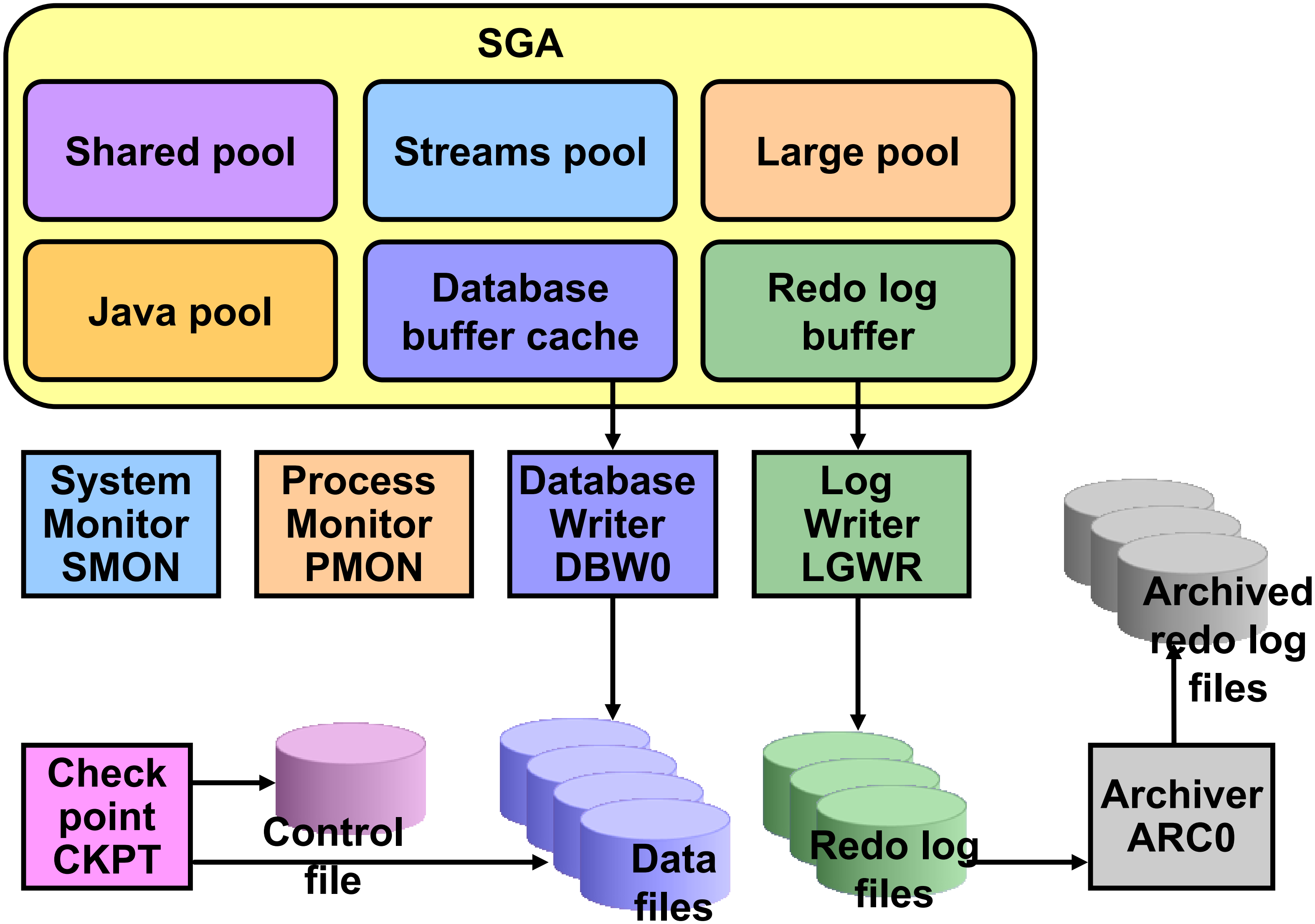
After completing this lesson, you should be able to:

- **Describe the Oracle Database architecture and components**
- **Make qualified decisions about your tuning actions**

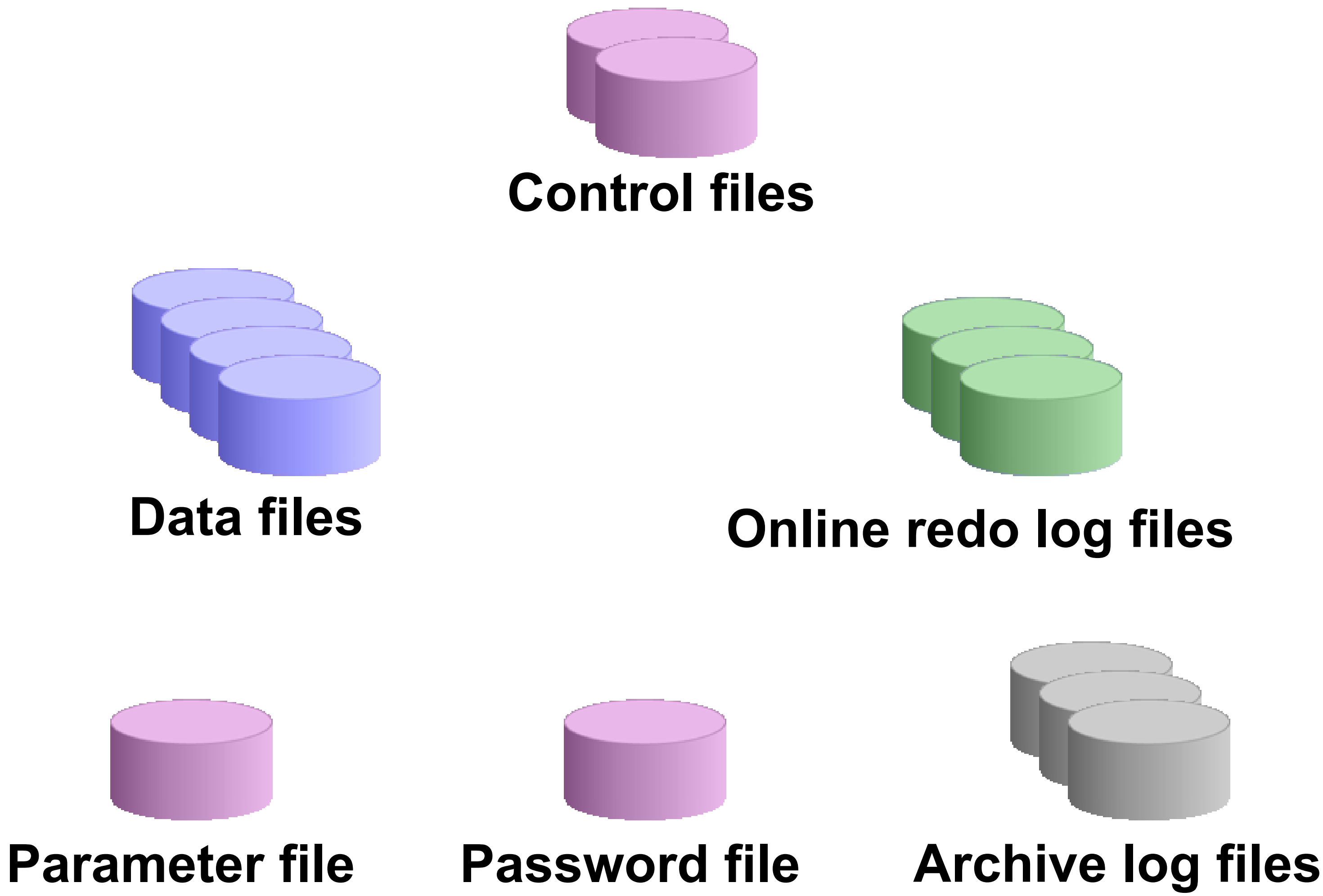
Oracle Database Architecture: Overview

- The Oracle Database consists of two main components:
  - The database: physical structures
  - The instance: memory structures
- The size and structure of these components impact performance.

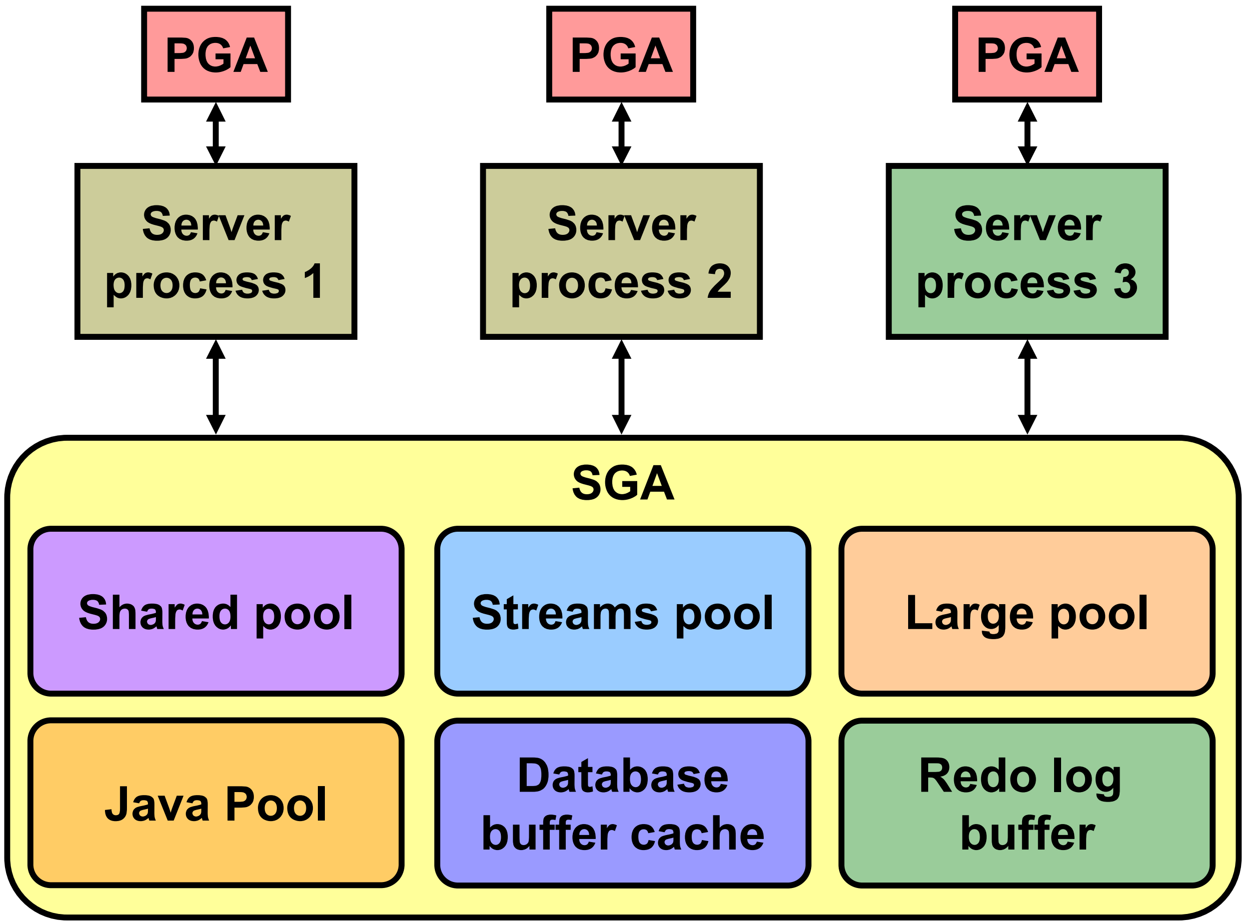
Oracle Instance Management



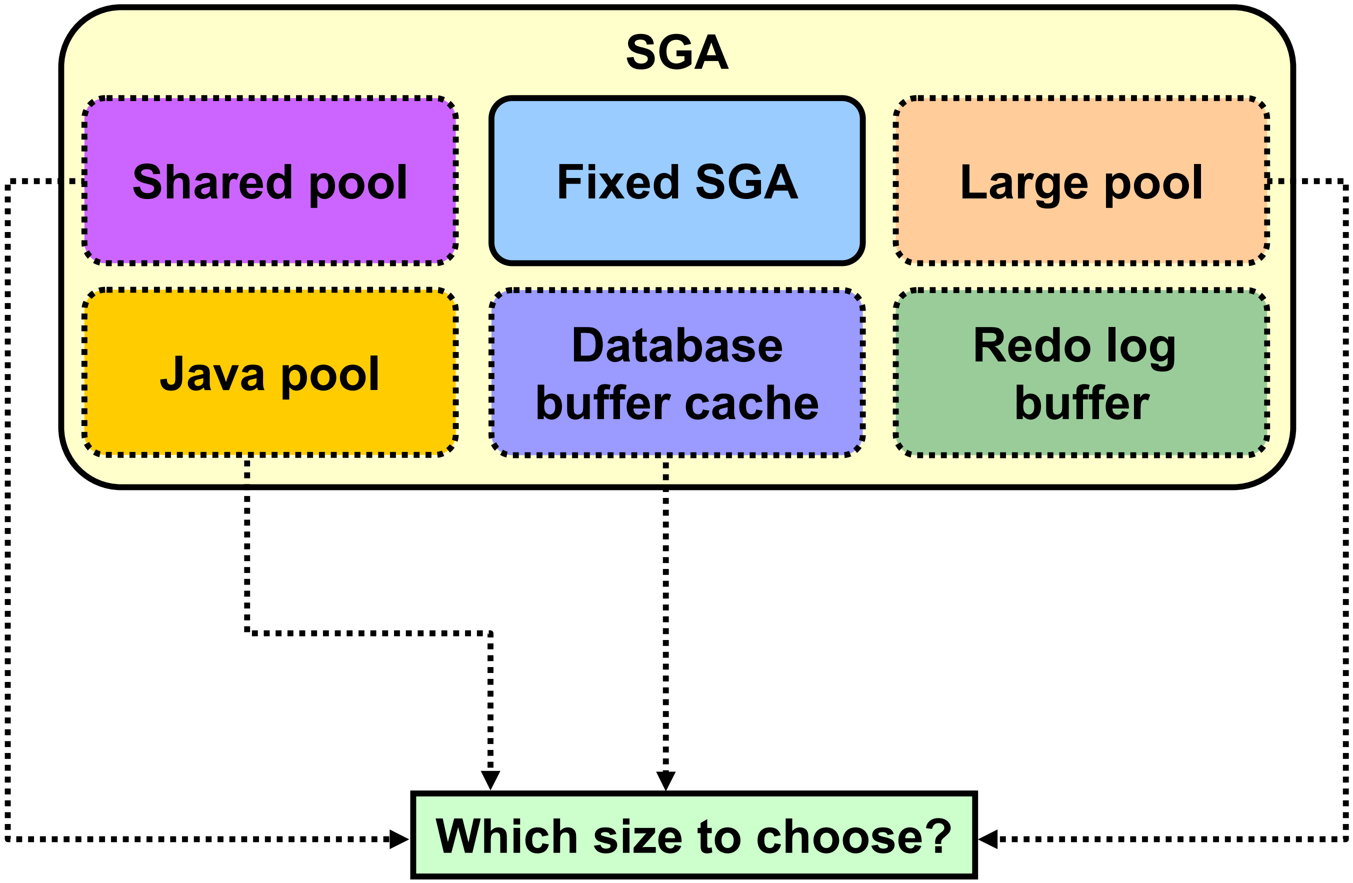
Database Physical Structure



Oracle Memory Structures



Automatic Shared Memory Management



Shared Pool

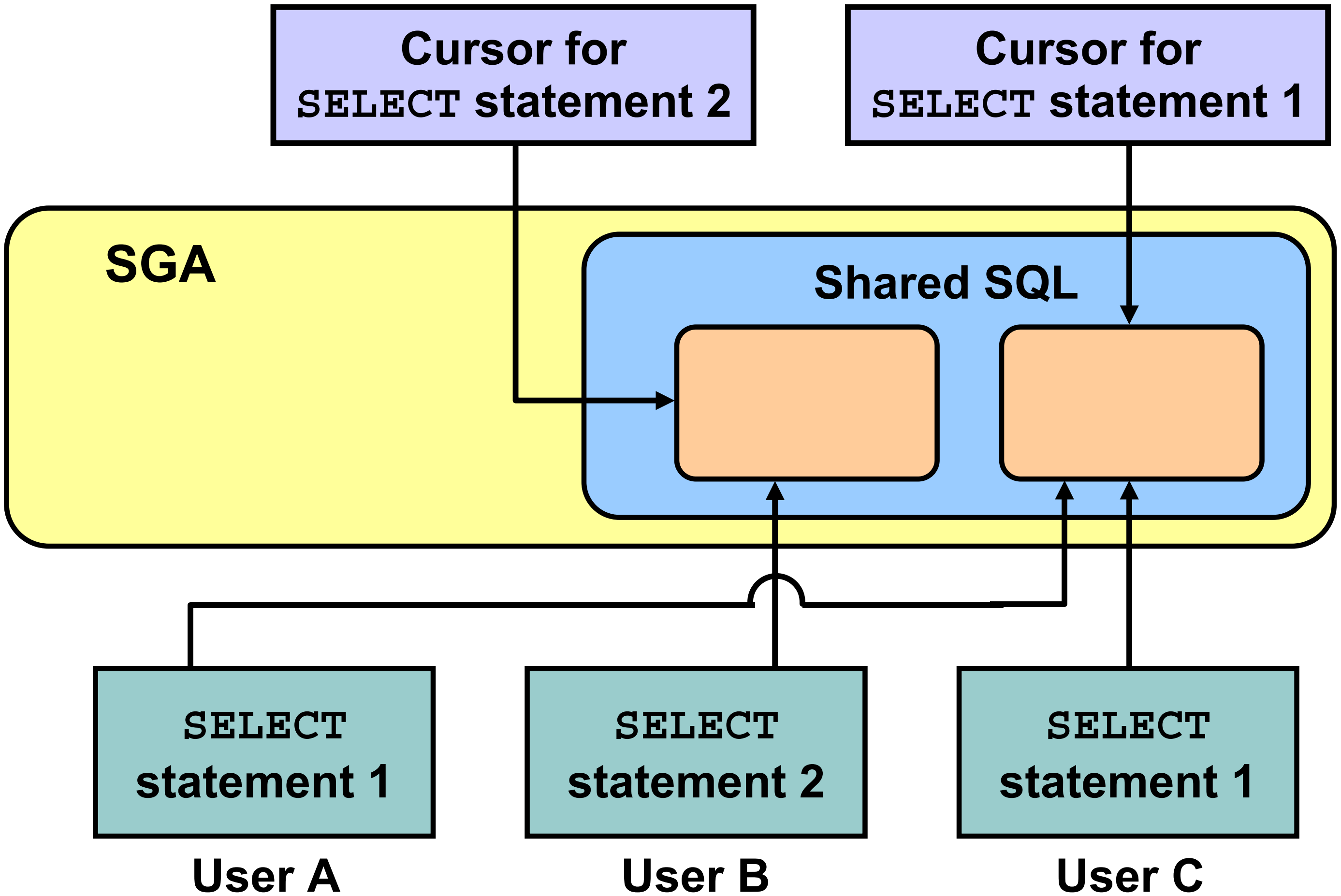
The shared pool consists of:

- Data dictionary cache containing information on objects, storage, and privileges
- Library cache containing information such as SQL statements, parsed or compiled PL/SQL blocks, and Java classes

Appropriate sizing of the shared pool affects performance by:

- Reducing disk reads
- Allowing shareable SQL code
- Reducing parsing, thereby saving CPU resources
- Reducing latching overhead, thereby improving scalability

Shared SQL Areas



Program Global Area (PGA)

- PGA is a memory area that contains:
  - Session information
  - Cursor information
  - SQL execution work areas
    - Sort area
    - Hash join area
    - Bitmap merge area
    - Bitmap create area
- Work area size influences SQL performance.
- Work areas can be automatically or manually managed.

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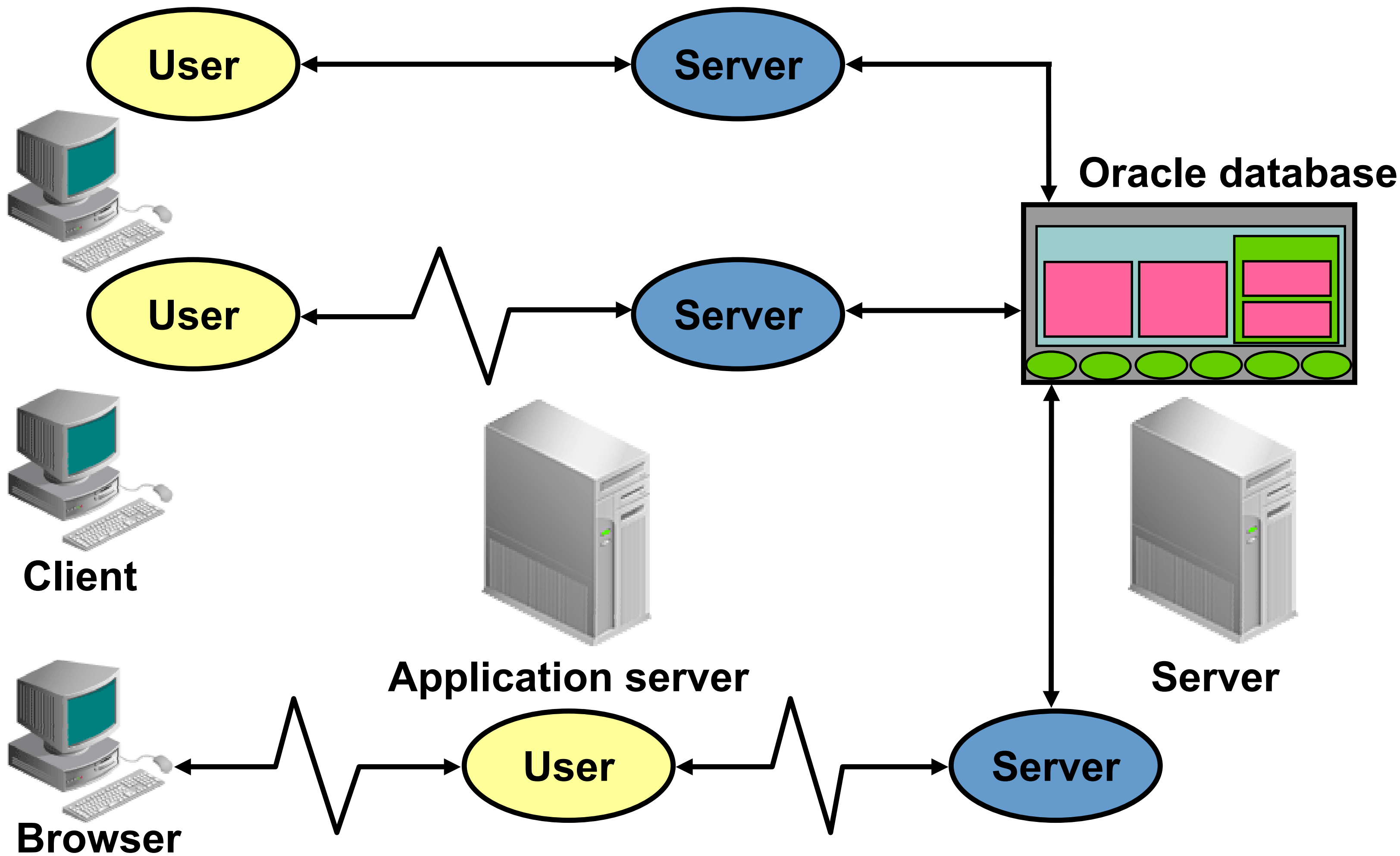
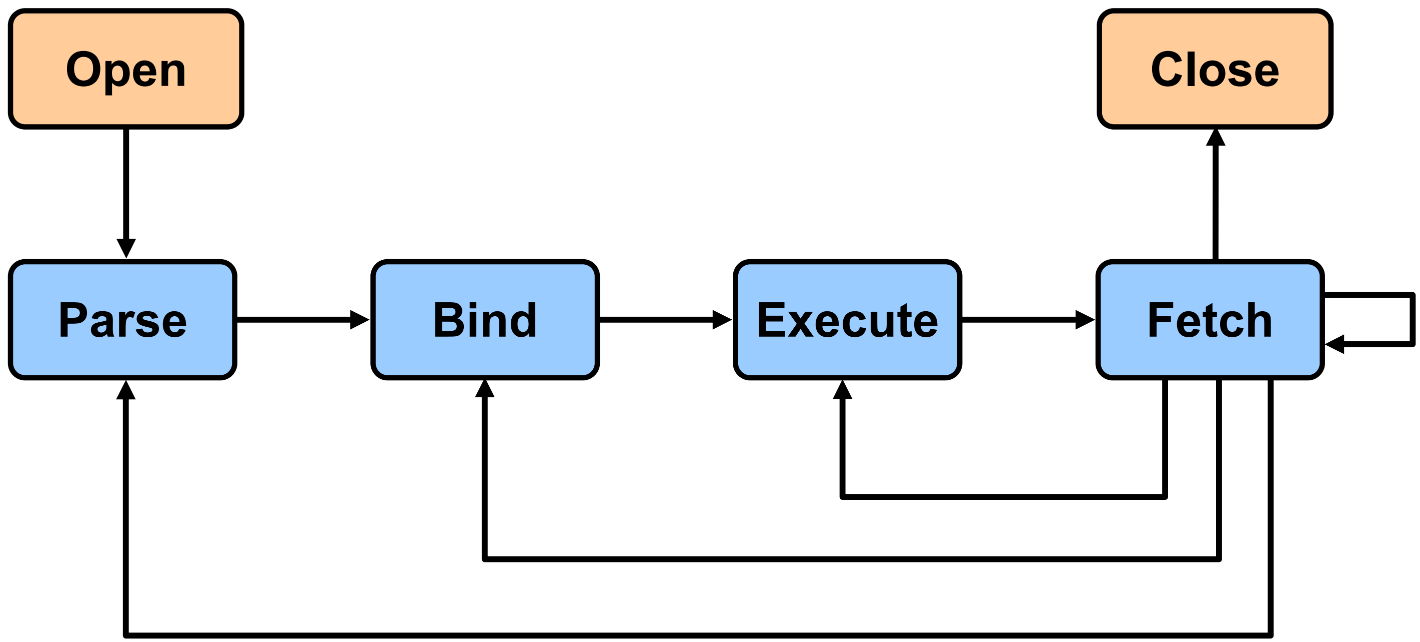
Automated SQL Execution Memory (PGA) Management

- **Allocation and tuning of PGA memory is simplified and improved.**
  - **Efficient memory allocation for varying workloads**
  - **Queries optimized for both throughput and response times**
- **DBAs can use parameters to specify the policy for PGA sizing.**

Connecting to an Instance



SQL Statement Processing Phases



SQL Statement Processing Phases: Parse

- Parse phase:
  - Searches for the statement in the shared pool
  - Checks syntax
  - Checks semantics and privileges
  - Merges view definitions and subqueries
  - Determines execution plan
- Minimize parsing as much as possible:
  - Parse calls are expensive.
  - Avoid reparsing
  - Parse once, execute many times

SQL Statement Processing Phases: Bind

- **Bind phase:**
  - **Checks the statement for bind variables**
  - **Assigns or reassigns a value to the bind variable**
- **Bind variables impact performance when:**
  - **They are not used, and your statement would benefit from a shared cursor**
  - **They are used, and your statement would benefit from a different execution plan**

SQL Statement Processing Phases: Execute and Fetch

- **Execute phase:**
  - **Executes the SQL statement**
  - **Performs necessary I/O and sorts for data manipulation language (DML) statements**
- **Fetch phase:**
  - **Retrieves rows for a query**
  - **Sorts for queries when needed**
  - **Uses an array fetch mechanism**

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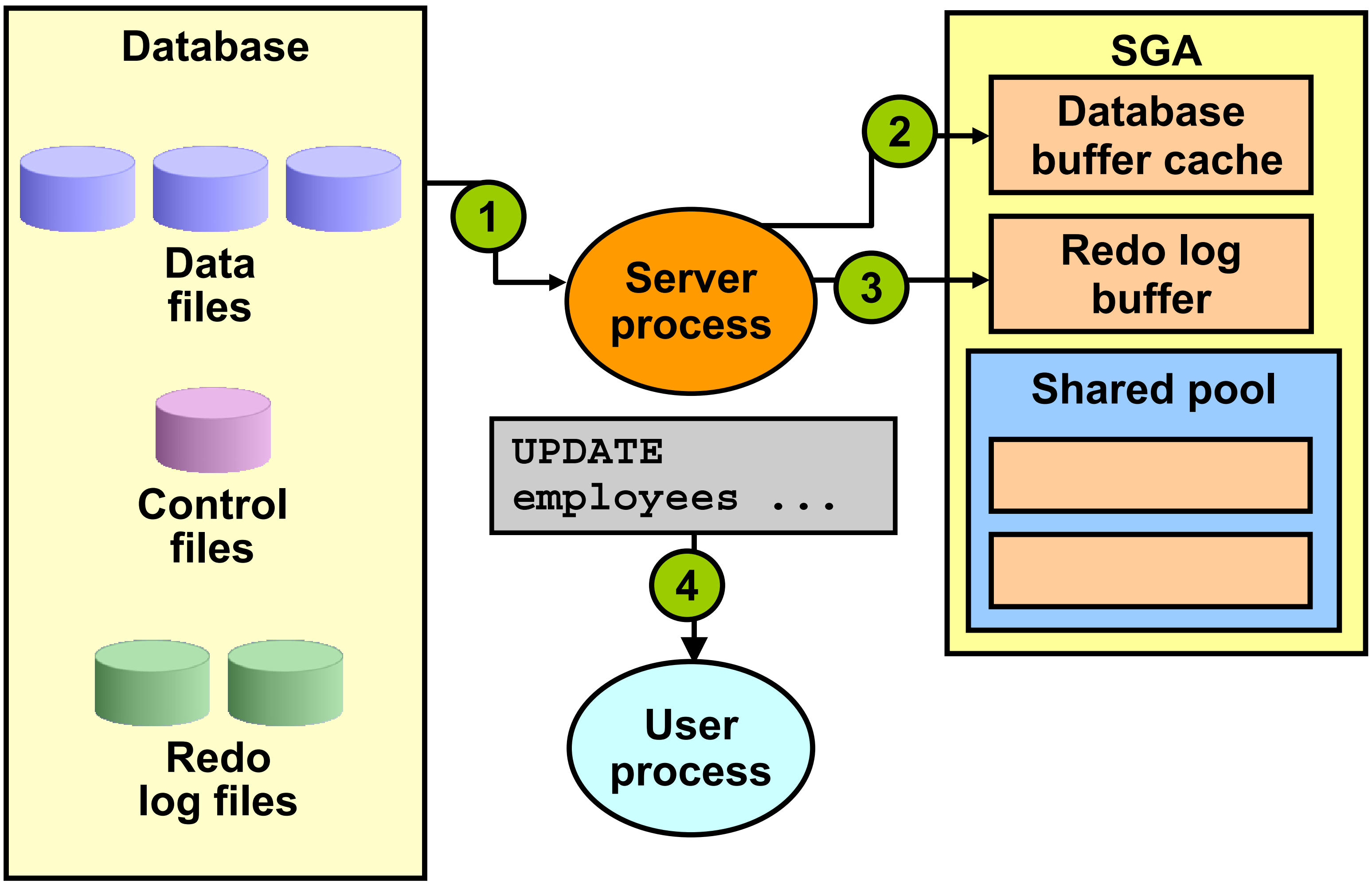
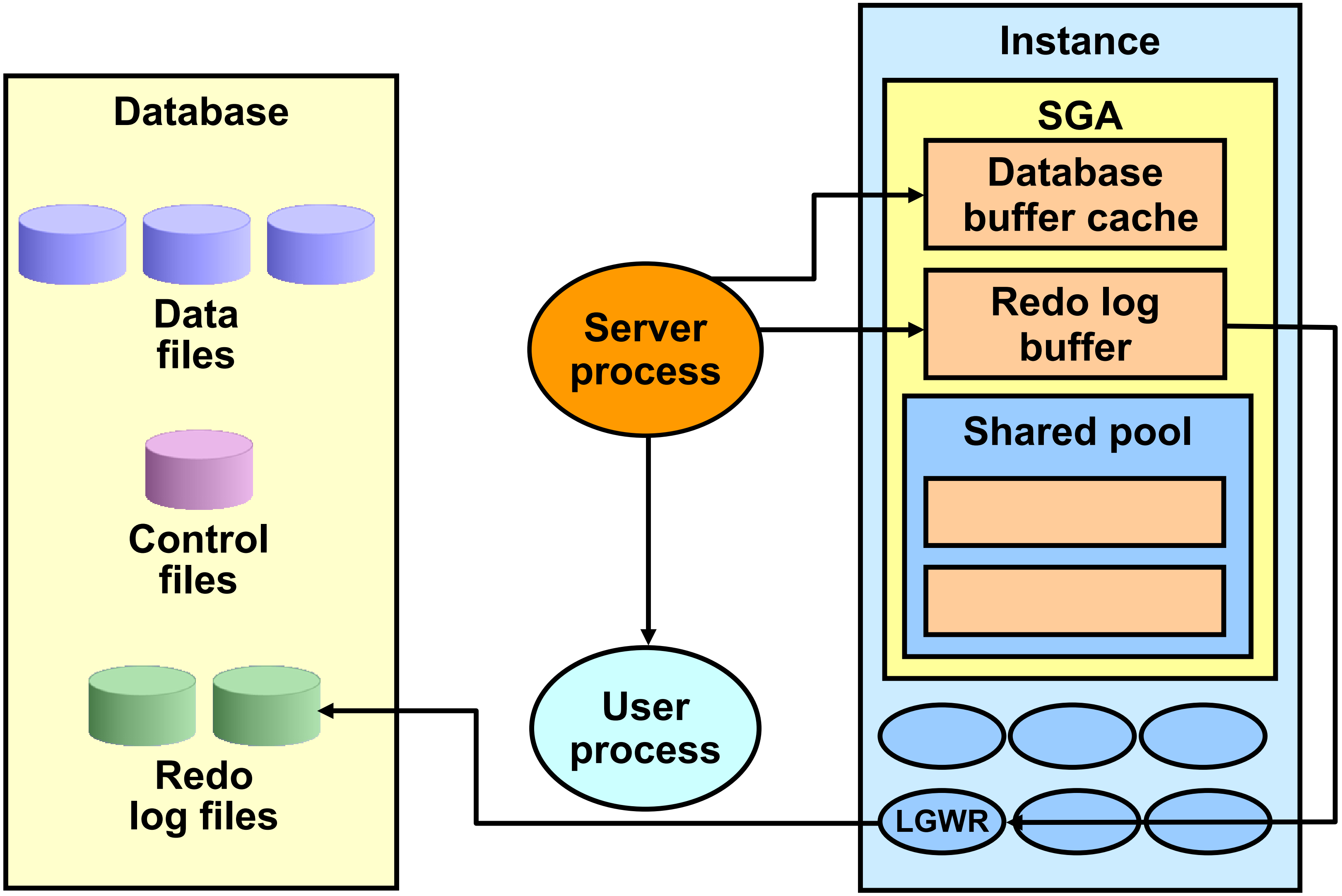
Processing a DML Statement



`COMMIT` Processing



Functions of the Oracle Query Optimizer

The Oracle query optimizer determines the most efficient execution plan and is the most important step in the processing of any SQL statement.

The optimizer:

- Evaluates expressions and conditions
- Uses object and system statistics
- Decides how to access the data
- Decides how to join tables
- Decides which path is most efficient

Top Database Performance Issues

- Bad connection management
- Poor use of cursors and the shared pool
- Bad SQL
- Nonstandard initialization parameters
- I/O issues
- Long full-table scans
- In-disk sorts
- High amounts of recursive SQL
- Schema errors and optimizer problems

Summary

In this lesson, you should have learned about the Oracle Database architecture and various components that require tuning.

2

Following a Tuning Methodology

Objectives

After completing this lesson, you should be able to do the following:

- Determine performance problems
- Manage performance
- Describe tuning methodologies
- Identify goals for tuning
- Describe automatic SQL tuning features
- List manual SQL tuning steps

Performance Problems

- Inadequate consumable resources
  - CPU
  - I/O
  - Memory (may be detected as an I/O problem)
  - Data communications resources
- High-load SQL
- Contention

Factors to Be Managed

- Schema
  - Data design
  - Indexes
- Application
  - SQL statements
  - Procedural code
- Instance
- Database
- User expectations
- Hardware and network tuning

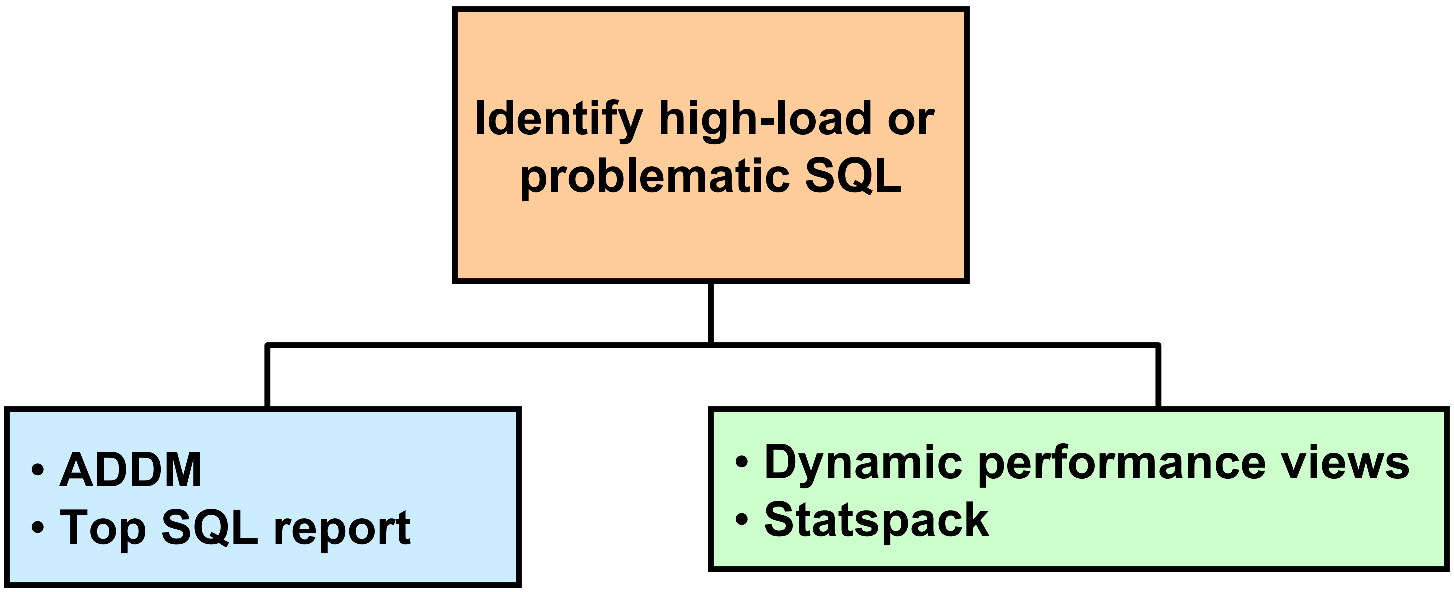
Tuning Goals

- Reduce the response time
- Reduce resource usage

Overview of SQL Tuning

1. Identify causes of poor performance.
2. Identify problematic SQL.
   - Automatic: ADDM, Top SQL
   - Manual: V$ views, statspack
3. Apply a tuning method.
   - Manual tuning
   - Automatic SQL tuning
4. Implement changes to:
   - SQL statement constructs
   - Access structures such as indexes

Identifying High-Load SQL



Manual Tuning

1. Gather information about the referenced objects.
2. Gather optimizer statistics.
3. Review execution plans.
4. Restructure SQL statements.
5. Restructure indexes and create materialized views.
6. Maintain execution plans.

Gather Information About Referenced Objects

- SQL text
- Structure of tables and indexes
- Optimizer statistics
- Views
- Optimizer plan: current and prior

Gathering Optimizer Statistics

- Gather statistics for all tables.
- Gather new statistics when existing statistics become stale.

Reviewing the Execution Plan

- Driving table has the best filter.
- Fewest number of rows are being returned to the next step.
- The join method is appropriate for the number of rows being returned.
- Views are used efficiently.
- There are no unintentional Cartesian products.
- Each table is being accessed efficiently.
- Examine the predicates in the SQL statement and the number of rows in the table.
- A full table scan does not mean inefficiency.

Restructuring the SQL Statements

- Compose predicates by using `AND` and = .
- Avoid transformed columns in the `WHERE` clause.
- Avoid mixed-mode expressions and beware of implicit type conversions.
- Write separate SQL statements for specific tasks and use SQL constructs appropriately.
- Use `EXISTS` or `IN` for subqueries as required.
- Cautiously change the access path and join order with hints.

Restructuring the Indexes

- Remove unnecessary indexes to speed the DML.
- Index the performance-critical access paths.
- Reorder columns in existing concatenated indexes.
- Add columns to the index to improve selectivity.
- Create appropriate indexes based on usage type:
  - B*tree
  - Bitmap
  - Bitmap join
  - Concatenated
- Consider index-organized tables.

Maintaining Execution Plans over Time

- Stored outlines
- Stored statistics
- Locking statistics

Automatic SQL Tuning

- Automatic SQL tuning facilitates these steps:
  - Gather information on the referenced objects.
  - Verify optimizer statistics.
  - Review execution plans.
  - Restructure SQL statements
  - Restructure indexes and create materialized views.
  - Maintain execution plans.
- Four types of analysis are performed in automatic SQL tuning:
  - Statistics analysis
  - SQL profiling
  - Access path analysis
  - SQL structure analysis

Automatic Tuning Mechanisms

You can perform automatic SQL tuning using:

- SQL Tuning Advisor
- SQL Access advisor

SQL Tuning Advisor

The SQL Tuning Advisor does the following:

- Accepts input from:
  - Automatic Database Diagnostic Monitor (ADDM)
  - Automatic Workload Repository (AWR)
  - Cursor cache
  - Custom SQL as defined by the user
- Provides:
  - Recommendations
  - Rationale
  - Expected benefits
  - SQL commands for implementing the recommendations

SQL Access Advisor

The SQL Access Advisor does the following:

- Provides comprehensive advice on schema design by accepting input from:
  - Cursor cache
  - Automatic Workload Repository (AWR)
  - User-defined workload
  - Hypothetical workload if a schema contains dimensions or primary/foreign key relationships
- Analyzes the entire workload and recommends:
  - Creating new indexes as needed
  - Dropping any unused indexes
  - Creating new materialized views and materialized view logs

Summary

In this lesson, you should have learned how to:

- Manage performance
  - Start early; be proactive
  - Set measurable objectives
  - Monitor requirements compliance
  - Handle exceptions and changes
- Identify performance problems
  - Inadequate consumable resources
  - Inadequate design resources
  - Critical resources
  - Excessive demand

Summary

In this lesson, you should have learned how to:

- Tune SQL statements
  - Analyze the results at each step
  - Tune the physical schema
  - Choose when to use SQL
  - Reuse SQL statements when possible
  - Design and tune the SQL statement
  - Get maximum performance with the optimizer

3

Designing and Developing for Performance

Objectives

After completing this lesson, you should be able to describe the basic steps involved in designing and developing for performance.

Understanding Scalability

- Scalability is a system's ability to process more workload, with a proportional increase in system resource use.
- Poor scalability leads to system resource exhaustion to the extent that additional throughput is impossible when the system's workload is increased.

Scalability with Application Design, Implementation, and Configuration

Applications have a significant impact on scalability.

- Poor schema design can cause expensive SQL that does not scale.
- Poor transaction design can cause locking and serialization problems.
- Poor connection management can cause unsatisfactory response times and unreliable systems.

Configuring the Appropriate System Architecture for Your Requirements

- Interactive applications (OLTP)
- Process-driven applications (OLAP)

Proactive Tuning Methodology

- Simple design
- Data modeling
- Tables and indexes
- Using views
- Writing efficient SQL
- Cursor sharing
- Using bind variables
- SQL versus PL/SQL
- Dynamic SQL

Simplicity In Application Design

- Simple tables
- Well-written SQL
- Indexing only as required
- Retrieving only required information

Data Modeling

- Accurately represent business practices
- Focus on the most frequent and important business transactions
- Use modeling tools
- Normalize the data

Table Design

- Compromise between flexibility and performance
  - Principally normalize
  - Selectively denormalize
- Use Oracle performance features
  - Default values
  - Check constraints
  - Materialized views
  - Clusters
- Focus on business-critical tables

Index Design

- Index keys
  - Primary key
  - Unique key
  - Foreign keys
- Index data that is frequently queried
- Use SQL as a guide to index design

Using Views

- Simplifies application design
- Is transparent to the end user
- Can cause suboptimal execution plans

SQL Execution Efficiency

- Good database connectivity
- Using cursors
- Minimizing parsing
- Using bind variables

Importance of Sharing Cursors

- Reduces parsing
- Dynamically adjusts memory
- Improves memory usage

Writing SQL to Share Cursors

- Create generic code using the following:
  - Stored procedures and packages
  - Database triggers
  - Any other library routines and procedures
- Write to format standards:
  - Case
  - White space
  - Comments
  - Object references
  - Bind variables

Controlling Shared Cursors

The `CURSOR_SHARING` initialization parameter can be set to:

- `EXACT` (default)
- `SIMILAR` (not recommended)
- `FORCE`

Performance Checklist

- Set initialization parameters and storage options.
- Verify resource usage of SQL statements.
- Validate connections by middleware.
- Verify cursor sharing.
- Validate migration of all required objects.
- Verify validity and availability of optimizer statistics.

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Summary

In this lesson, you should have learned the basic steps that are involved in designing and developing for performance.

4

Introduction to the Optimizer

Objectives

After completing this lesson, you should be able to do the following:

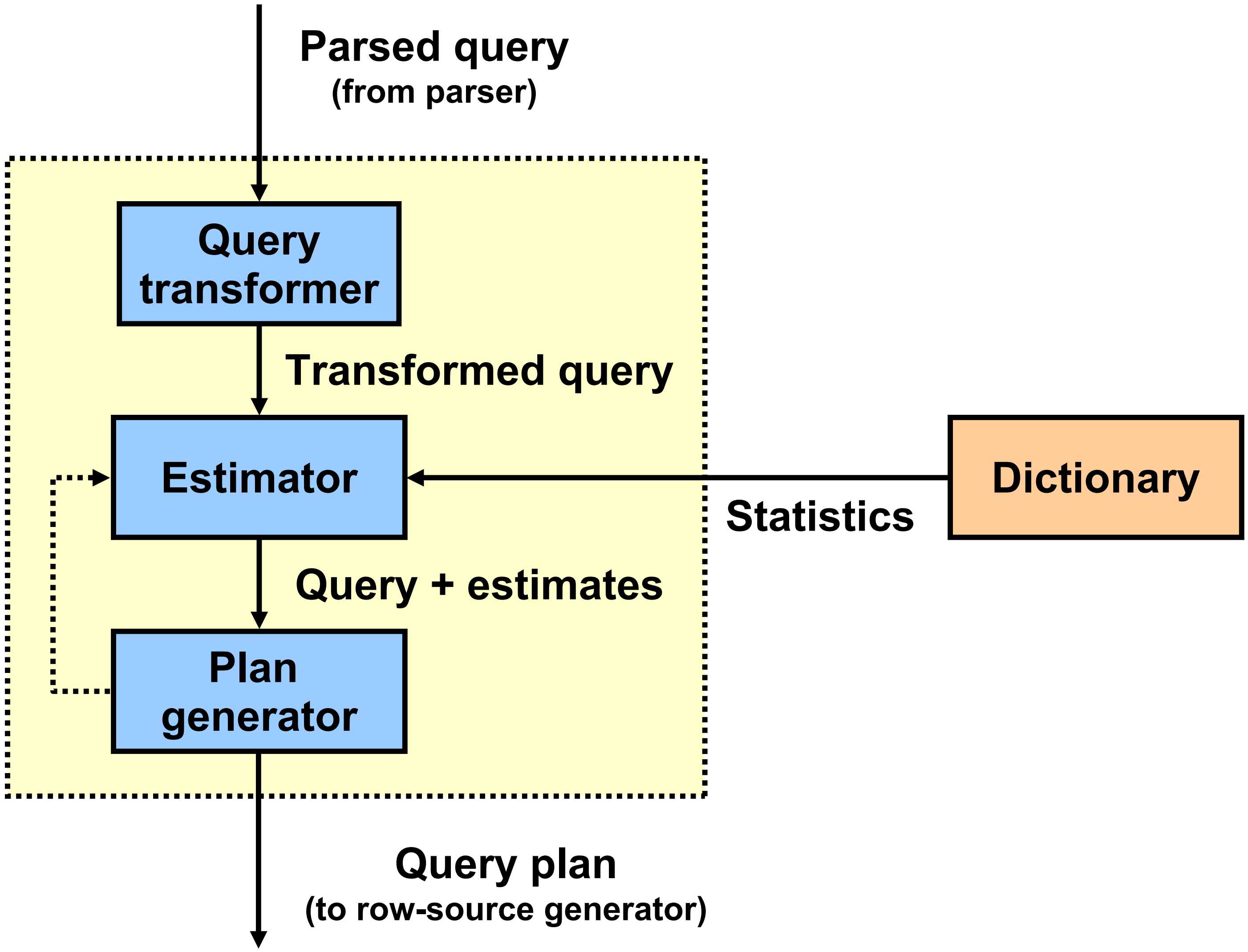
- Describe the functions of the Oracle optimizer
- Identify the factors influencing the optimizer
- Set the optimizer approach at the instance and session level

Oracle Optimizer

The optimizer creates an execution plan for every SQL statement by:

- Evaluating expressions and conditions
- Using object and system statistics
- Deciding how to access the data
- Deciding how to join tables
- Deciding which path is most efficient
- Comparing the cost for execution of different plans
- Determining the least-cost plan

Functions of the Query Optimizer



Selectivity

- Selectivity represents a fraction of rows from a row set.
- Selectivity lies in a value range from 0.0 to 1.0.
- When statistics are available, the estimator uses them to estimate selectivity.
- With histograms on columns that contain skewed data, the results are good selectivity estimates.

Cardinality and Cost

- Cardinality represents the number of rows in a row set.
- Cost represents the units of work or resource that are used.

Query Optimizer Statistics in the Data Dictionary

- The Oracle optimizer requires statistics to determine the best execution plan.
- Statistics
  - Stored in the data dictionary tables
  - Must be true representations of data
  - Gathered using:
    - `DBMS_STATS` package
    - Dynamic sampling

Enabling Query Optimizer Features

- The optimizer behavior can be set to prior releases of the database.
- The `OPTIMIZER_FEATURES_ENABLE` initialization parameter can be set to values of different database releases (such as 8.1.7 or 10.0.0).
- Example:

```
OPTIMIZER_FEATURES_ENABLE=9.2.0;
```

Controlling the Behavior of the Optimizer

Optimizer behavior can be controlled using the following initialization parameters:

- `CURSOR_SHARING`
- `DB_FILE_MULTIBLOCK_READ_COUNT`
- `OPTIMIZER_INDEX_CACHING`
- `OPTIMIZER_INDEX_COST_ADJ`
- `OPTIMIZER_MODE`
- `PGA_AGGREGATE_TARGET`

Choosing an Optimizer Approach

- `OPTIMIZER_MODE` **initialization parameter**
- `OPTIMIZER_MODE` **parameter of** `ALTER SESSION` **statement**
- **Optimizer statistics in the data dictionary**
- **Optimizer SQL hints for influencing the optimizer decision**

Setting the Optimizer Approach

- At the instance level, set the following parameter:

```
OPTIMIZER_MODE =  {FIRST_ROWS(_n)|ALL_ROWS}
```

- For a session, use the following SQL command:

```
ALTER SESSION SET optimizer_mode =
      {first_rows(_n)|all_rows}
```

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Optimizing for Fast Response

- `OPTIMIZER_MODE` **is set to** `FIRST_ROWS` **or** `FIRST_ROWS_`*n*, **where *n* is 1, 10, 100, or 1000.**
- **This approach is suitable for online users.**
- **The optimizer generates a plan with the lowest cost to produce the first row or the first few rows.**
- **The value of *n* should be chosen based on the online user requirement (specifically, how the result is displayed to the user).**
- **The optimizer explores different plans and computes the cost to produce the first *n* rows for each plan.**

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Optimizing SQL Statements

Best throughput

- Time required to complete the request
- Suitable for:
  - Batch processing
  - Report applications

Fast response

- Time for retrieving the first rows
- Suitable for:
  - Interactive applications
  - Web-based or GUI applications

How the Query Optimizer Executes Statements

The factors considered by the optimizer are:

- Access path
- Join method
- Join order

Access Paths

- Full-table scans
- Row ID scans
- Index scans
- Cluster scans
- Hash scans

Join Orders

A join order is the order in which different join items (such as tables) are accessed and joined together.

Join Methods

The different join methods considered by the optimizer are:

- Nested-loop join
- Hash join
- Sort-merge join
- Cartesian join

Summary

In this lesson, you should have learned about:

- Functions of the optimizer
- Cost factors that are considered by the optimizer
- Setting the optimizer approach

5

Optimizer Operations

Objectives

After completing this lesson, you should be able to do the following:

- Describe different access paths
- Optimize sort performance
- Describe different join techniques
- Explain join optimization
- Find optimal join execution plans

Review: How the Query Optimizer Executes Statements

The factors considered by the optimizer are:

- Access path
- Join order
- Join method

Access Paths

- Full table scan
- Row ID scan
- Index scan
- Sample table scan

Choosing an Access Path

- Available access paths for the statement
- Estimated cost of executing the statement, using each access path or combination of paths

Full Table Scans

- Lack of index
- Large amount of data
- Small table

Row ID Scans

- The row ID specifies the data file and data block containing the row as well as the location of the row in that block.
- Using the row ID is the fastest way to retrieve a single row.
- Every index scan does not imply access by row ID.

Index Scans

Types of index scans:

- Index unique scan
- Index range scan
- Index range scan descending
- Index skip scan

Index Scans

Types of index scans:

- **Full scan**
- **Fast-full index scan**
- **Index join**
- **Bitmap join**

Joining Multiple Tables

You can join only two row sources at a time. Joins with more than two tables are executed as follows:

1. Two tables are joined, resulting in a row source.
2. The next table is joined with the row source that results from step 1.
3. Step 2 is repeated until all tables are joined.

Join Terminology

- Join statement
- Join predicate, nonjoin predicate
- Single-row predicate

```
SELECT c.cust_last_name,c.cust_first_name,
       co.country_id, co.country_name
FROM   customers c JOIN countries co
ON     (c.country_id = co.country_id)
AND    ( co.country_id = '52790'
OR      c.cust_id = 205);
```

Join predicate

Nonjoin predicate

Single-row predicate

Join Terminology

- **Natural join**

```
SELECT c.cust_last_name, co.country_name
FROM   customers c NATURAL JOIN countries co;
```

- **Join with nonequal predicate**

```
SELECT s.amount_sold, p.promo_name
ON( s.time_id
From sales s, promotions p
BETWEEN p.promo_begin_date
AND p.promo_end_date );
```

- **Cross join**

```
SELECT *
  FROM   customers c CROSS JOIN countries co;
```

SQL:1999 Outer Joins

- Plus (+) sign is not used.
- Keyword `OUTER JOIN` is used instead.

```
SELECT s.time_id, t.time_id
FROM   sales s
RIGHT OUTER JOIN times t
ON     (s.time_id = t.time_id);
```

Oracle Proprietary Outer Joins

- Join predicates with a plus (+) sign
- Nonjoin predicates with a plus (+) sign
- Predicates without a plus (+) sign disable outer joins

```
SELECT s.time_id, t.time_id
FROM   sales s, times t
WHERE  s.time_id (+) = t.time_id;
```

Full Outer Joins

- A full outer join acts like a combination of the left and right outer joins.
- In addition to the inner join, rows in both tables that have not been returned in the result of the inner join are preserved and extended with nulls.

```
SELECT c.cust_id, c.cust_last_name
,      co.country_name
FROM   customers c
FULL   OUTER JOIN countries co
ON     (c.country_id = co.country_id);
```

Execution of Outer Joins

Indexes can be used for outer join predicates.

```
SELECT  c.cust_id,  co.country_name
FROM    customers c
LEFT OUTER JOIN countries co
ON  (c.country_id = co.country_id)
AND     co.country_id = 'IT';
```

Join Order Rules

Rule 1

A *single-row predicate* forces its row source to be placed first in the join order.

Rule 2

For *outer joins*, the table with the outer-joined table must come after the other table in the join order for processing the join.

Join Optimization

- As a first step, a list of possible join orders is generated.
- This potentially results in the following:

```
Number of Tables   Join Orders
----------------   -----------
2                  2! =  2
3                  3! =  6
4                  4! = 24
```

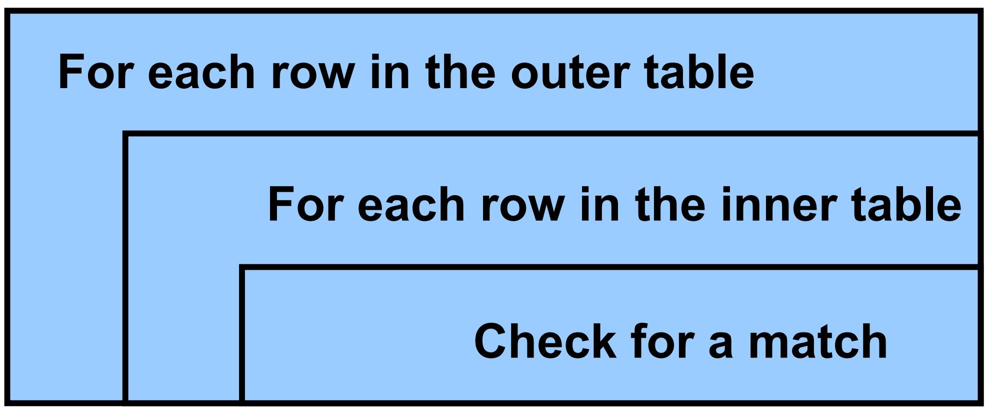
- Parse time grows factorially when adding tables to a join.

Join Methods

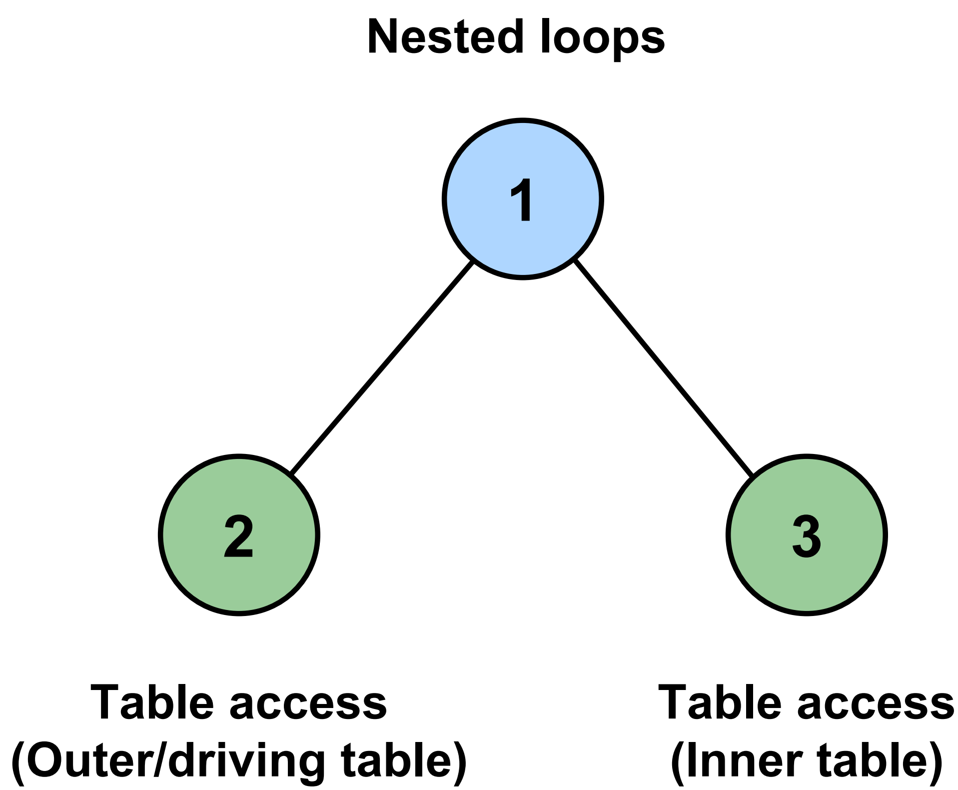
- A join operation combines the output from two row sources and returns one resulting row source.
- Join operation types include the following:
  - Nested loop join
  - Sort-merge join
  - Hash join

Nested Loop Joins

- One of the two tables is defined as the *outer* table (or the *driving* table).
- The other table is called the *inner* table.
- For each row in the outer table, all matching rows in the inner table are retrieved.



Nested Loop Join Plan



When Are Nested Loop Joins Used?

Nested loop joins are used when:

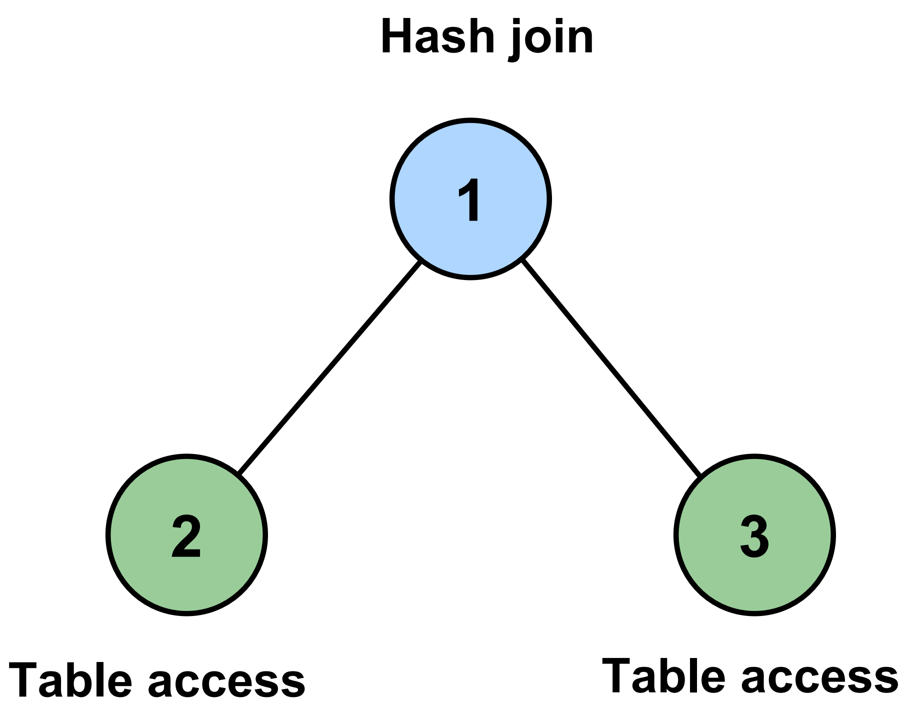
- **Joining a few rows that have a good driving condition**
- **Order of tables is important**
- `USE_NL(table1 table2)` **hint is used**

Hash Joins

A hash join is executed as follows:

- Both tables are split into as many partitions as required, using a full table scan.
- For each partition pair, a hash table is built in memory on the smallest partition.
- The other partition is used to probe the hash table.

Hash Join Plan



When Are Hash Joins Used?

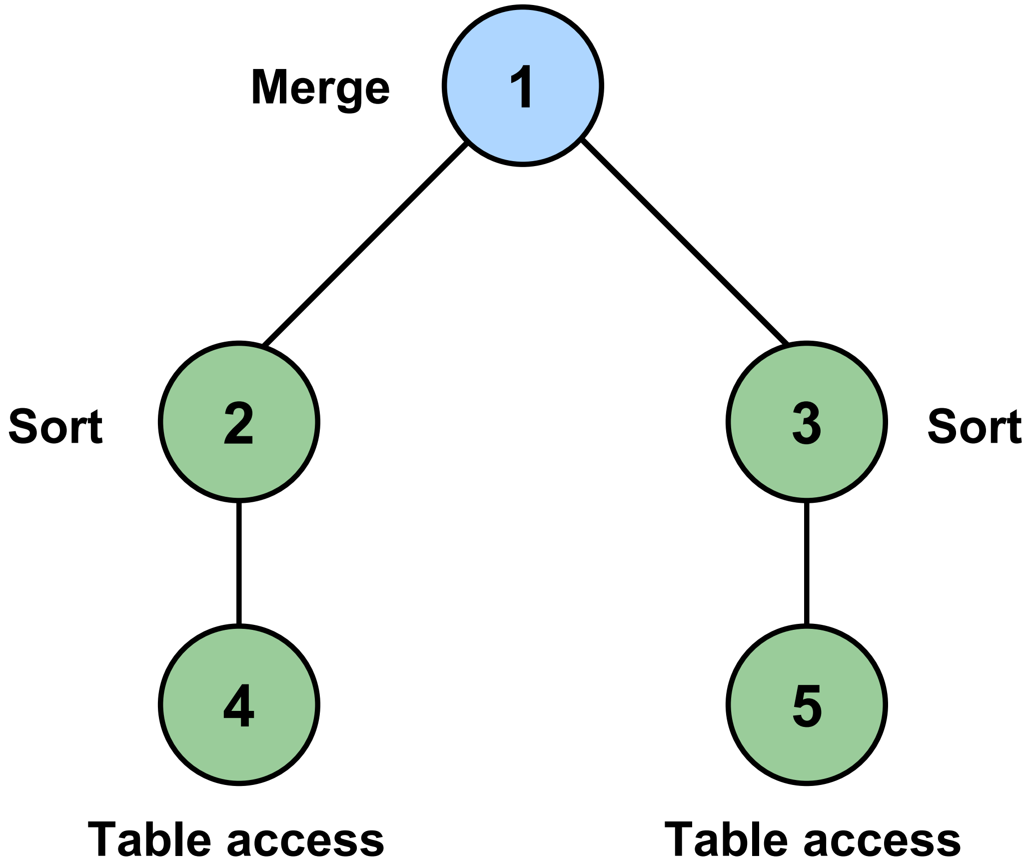
- Hash joins are used if either of the following conditions is true:
  - A large amount of data needs to be joined.
  - A large fraction of the table needs to be joined.
- Use the `USE_HASH` hint.

Sort-Merge Joins

A sort-merge join is executed as follows:

1. The rows from each row source are sorted on the join predicate columns.
2. The two sorted row sources are then merged and returned as the resulting row source.

Sort-Merge Join Plan

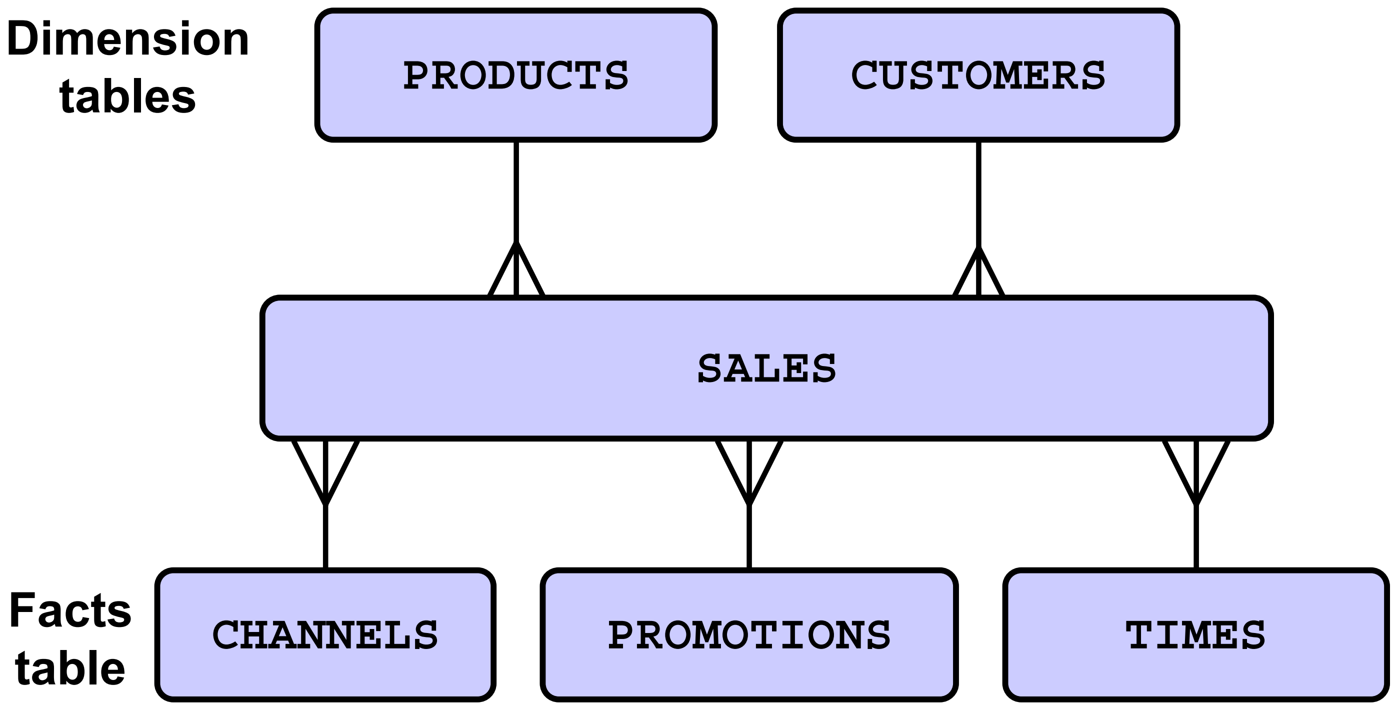


When Are Sort-Merge Joins Used?

Sort-merge joins can be used if either of the following conditions is true:

- Join condition is not an equijoin.
- Sorts are required for other operations.

Star Joins


Dimension
tables
PRODUCTS
CUSTOMERS
SALES
Facts
table
CHANNELS
PROMOTIONS
TIMES

How the Query Optimizer Chooses Execution Plans for Joins

The query optimizer determines:

- Row sources
- Type of join
- Join method
- Cost of execution plans
- Other costs such as:
  - I/O
  - CPU time
  - `DB_FILE_MULTIBLOCK_READ_COUNT`
- Hints specified

Subqueries and Joins

- Subqueries (like joins) are statements that reference multiple tables
- Subquery types:
  - Noncorrelated subquery
  - Correlated subquery
  - `NOT IN` subquery (antijoin)
  - `EXISTS` subquery (semijoin)

Sort Operations

- `SORT UNIQUE`
- `SORT AGGREGATE`
- `SORT GROUP BY`
- `SORT JOIN`
- `SORT ORDER BY`

Tuning Sort Performance

- Because sorting large sets can be expensive, you should tune sort parameters.
- Note that `DISTINCT`, `GROUP BY`, and most set operators cause implicit sorts.
- Minimize sorting by one of the following:
  - Try to avoid `DISTINCT` and `GROUP BY`.
  - Use `UNION ALL` instead of `UNION`.
  - Enable index access to avoid sorting.

Top-N SQL

```
SELECT *
FROM (SELECT prod_id
          ,      prod_name
          ,      prod_list_price
          ,      prod_min_price
      FROM products
      ORDER BY prod_list_price DESC)
WHERE ROWNUM <= 5;
```

Memory and Optimizer Operations

- Memory-intensive operations use up work areas in the Program Global Area (PGA).
- Automatic PGA memory management simplifies and improves the way PGA memory is allocated.
- The size of a work area must be big enough to avoid multi-pass execution.
- A reasonable amount of PGA memory allows single-pass executions.
- The size of PGA is controlled with:
  - `PGA_AGGREGATE_TARGET`
  - `WORKAREA_SIZE_POLICY`

Summary

In this lesson, you should have learned how to:

- Describe available join operations
- Optimize join performance against different requirements
- Influence the join order
- Explain why tuning joins is more complicated than tuning single table statements

6

Execution Plans

Objectives

After completing this lesson, you should be able to do the following:

- Use the EXPLAIN PLAN command to show how a statement is processed
- Use the DBMS_XPLAN package
- Use the Automatic Workload Repository
- Query the V$SQL_PLAN performance view
- Use the SQL*Plus AUTOTRACE setting to show SQL statement execution plans and statistics

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What Is an Execution Plan?

An execution plan is a set of steps that are performed by the optimizer in executing a SQL statement and performing an operation.

Methods for Viewing Execution Plans

- `EXPLAIN PLAN`
- SQL Trace
- Statspack
- Automatic Workload Repository
- `V$SQL_PLAN`
- SQL*Plus `AUTOTRACE`

Using Execution Plans

- Determining the current execution plan
- Identifying the effect of indexes
- Determining access paths
- Verifying the use of indexes
- Verifying which execution plan may be used

DBMS_XPLAN Package: Overview

- The DBMS_XPLAN package provides an easy way to display the output from:
  – EXPLAIN PLAN command
  – Automatic Workload Repository (AWR)
  – V$SQL_PLAN and V$SQL_PLAN_STATISTICS_ALL fixed views
- The DBMS_XPLAN package supplies three table functions that can be used to retrieve and display the execution plan:
  – DISPLAY
  – DISPLAY_CURSOR
  – DISPLAY_AWR

`EXPLAIN PLAN` Command

- **Generates an optimizer execution plan**
- **Stores the plan in the `PLAN` table**
- **Does not execute the statement itself**

`EXPLAIN PLAN` Command

```
EXPLAIN PLAN [SET STATEMENT_ID = 'text']
             [INTO your plan table]
FOR statement
```

EXPLAIN PLAN Command: Example

```
EXPLAIN PLAN
SET STATEMENT_ID = 'demo01' FOR
SELECT e.last_name, d.department_name
FROM hr.employees e, hr.departments d
WHERE e.department_id = d.department_id;

Explained.
```

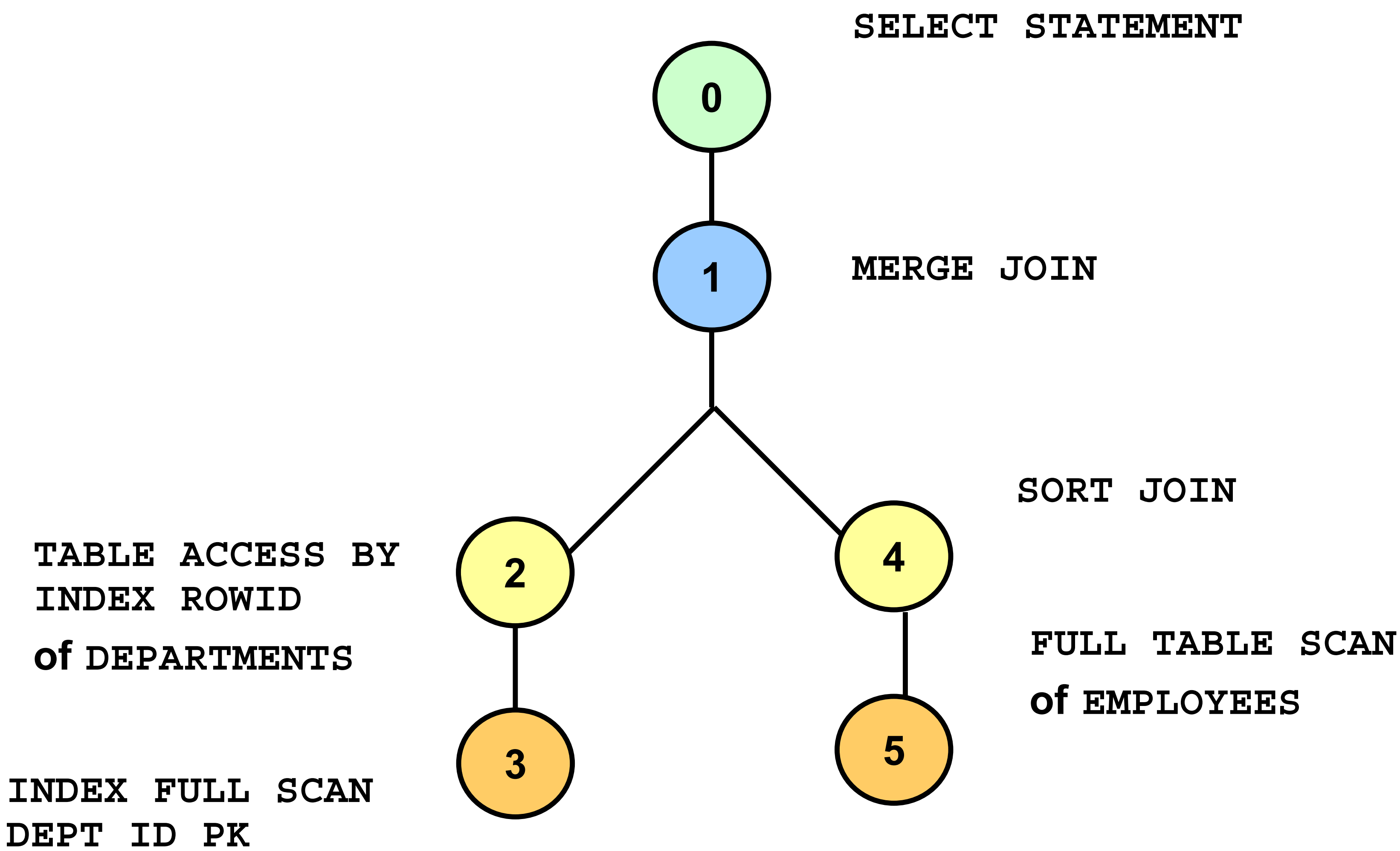
Note: The EXPLAIN PLAN command does not actually execute the statement.

EXPLAIN PLAN Command: Output

```
SELECT PLAN_TABLE_OUTPUT FROM TABLE(DBMS_XPLAN.DISPLAY());
```

```
Plan hash value: 2933537672

--------------------------------------------------------------------------------
| Id  | Operation                    | Name          | Rows  | Bytes | Cost  (%CPU|
--------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |               |   106 |  2862 |      6   (17|
|   1 |  MERGE JOIN                  |               |   106 |  2862 |      6   (17|
|   2 |   TABLE ACCESS BY INDEX ROWID| DEPARTMENTS   |    27 |   432 |      2    (0|
|   3 |    INDEX FULL SCAN           | DEPT_ID_PK    |    27 |       |      1    (0|
|*  4 |   SORT JOIN                  |               |   107 |  1177 |      4   (25|
|   5 |    TABLE ACCESS FULL         | EMPLOYEES     |   107 |  1177 |      3    (0|
--------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------


   4 - access("E"."DEPARTMENT_ID"="D"."DEPARTMENT_ID")
       filter("E"."DEPARTMENT_ID"="D"."DEPARTMENT_ID")

18 rows selected.
```

Parse Tree


SELECT STATEMENT
0
1
MERGE JOIN
SORT JOIN
TABLE ACCESS BY
INDEX ROWID
of DEPARTMENTS
2
4
FULL TABLE SCAN
of EMPLOYEES
3
5
INDEX FULL SCAN
DEPT_ID_PK

Using the `V$SQL_PLAN` View

- `V$SQL_PLAN` provides a way of examining the execution plan for cursors that were recently executed.
- Information in `V$SQL_PLAN` is very similar to the output of an `EXPLAIN PLAN` statement:
  – `EXPLAIN PLAN` shows a theoretical plan that can be used if this statement were to be executed.
  – `V$SQL_PLAN` contains the actual plan used.

V$SQL_PLAN Columns

HASH_VALUE	Hash value of the parent statement in the library cache
ADDRESS	Object number of the table or the index
CHILD_NUMBER	Child cursor number using this execution plan
POSITION	Order of processing for operations that all have the same PARENT_ID
PARENT_ID	ID of the next execution step that operates on the output of the current step
ID	Number assigned to each step in the execution plan

Note: This is only a partial listing of the columns.

Querying V$SQL_PLAN

```
SELECT PLAN_TABLE_OUTPUT FROM
TABLE(DBMS_XPLAN.DISPLAY_CURSOR('47ju6102uvq5q'));
```

```
SQL_ID  47ju6102uvq5q, child number 0
-------------------------------------
SELECT e.last_name, d.department_name
FROM hr.employees e, hr.departments d WHERE
e.department_id =d.department_id

Plan hash value: 2933537672
--------------------------------------------------------------------------------
| Id  | Operation                    | Name          | Rows  | Bytes | Cost (%CPU|
--------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |               |       |       |     6 (100|
|   1 |  MERGE JOIN                  |               |   106 |  2862 |     6  (17|
|   2 |   TABLE ACCESS BY INDEX ROWID| DEPARTMENTS   |    27 |   432 |     2   (0|
|   3 |    INDEX FULL SCAN           | DEPT_ID_PK    |    27 |       |     1   (0|
|*  4 |   SORT JOIN                  |               |   107 |  1177 |     4  (25|
|   5 |    TABLE ACCESS FULL         | EMPLOYEES     |   107 |  1177 |     3   (0|
--------------------------------------------------------------------------------
Predicate Information (identified by operation id):
---------------------------------------------------


   4 - access("E"."DEPARTMENT_ID"="D"."DEPARTMENT_ID")
       filter("E"."DEPARTMENT_ID"="D"."DEPARTMENT_ID")

24 rows selected.
```

V$SQL_PLAN_STATISTICS View

- **V$SQL_PLAN_STATISTICS provides actual execution statistics.**
- **V$SQL_PLAN_STATISTICS_ALL enables side-by-side comparisons of the optimizer estimates.**

Automatic Workload Repository

- Collects, processes, and maintains performance statistics for problem-detection and self-tuning purposes
- Statistics include:
  - Object statistics
  - Time-model statistics
  - Some system and session statistics
  - Active Session History (ASH) statistics
- Automatically generates snapshots of the performance data

Managing AWR with PL/SQL

- Creating snapshots
- Dropping snapshots
- Managing snapshot settings

AWR Views

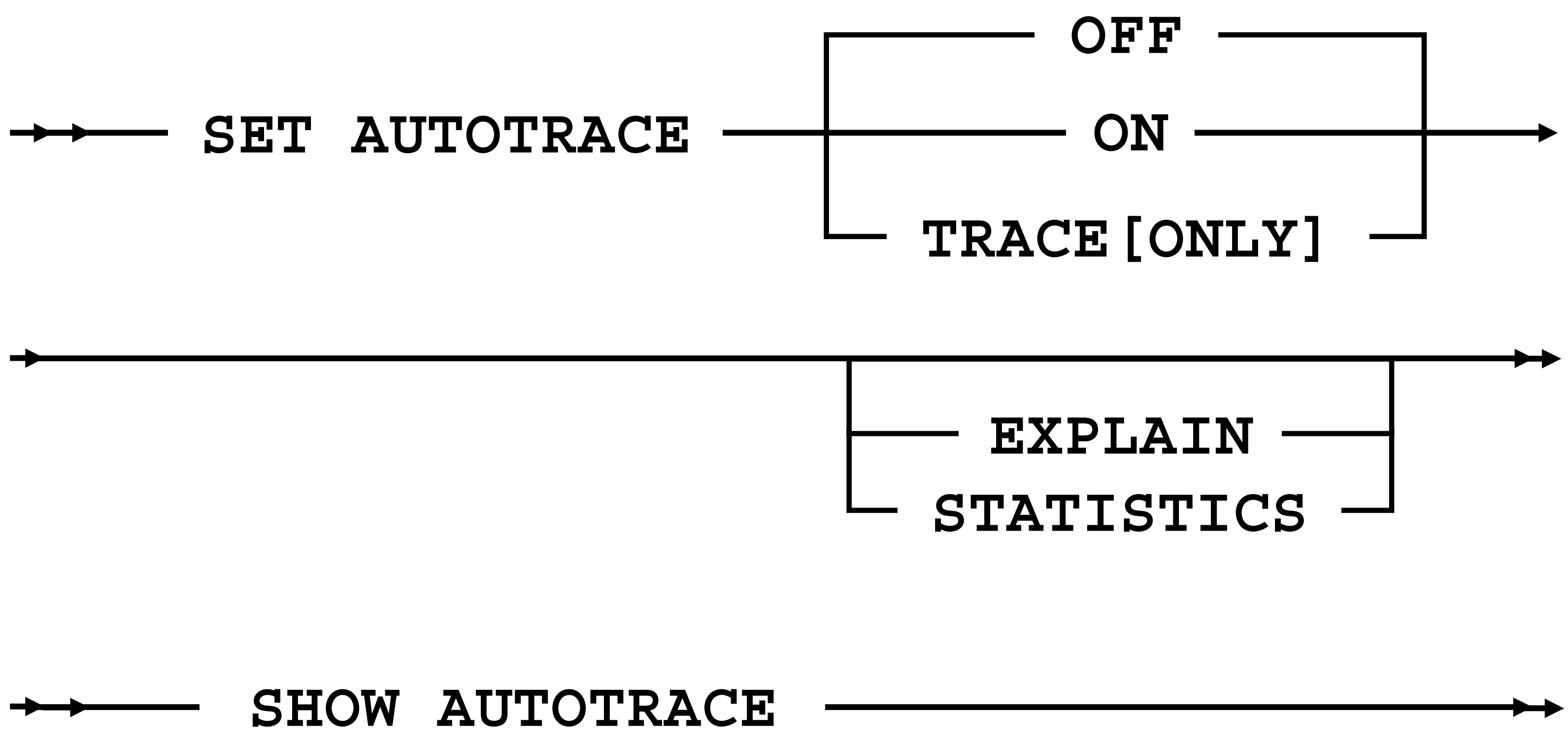
- V$ACTIVE_SESSION_HISTORY
- V$metric views
- DBA_HIST views:
  - DBA_HIST_ACTIVE_SESS_HISTORY
  - DBA_HIST_BASELINE
    DBA_HIST_DATABASE_INSTANCE
  - DBA_HIST_SNAPSHOT
  - DBA_HIST_SQL_PLAN
  - DBA_HIST_WR_CONTROL

Querying the AWR

```
SELECT PLAN_TABLE_OUTPUT FROM TABLE
(DBMS_XPLAN.DISPLAY_AWR('454rug2yva18w'));
```

```
PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------------
SQL_ID 454rug2yva18w
--------------------
select /* example */ * from hr.employees natural join hr.departments

Plan hash value: 4179021502

----------------------------------------------------------------------------------
| Id  | Operation           | Name        | Rows  | Bytes | Cost (%CPU)| Time     |
----------------------------------------------------------------------------------
|   0 | SELECT STATEMENT    |             |       |       |     6 (100)|          |
|   1 |  HASH JOIN          |             |    11 |   968 |     6  (17)| 00:00:01 |
|   2 |   TABLE ACCESS FULL| DEPARTMENTS |    11 |   220 |     2   (0)| 00:00:01 |
|   2 |   TABLE ACCESS FULL| DEPARTMENTS |    11 |   220 |     2   (0)| 00:00:01 |
|   3 |   TABLE ACCESS FULL| EMPLOYEES   |   107 |  7276 |     3   (0)| 00:00:01 |
----------------------------------------------------------------------------------
```

SQL*Plus AUTOTRACE



SQL*Plus AUTOTRACE: Examples

- To start tracing statements using AUTOTRACE

```
set autotrace on
```

- To hide statement output

```
set autotrace traceonly
```

- To display execution plans only

```
set autotrace traceonly explain
```

- Control the layout with column settings

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SQL*Plus AUTOTRACE: Statistics

```
set autotrace traceonly statistics

SELECT *
FROM products;
```

```
Statistics
----------------------------------------------------------
          1  recursive calls
          0  db block gets
          9  consistent gets
          3  physical reads
          0  redo size
      15028  bytes sent via SQL*Net to client
        556  bytes received via SQL*Net from client
          6  SQL*Net roundtrips to/from client
          0  sorts (memory)
          0  sorts (disk)
         72  rows processed
```

Summary

In this lesson, you should have learned how to:

- Use `EXPLAIN PLAN` to view execution plans
- Query `V$SQL_PLAN` to see the execution plan for cursors that were recently executed
- Use the Automatic Workload Repository
- Use SQL*Plus `AUTOTRACE` to run statements and display execution plans and statistics

Practice 6: Overview

This practice covers the following topics:

- **Using `AUTOTRACE`**
- **Using `EXPLAIN PLAN`**
- **Using AWR**
- **Retrieving the execution plan using `DBMS_XPLAN`**

Gathering Statistics

Objectives

After completing this lesson, you should be able to do the following:

- Identify table, index, and column statistics
- Describe the Automatic Statistics Gathering mechanism
- Use the `DBMS_STATS` package to collect statistics manually
- Identify predicate selectivity calculations

What Are Optimizer Statistics?

- Collection of data that describes the database and the objects in the database
- Information used by query optimizer to estimate:
  – Selectivity of predicates
  – Cost of each execution plan
  – Access method and join method
  – CPU and I/O costs

Types of Optimizer Statistics

- Object statistics
  - Table statistics
  - Column statistics
  - Index statistics
- System statistics
  - I/O performance and utilization
  - CPU performance and utilization

How Statistics Are Gathered

- **Automatic statistics gathering**
  - **`GATHER_STATS_JOB`**
- **Manual statistics gathering**
  - **`DBMS_STATS` package**
- **Dynamic sampling**

Automatic Statistics Gathering

- **Oracle Database 10*g* automates optimizer statistics collection:**
  - **Statistics are gathered automatically on all database objects.**
  - `GATHER_STATS_JOB` **is used for statistics collection and maintenance.**
  - **Scheduler interface is used for scheduling the maintenance job.**
- **Automated statistics collection:**
  - **Eliminates need for manual statistics collection**
  - **Significantly reduces the chances of getting poor execution plans**

Manual Statistics Gathering

You can use the `DBMS_STATS` package to:

- Generate and manage statistics for use by the optimizer
- Gather, modify, view, export, import, and delete statistics
- Identify or name statistics that are gathered
- Gather statistics on:
  - Indexes, tables, columns, and partitions
  - All schema objects in a schema or database
- Gather statistics either serially or in parallel

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Managing Automatic Statistics Collection

- **Job configuration options**
- **Statistics-collection configuration options**

Job Configuration Options

- **Setting status: `ENABLED` or `DISABLED`**
- **Maintaining schedule: maintenance window**

Managing the Job Scheduler

Verifying Automatic Statistics Gathering:

```
SELECT owner, job_name,enabled
FROM DBA_SCHEDULER_JOBS
WHERE JOB_NAME = 'GATHER_STATS_JOB';
```

Disabling and enabling Automatic Statistics Gathering:

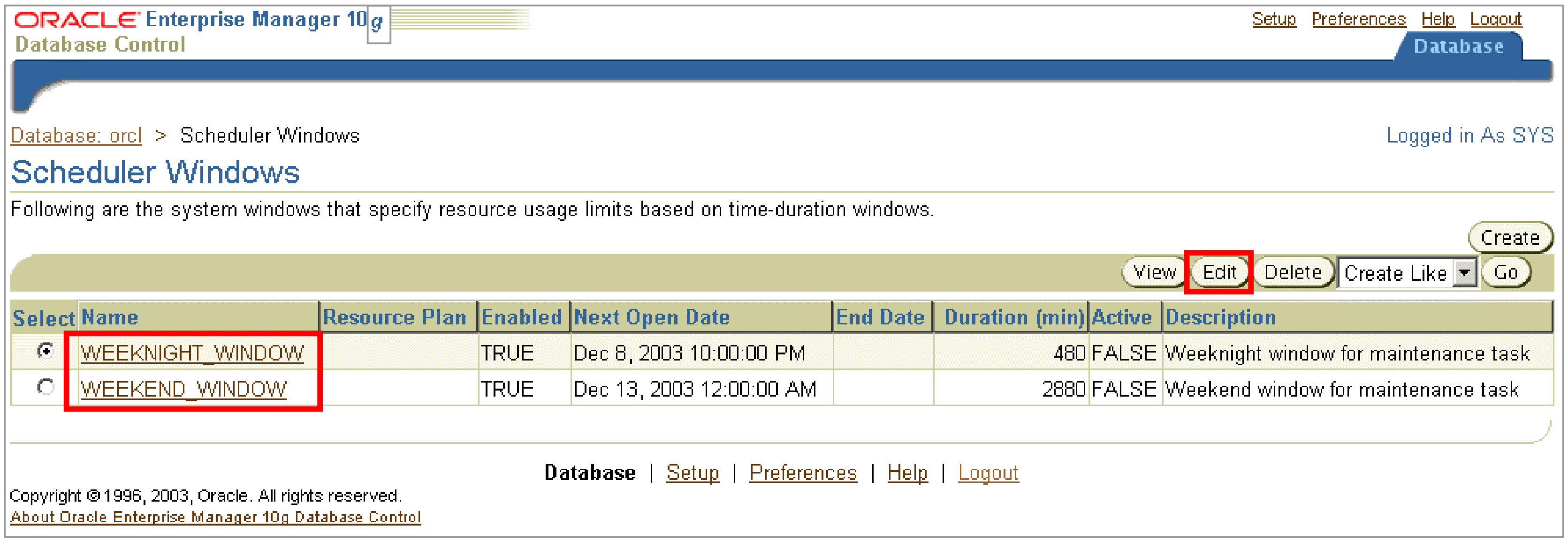
```
BEGIN
DBMS_SCHEDULER.DISABLE('GATHER_STATS_JOB');
END;
/
BEGIN
DBMS_SCHEDULER.ENABLE('GATHER_STATS_JOB');
END;
/
```

Managing the Maintenance Window

- WEEKNIGHT_WINDOW
- WEEKEND_WINDOW

```
EXECUTE DBMS_SCHEDULER.SET_ATTRIBUTE(
   'WEEKNIGHT_WINDOW',
   'repeat_interval',
   'freq=daily; byday= MON, TUE, WED, THU, FRI;
      byhour=0; byminute=0; bysecond=0');
```

Changing the `GATHER_STATS_JOB` Schedule



Statistics Collection Configuration

- DML monitoring
- Sampling
- Degree of parallelism
- Histograms
- Cascade

DML Monitoring

- The DML monitoring facility:
  - Tracks DML statements and truncation of tables
  - Is used by the Automatic Statistics Gathering mechanism for identifying segments with stale statistics
  - Is enabled by default when `STATISTICS_LEVEL` is set to `TYPICAL` or `ALL`
- You can:
  - View the information on DML changes in the `USER_TAB_MODIFICATIONS` view
  - Use `DBMS_STATS.FLUSH_DATABASE_MONITORING_INFO` to update the view with current information
  - Use `GATHER_DATABASE_STATS` or `GATHER_SCHEMA_STATS` for manual statistics gathering for tables with stale statistics when `OPTIONS` is set to `GATHER STALE` or `GATHER AUTO`

Sampling

- Statistics gathering relies on sampling to minimize resource usage.
- You can use the `ESTIMATE_PERCENT` argument of the `DBMS_STATS` procedures to change the sampling percentage to any value.
- Set to `DBMS_STATS.AUTO_SAMPLE_SIZE` (default) to maximize performance gains.
- `AUTO_SAMPLE_SIZE` enables the database to determine the appropriate sample size for each object automatically.

```
EXECUTE DBMS_STATS.GATHER_SCHEMA_STATS
('SH',DBMS_STATS.AUTO_SAMPLE_SIZE);
```

Degree of Parallelism

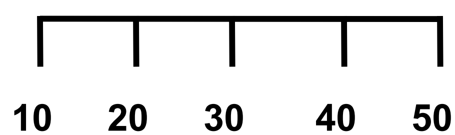
- Automatic Statistics Gathering operations can run either serially or in parallel.
- By default, the degree of parallelism is determined automatically.
- You can also manually specify the degree of parallelism using the `DEGREE` argument of the `DBMS_STATS` procedures.
- Setting the `DEGREE` parameter to `DBMS_STATS.AUTO_DEGREE` (default) enables the Oracle Database to choose an appropriate degree of parallelism even when collecting statistics manually.

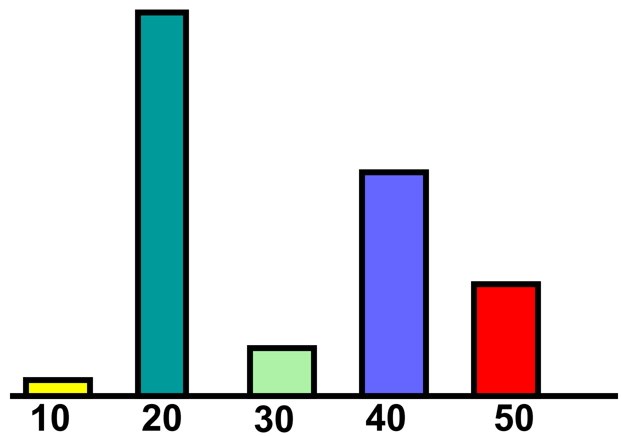
Histograms

- Influence optimizer decisions on selecting the optimal execution plan
- Provide improved selectivity estimates in the presence of data skew
- Enable optimal execution plans with nonuniform data distributions

Column Value	Count of Rows
10	10
20	1050
30	126
40	567
50	248

Number of buckets = 5





Creating Histograms

- The Automatic Statistics Gathering mechanism creates histograms as needed by default.
- You can use the `DBMS_STATS` package to change this default.
- You can use `DBMS_STATS` to create histograms manually.
- The following example shows how to create a histogram with 50 buckets on `PROD_LIST_PRICE`:

```
EXECUTE dbms_stats.gather_table_stats
        ('sh','products',
          method_opt => 'for columns size 50
                         prod_list_price');
```

Viewing Histogram Statistics

```
SELECT column_name, num_distinct,
num_buckets, histogram
  FROM USER_TAB_COL_STATISTICS
WHERE histogram <> 'NONE';
```

1

```
SELECT column_name, num_distinct,
num_buckets, histogram
  FROM USER_TAB_COL_STATISTICS
WHERE column_name = 'PROD_LIST_PRICE';
```

2

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Histogram Tips

- The default option for `DBMS_STATS` `METHOD_OPTS is FOR ALL COLUMNS SIZE AUTO`, which enables automatic creation of histograms as needed.
- Alternatively, you can create histograms manually:
  – On skewed columns that are used frequently in `WHERE` clauses of queries
  – On columns that have a highly skewed data distribution

Histogram Tips

- **Do not use histograms unless they substantially improve performance.**
  - **Histograms allocate additional storage.**
  - **Histograms, like all other optimizer statistics, are static.**
  - **Recompute the histogram when the data distribution of a column changes frequently.**
  - **For queries with bind variables**

Bind Variable Peeking

- The optimizer peeks at the values of bind variables on the first invocation of a cursor.
- This is done to determine the selectivity of the predicate.
- Peeking does not occur for subsequent invocations of the cursor.
- Cursor is shared, based on the standard cursor-sharing criteria even for different bind values.

Cascading to Indexes

- The Automatic Statistics Gathering mechanism is configured by default to gather index statistics while gathering statistics on the parent tables.
- You can change the default behavior by modifying the `CASCADE` option of the `DBMS_STATS` package.
- Set the `CASCADE` option to:
  - `TRUE` to gather index statistics
  - `DBMS_STATS.AUTO_CASCADE` to have the Oracle Database determine whether index statistics are to be collected or not

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Managing Statistics Collection: Example

```
dbms_stats.gather_table_stats
('sh'                     -- schema
,'customers'              -- table
, null                    -- partition
, 20                    -- sample size(%)
, false                   -- block sample?
,'for all columns' -- column spec
, 4                       -- degree of parallelism
,'default'                  -- granularity
, true ); -- cascade to indexes
```

```
dbms_stats.set_param('CASCADE',
                  'DBMS_STATS.AUTO_CASCADE');
dbms_stats.set_param('ESTIMATE_PERCENT','5');
dbms_stats.set_param('DEGREE','NULL');
```

When to Gather Manual Statistics

- Rely mostly on automatics statistics collection
- Change frequency of automatic statistics collection to meet your needs
- Gather statistics manually:
  – For objects that are volatile
  – For objects modified in batch operations

Statistics Gathering: Manual Approaches

- Dynamic sampling:

```
BEGIN
DBMS_STATS.DELETE_TABLE_STATS('OE','ORDERS');
DBMS_STATS.LOCK_TABLE_STATS('OE','ORDERS');
END;
```

- Manual statistics collection:

```
BEGIN
DBMS_STATS.GATHER_TABLE_STATS('OE','ORDERS');
DBMS_STATS.LOCK_TABLE_STATS('OE','ORDERS');
END;
```

- For objects modified in batch operations: gather statistics as part of the batch operation
- For new objects: gather statistics immediately after object creation

Dynamic Sampling

Dynamic sampling is used to automatically collect statistics when:

- The cost of collecting the statistics is minimal compared to the execution time
- The query is executed many times

Locking Statistics

- Prevents automatic gathering
- Is used primarily for volatile tables
  - Lock without statistics implies dynamic sampling.
  - Lock with statistics is for representative values.

```
EXECUTE DBMS_STATS.LOCK_TABLE_STATS
('owner name', 'table name');
```

```
EXECUTE DBMS_STATS.LOCK_SCHEMA_STATS
('owner name');
```

```
SELECT stattype_locked
FROM dba_tab_statistics;
```

Verifying Table Statistics

```
SELECT last_analyzed analyzed, sample_size,
      monitoring,table_name
FROM dba_tables
WHERE table_name ='EMPLOYEES';

ANALYZED   SAMPLE_SIZE MON TABLE_NAME
---------  ----------- --- -------------------
09-FEB-04         2000 YES EMPLOYEES
```

Verifying Column Statistics

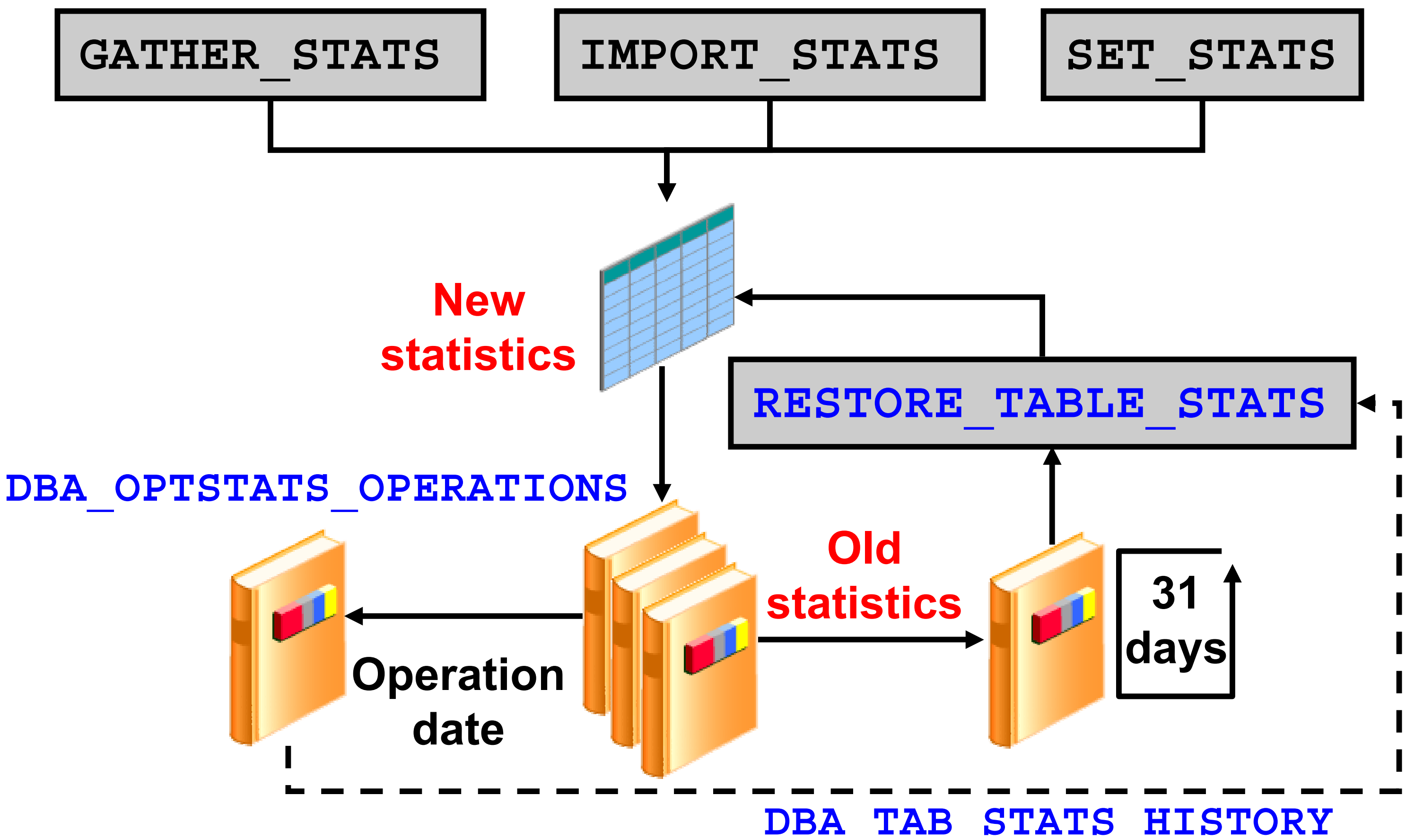
```
SELECT column_name, num_distinct,histogram,
 num_buckets, density, last_analyzed analyzed
FROM dba_tab_col_statistics
WHERE table_name  ='SALES'
ORDER BY column_name;
```

```
COLUMN_NAME    NUM_DISTINCT HISTOGRAM   NUM_BUCKETS DENSITY    ANALYZED
-------------- ------------ ----------- ----------- ---------- ---------
AMOUNT_SOLD            3586 NONE                  1 .000278862 09-FEB-04
CHANNEL_ID                4 NONE                  1        .25 09-FEB-04
CUST_ID                7059 NONE                  1 .000141663 09-FEB-04
PROD_ID                  72 FREQUENCY            72 5.4416E-07 09-FEB-04
PROMO_ID                  4 NONE                  1        .25 09-FEB-04
QUANTITY_SOLD             1 NONE                  1          1 09-FEB-04
TIME_ID                1460 NONE                  1 .000684932 09-FEB-04
7 rows selected.
```

Verifying Index Statistics

```
SELECT index_name name, num_rows n_r,
       last_analyzed l_a, distinct_keys
       d_k, leaf_blocks l_b,
       avg_leaf_blocks_per_key a_l,
       join_index j_I
FROM dba_indexes
WHERE table_name = 'EMPLOYEES'
ORDER BY index_name;
```

History of Optimizer Statistics



Managing Historical Optimizer Statistics

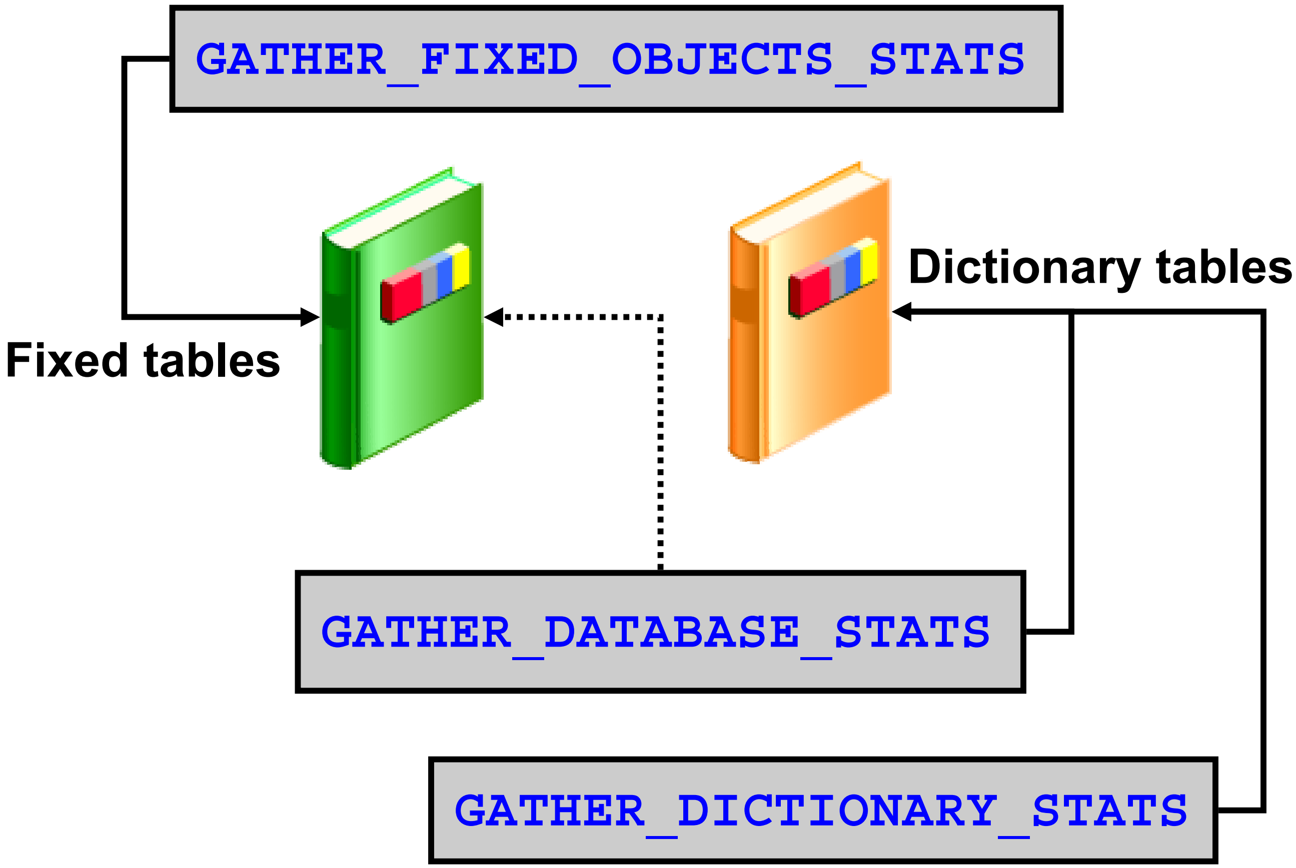
- `RESTORE_*_STATS()`
- `PURGE_STATS()`
- `ALTER_STATS_HISTORY_RETENTION()`

Generating System Statistics

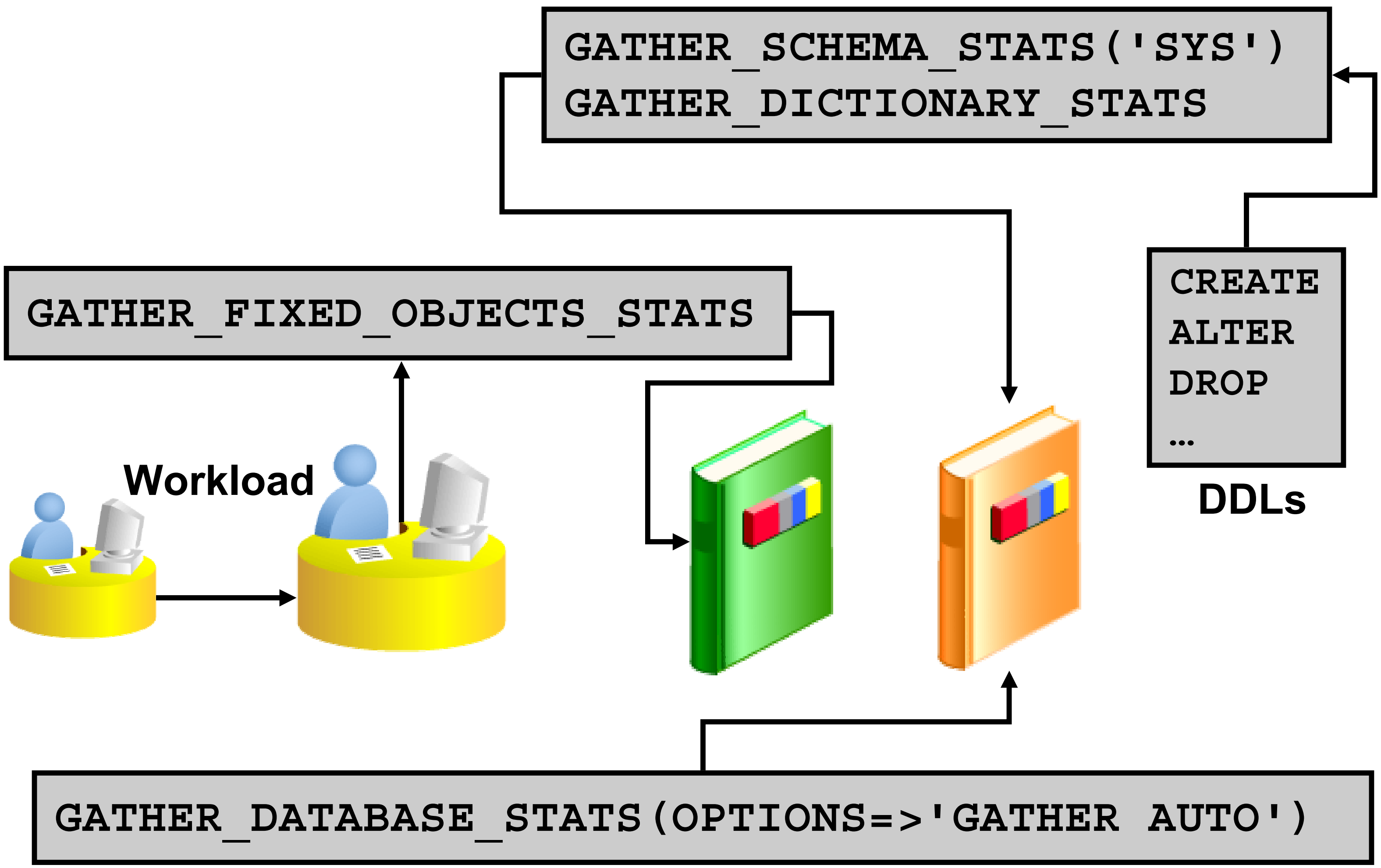
- I/O
- CPU

```
BEGIN
dbms_stats.gather_system_stats(
             gathering_mode => 'interval',
             interval => 720,
             stattab => 'mystats',
             statid => 'oltp');
END;
/
```

Statistics on Dictionary Objects



Dictionary Statistics: Best Practices



Summary

In this lesson, you should have learned how to:

- Use the Automatic Statistics Gathering mechanism
- Use the `DBMS_STATS` package for manual statistics gathering
- Determine selectivity for predicates with and without bind variables

Practice 7: Overview

This practice covers the following topics:

- Using `DBMS_STATS` to gather manual statistics
- Verifying the existence of the `gather_stats_job`
- Understanding the use of histograms
- Understanding bind variable peeking

8 Application Tracing

Objectives

After completing this lesson, you should be able to do the following:

- Configure the SQL Trace facility to collect session statistics
- Enable SQL Trace and locate your trace files
- Format trace files using the `TKPROF` utility
- Interpret the output of the `TKPROF` command

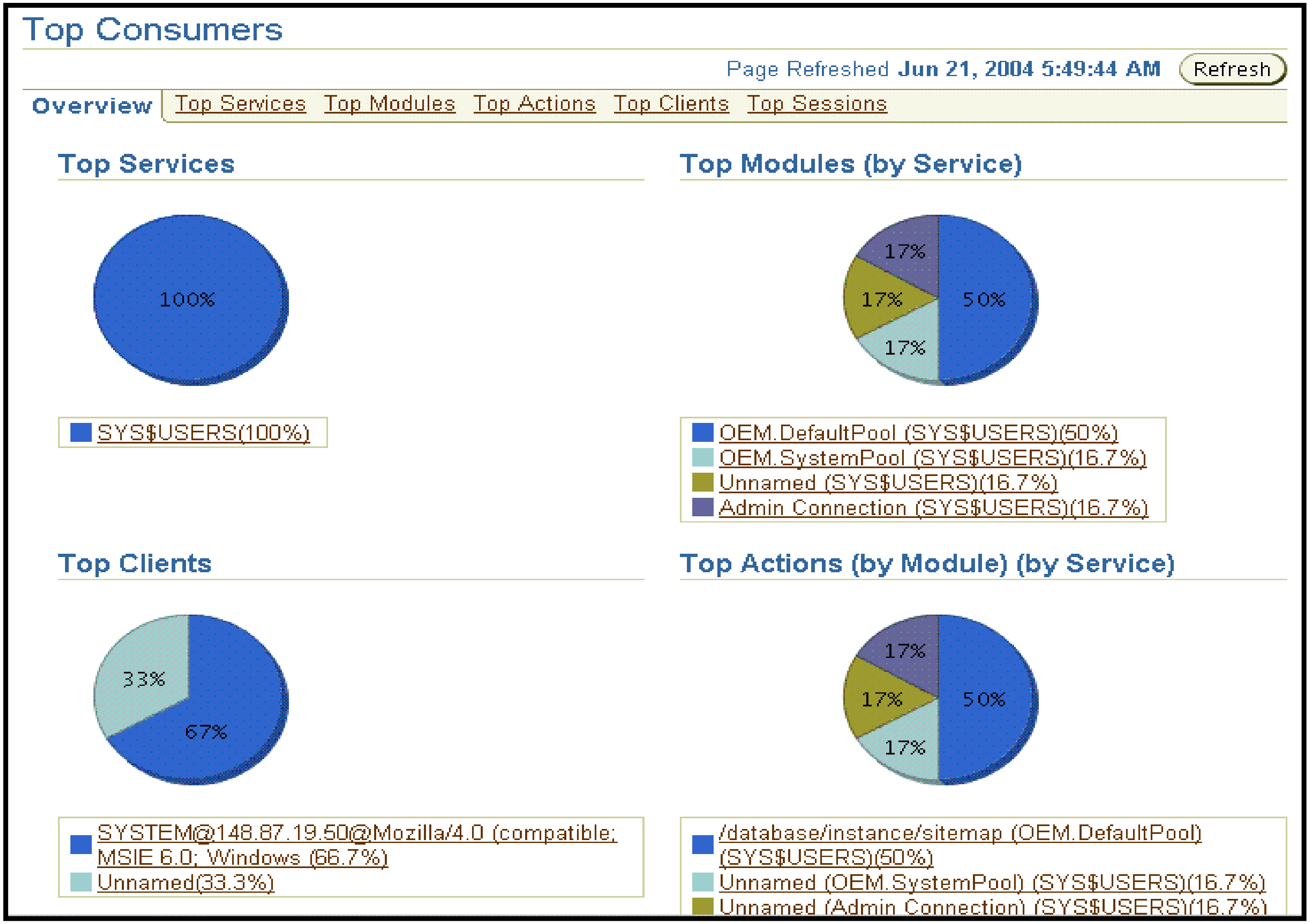
Overview of Application Tracing

- End to End Application Tracing
  - Enterprise Manager
  - `DBMS_MONITOR`
- `trcsess` utility
- SQL Trace and `TKPROF`

End to End Application Tracing

- Simplifies the process of diagnosing performance problems in multitier environments
- Can be used to
  - Identify high-load SQL
  - Monitor what a user's session is doing at the database level
- Simplifies management of application workloads by tracking specific modules and actions in a service

End to End Application Tracing Using EM



Using DBMS_MONITOR

```
EXECUTE DBMS_MONITOR.CLIENT_ID_STAT_ENABLE(
        client_id => 'OE.OE',
        waits => TRUE, binds => FALSE);
```

1

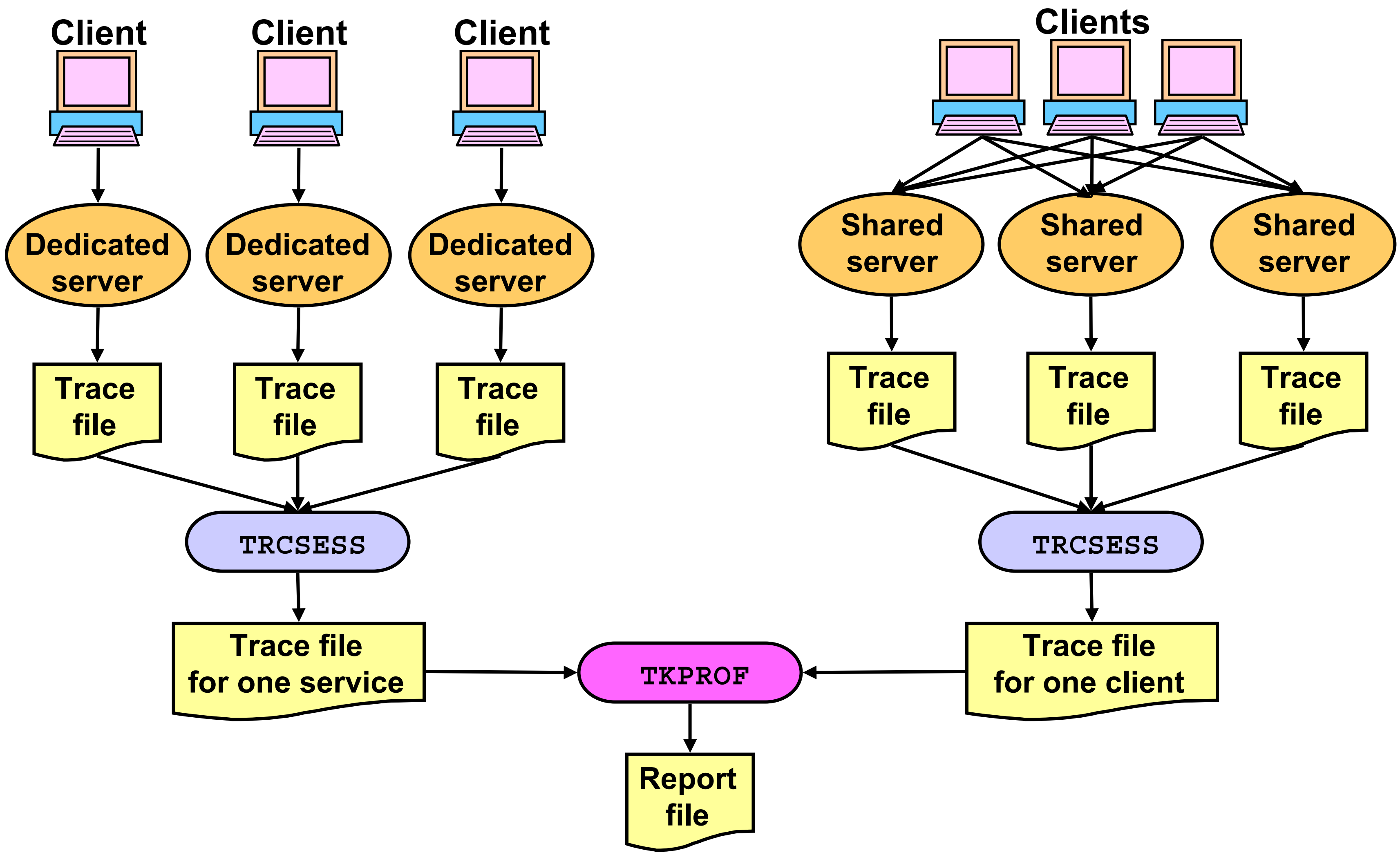
```
EXECUTE DBMS_MONITOR.SERV_MOD_ACT_STAT_ENABLE(
         service_name =>'ACCTG',
         module_name => 'PAYROLL');
EXECUTE DBMS_MONITOR.SERV_MOD_ACT_STAT_ENABLE(
         service_name =>'ACCTG',
         module_name => 'GLEDGER',
         action_name => 'INSERT ITEM');
```

2

Viewing Gathered Statistics for End to End Application Tracing

- **The accumulated statistics for a specified service can be displayed in the `V$SERVICE_STATS` view.**
- **The accumulated statistics for a combination of specified service, module, and action can be displayed in the `V$SERV_MOD_ACT_STATS` view.**
- **The accumulated statistics for elapsed time of database calls and for CPU use can be displayed in the `V$SVCMETRIC` view.**
- **All outstanding traces can be displayed in an Oracle Enterprise Manager report or with the `DBA_ENABLED_TRACES` view.**

`trcsess` Utility



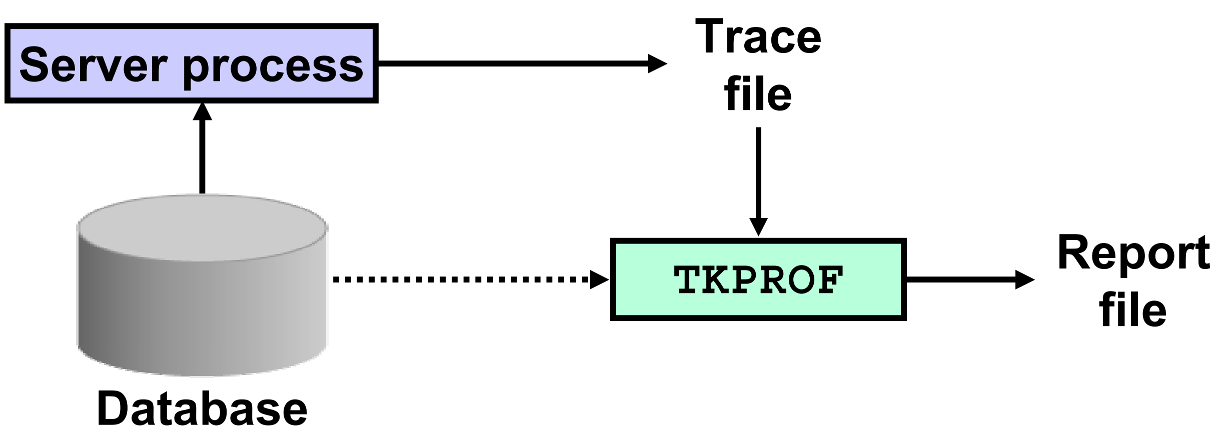
`trcsess` Utility

```
SQL>  select sid||'.'||serial#, username
  2 from v$session
  3  where username in ('HR',  'SH');
 SID||'.'||SERIAL#  USERNAME
------------------- --------------------------
236.57                   HR
245.49845                SH
```

```
$ trcsess session= 236.57 orcl_ora_11155.trc
  output=x.txt
```

SQL Trace Facility

- Usually enabled at the session level
- Gathers session statistics for SQL statements grouped by session
- Produces output that can be formatted by `TKPROF`

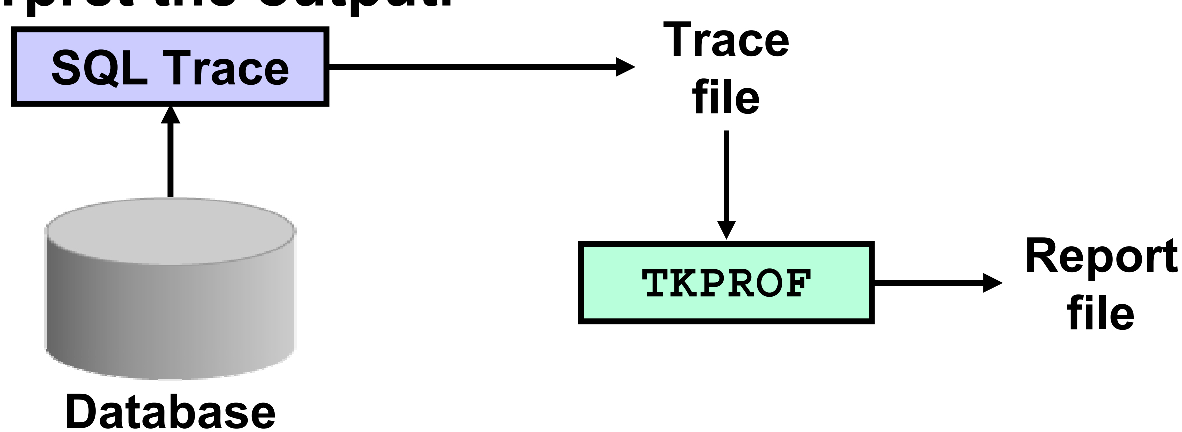


Information Captured by SQL Trace

- Parse, execute, and fetch counts
- CPU and elapsed times
- Physical reads and logical reads
- Number of rows processed
- Misses on the library cache
- Username under which each parse occurred
- Each commit and rollback

How to Use the SQL Trace Facility

1. Set the initialization parameters.
2. Enable tracing.
3. Run the application.
4. Disable Trace
5. Close the session.
6. Format the trace file.
7. Interpret the output.



Initialization Parameters

```
TIMED_STATISTICS = {false|true}
MAX_DUMP_FILE_SIZE = {n|unlimited}
USER_DUMP_DEST = directory_path
STATISTICS_LEVEL = {BASIC|TYPICAL|ALL}
```

Enabling SQL Trace

- For your current session:

```
SQL> ALTER SESSION SET sql_trace = true;
```

- For any session:

```
SQL> EXECUTE dbms_session.set_sql_trace(true);
```

```
SQL> EXECUTE dbms_system.set_sql_trace_in_session
  2   (session_id, serial_id, true);
```

- For an instance, set the following parameter:

```
SQL_TRACE = TRUE
```

Formatting Your Trace Files

```
OS> tkprof tracefile outputfile [options]
```

`TKPROF` command examples:

```
OS> tkprof
OS> tkprof ora_902.trc run1.txt
OS> tkprof ora_902.trc run2.txt sys=no
    sort=execpu print=3
```

`TKPROF` Command Options

```
SORT = option
PRINT = n
EXPLAIN = username/password
INSERT = filename
SYS = NO
AGGREGATE = NO
RECORD = filename
TABLE = schema.tablename
```

Output of the `TKPROF` Command

- Text of the SQL statement
- Trace statistics (for statement and recursive calls) separated into three SQL processing steps:

`PARSE`	Translates the SQL statement into an execution plan
`EXECUTE`	Executes the statement (This step modifies the data for `INSERT`, `UPDATE`, and `DELETE` statements.)
`FETCH`	Retrieves the rows returned by a query (Fetches are performed only for `SELECT` statements.)

Output of the `TKPROF` Command

There are seven categories of trace statistics:

`Count`	**Number of times the procedure was executed**
`CPU`	**Number of seconds to process**
`Elapsed`	**Total number of seconds to execute**
`Disk`	**Number of physical blocks read**
`Query`	**Number of logical buffers read for consistent read**
`Current`	**Number of logical buffers read in current mode**
`Rows`	**Number of rows processed by the fetch or execute**

Output of the TKPROF Command

The `TKPROF` output also includes the following:

- Recursive SQL statements
- Library cache misses
- Parsing user ID
- Execution plan
- Optimizer mode or hint
- Row source operation

```
...
Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 61

Rows     Row Source Operation
-------  ---------------------------------------------------
     24  TABLE ACCESS BY INDEX ROWID EMPLOYEES (cr=9 pr=0 pw=0 time=129 us)
     24   INDEX RANGE SCAN SAL_IDX (cr=3 pr=0 pw=0 time=1554 us)(object id ...
```

TKPROF Output with No Index: Example

```
...
select max(cust_credit_limit)
from customers
where cust_city ='Paris'


call     count       cpu    elapsed       disk      query    current        rows
------- ------  -------- ---------- ---------- ---------- ----------  ----------
Parse        1      0.02       0.02          0          0          0           0
Execute      1      0.00       0.00          0          0          0           0
Fetch        2      0.10       0.09       1408       1459          0           1
------- ------  -------- ---------- ---------- ---------- ----------  ----------
total        4      0.12       0.11       1408       1459          0           1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 61

Rows     Row Source Operation
-------  ---------------------------------------------------
      1  SORT AGGREGATE (cr=1459 pr=1408 pw=0 time=93463 us)
     77   TABLE ACCESS FULL CUSTOMERS (cr=1459 pr=1408 pw=0 time=31483 us)
```

TKPROF Output with Index: Example

```
...
select max(cust_credit_limit) from customers
where cust_city ='Paris'

call     count       cpu    elapsed       disk      query    current
rows
------- ------  -------- ---------- ---------- ---------- ----------  ---------
Parse        1      0.01       0.00          0          0          0          0
Execute      1      0.00       0.00          0          0          0          0
Fetch        2      0.00       0.00          0         77          0          1
------- ------  -------- ---------- ---------- ---------- ----------  ---------
total        4      0.01       0.00          0         77          0          1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 61

Rows     Row Source Operation
-------  ---------------------------------------------------
      1  SORT AGGREGATE (cr=77 pr=0 pw=0 time=732 us)
     77   TABLE ACCESS BY INDEX ROWID CUSTOMERS (cr=77 pr=0 pw=0 time=1760 us)
     77    INDEX RANGE SCAN CUST_CUST_CITY_IDX (cr=2 pr=0 pw=0 time=100
                                                            us)(object id
55097)
```

Summary

In this lesson, you should have learned how to:

- Set SQL Trace initialization parameters
  - `SQL_TRACE, TIMED_STATISTICS`
  - `USER_DUMP_DEST, MAX_DUMP_FILE_SIZE`
- Enable SQL Trace for a session

```
ALTER SESSION set sql_trace = true
dbms_session.set_sql_trace(...)
dbms_system.set_sql_trace_in_session(...)
```

- Format trace files with `TKPROF`
- Interpret the output

Practice 8: Overview

This practice covers the following topics:

- **Using `TKPROF`**
- **Using `DBMS_MONITOR`**

9

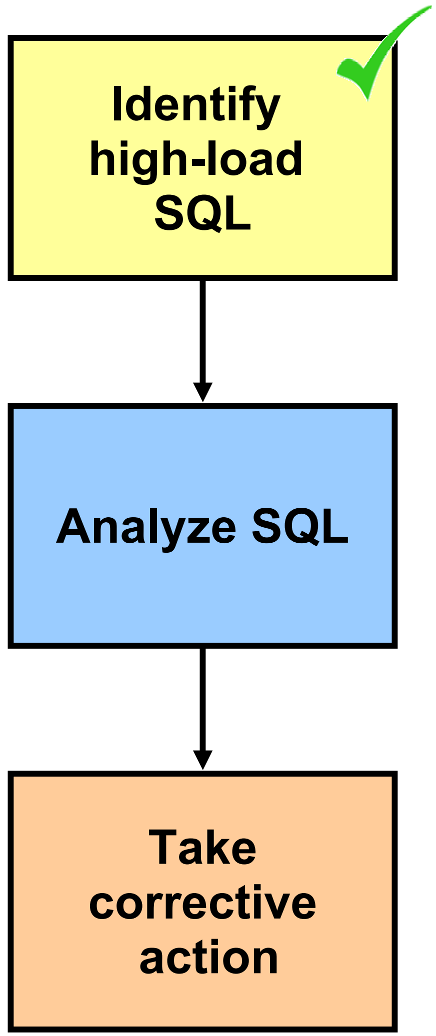
Identifying High-Load SQL

Objectives

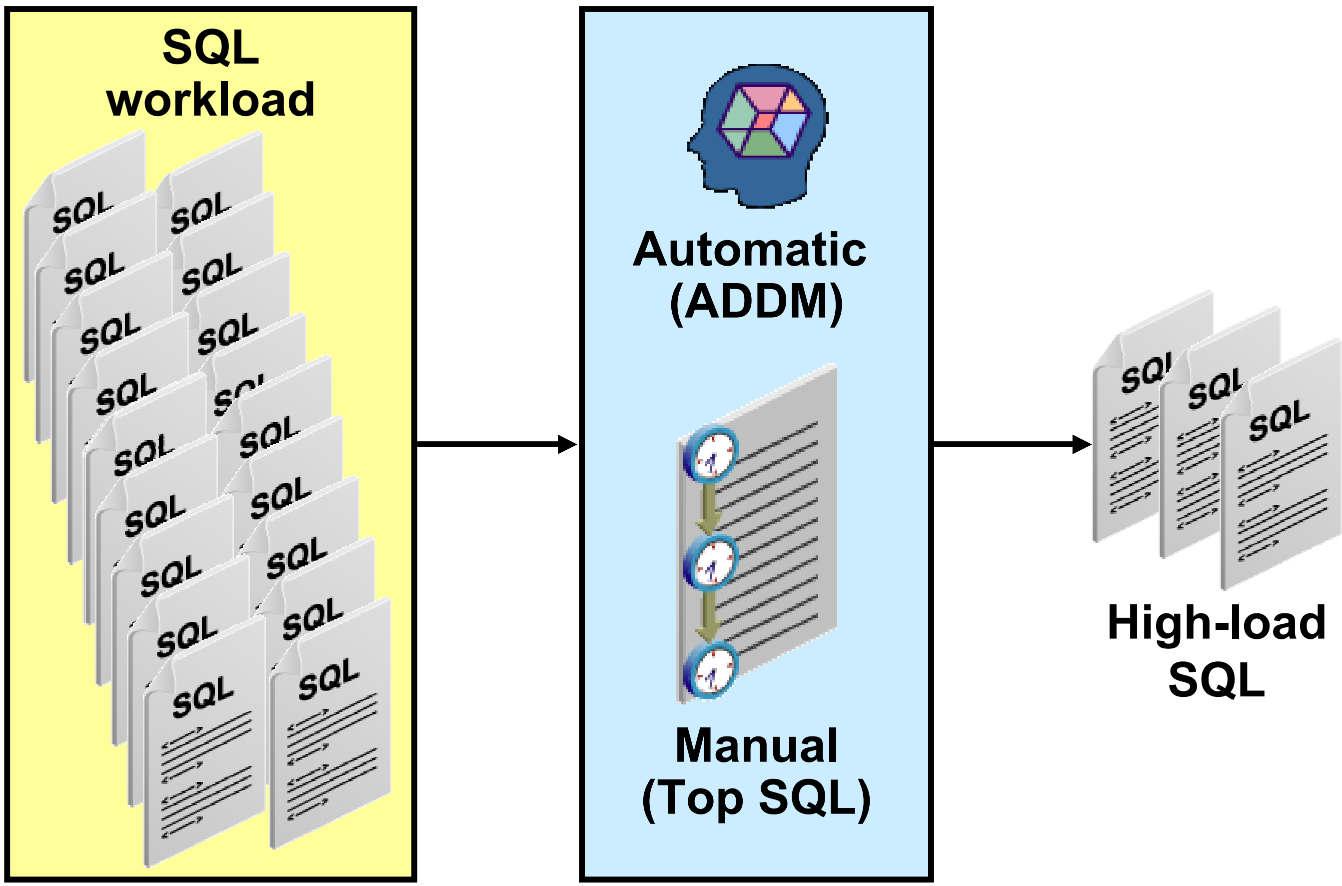
After completing this lesson, you should understand the different methods of identifying high-load SQL:

- ADDM
- Top SQL
- Dynamic performance views
- Statspack

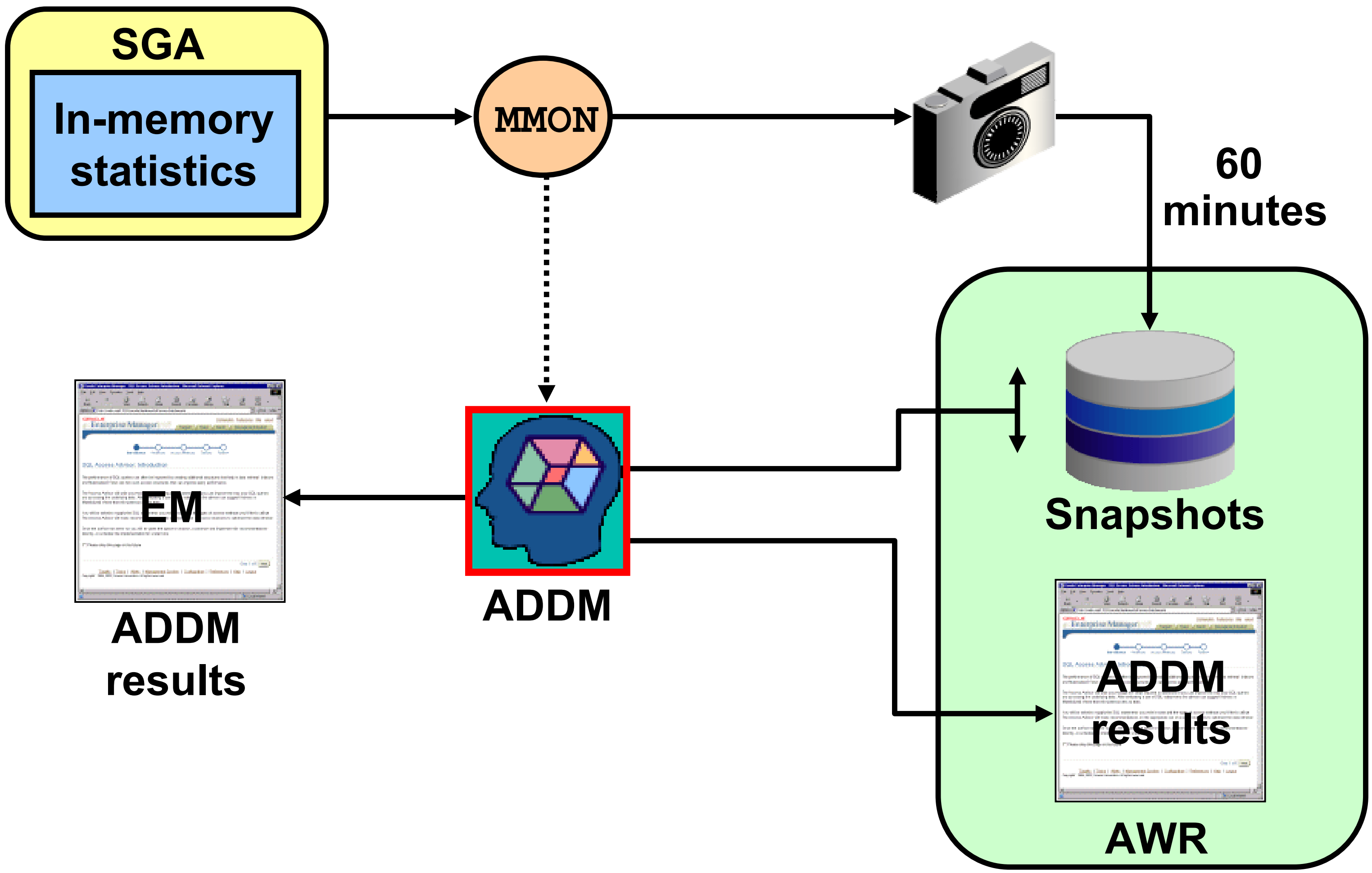
SQL Tuning Process: Overview



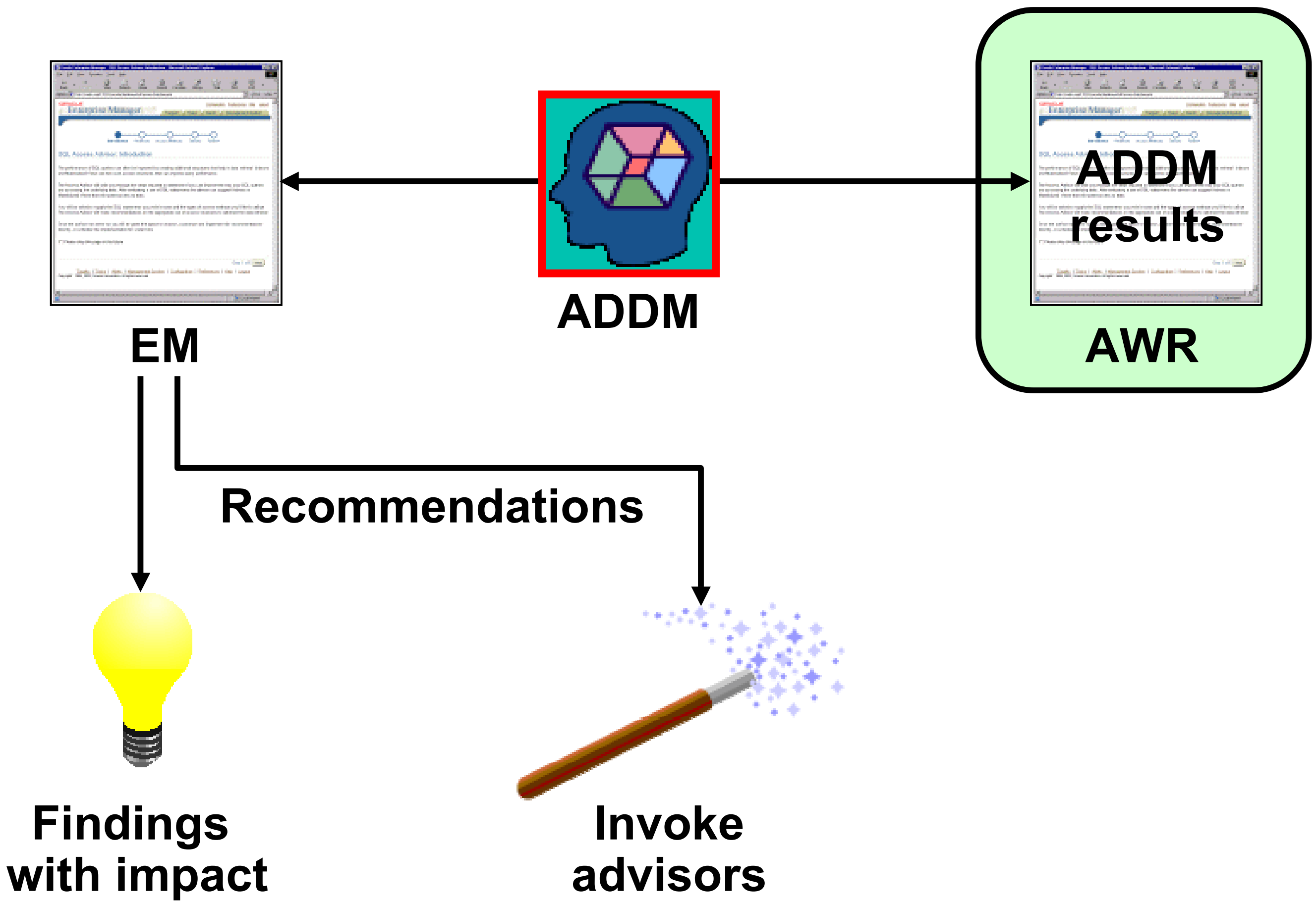
Identifying High-Load SQL



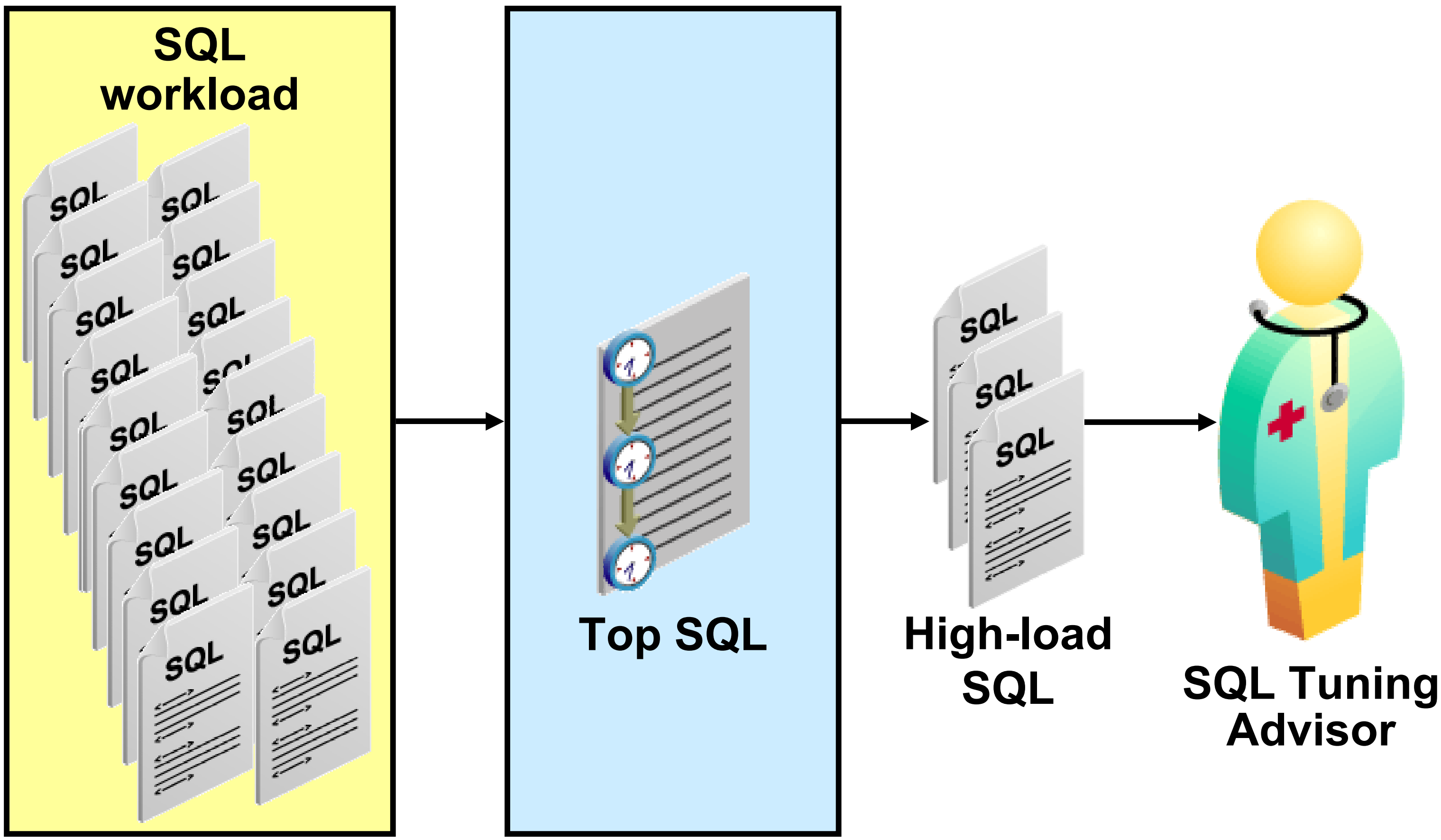
Automatic Database Diagnostic Monitor



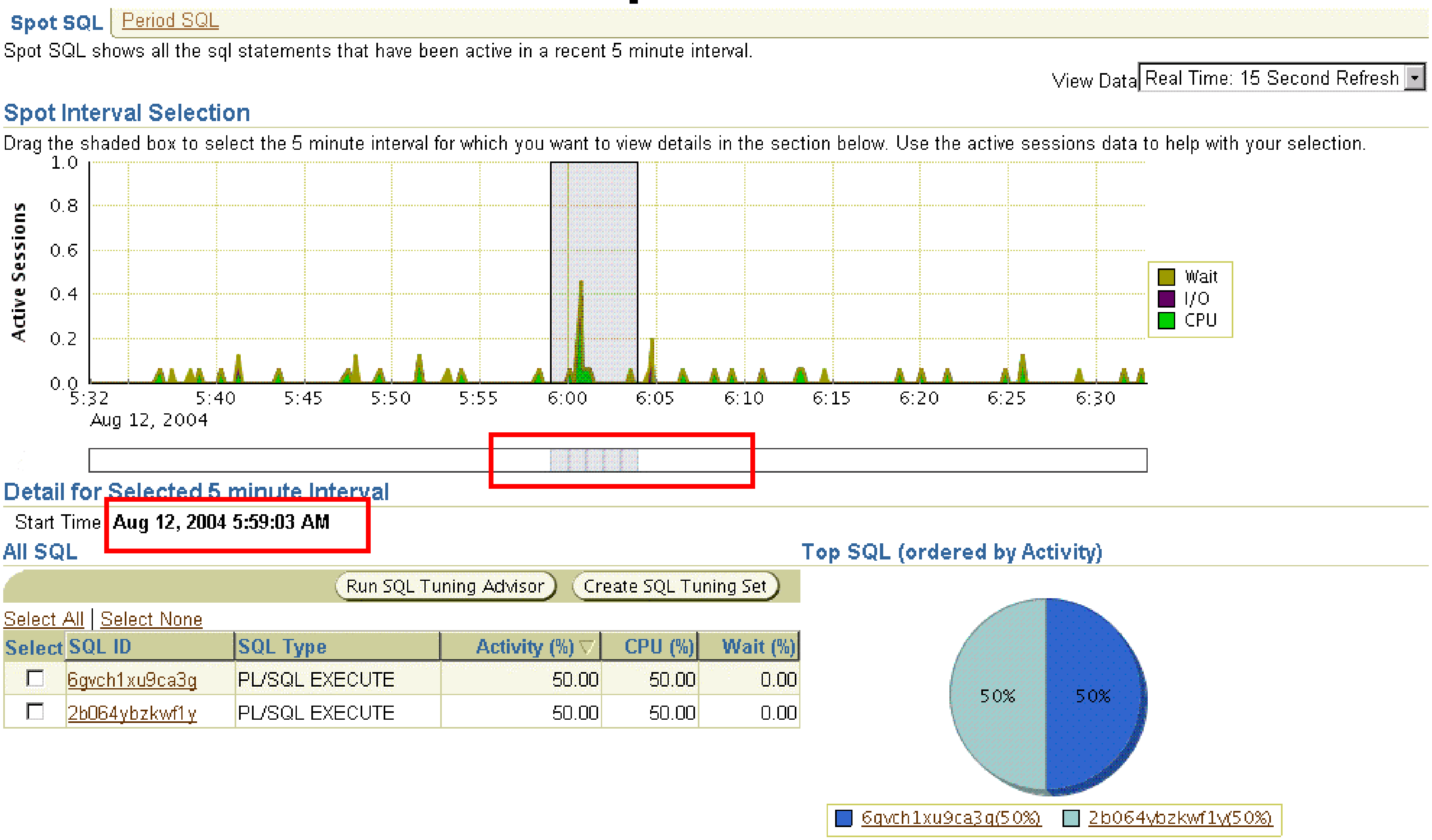
ADDM Output


ADDM results
AWR
ADDM
EM
Recommendations
Findings with impact
Invoke advisors

Manual Identification: Top SQL



Spot SQL

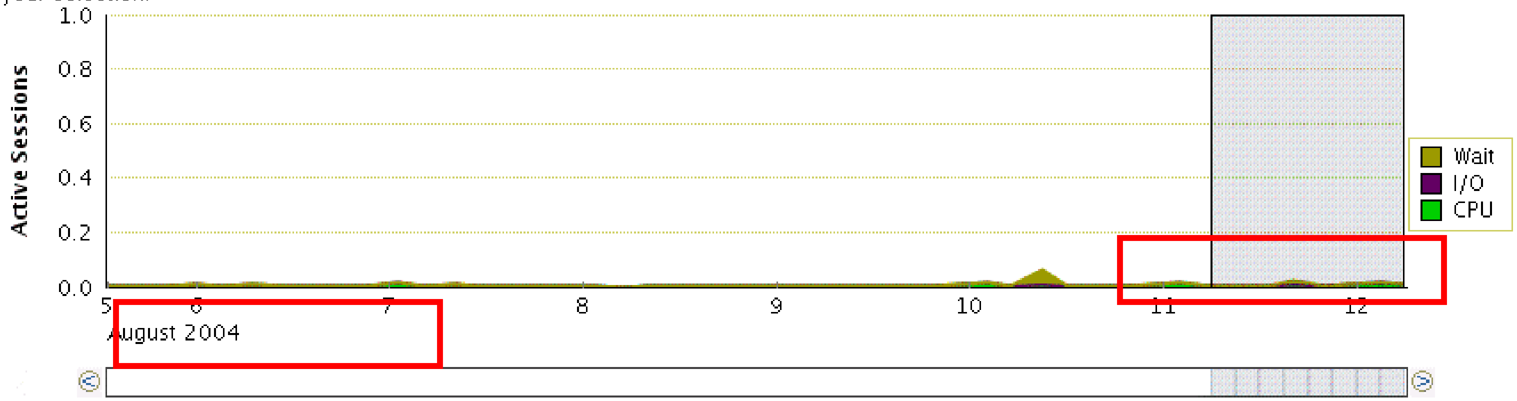

Spot SQL
Period SQL
Spot SQL shows all the sql statements that have been active in a recent 5 minute interval.
View Data
Real Time: 15 Second Refresh
Spot Interval Selection
Drag the shaded box to select the 5 minute interval for which you want to view details in the section below. Use the active sessions data to help with your selection.
Active Sessions
1.0
0.8
0.6
0.4
0.2
0.0
5:32
5:40
5:45
5:50
5:55
6:00
6:05
6:10
6:15
6:20
6:25
6:30
Aug 12, 2004
Wait
I/O
CPU
Detail for Selected 5 minute Interval
Start Time
Aug 12, 2004 5:59:03 AM
All SQL
Run SQL Tuning Advisor
Create SQL Tuning Set
Select All
Select None
Select
SQL ID
SQL Type
Activity (%)
CPU (%)
Wait (%)
6gvch1xu9ca3g
PL/SQL EXECUTE
50.00
50.00
0.00
2b064ybzkwf1y
PL/SQL EXECUTE
50.00
50.00
0.00
Top SQL (ordered by Activity)
50%
50%
6gvch1xu9ca3g(50%)
2b064ybzkwf1y(50%)

Period SQL

Spot SQL | **Period SQL**

Historical Interval Selection

Click on the band below the chart to select the historical 24 hour interval for which you want to view data in the graphs below. Use the active sessions data to help with your selection.



Detail for Selected 24 Hour Interval

Start Time **Aug 11, 2004 5:00:12 AM**

Run SQL Tuning Advisor | Create SQL Tuning Set

Select All | Select None   Previous 1-25 of 365 Next 25

Select	SQL Text	% of Total Elapsed Time	CPU Time (seconds)	Wait Time (seconds)	Elapsed Time Per Execution (seconds)	Module
☐	BEGIN EMD_NOTIFICATION.QUEUE_R	20.76	277.09	4.01	0.10	OEM.SystemPool
☐	call dbms_stats.gather_databas	10.68	89.23	55.44	144.67	
☐	begin MGMT_JOB_ENGINE.get_sche	7.98	106.71	1.42	0.00	OEM.SystemPool
☐	INSERT INTO MGMT_METRICS_RAW (C	7.55	74.45	27.83	0.00	OEM.SystemPool
☐	select cust_first_name -- ws	6.18	0.50	83.25	83.76	SQL*Plus
☐	DECLARE job BINARY_INTEGER :=	4.89	60.02	6.17	0.05	
☐	select c.CUST_GENDER, c.CUST_M	4.01	15.43	38.92	18.12	SQL*Plus

Manual Identification: Statspack

Statspack:

- Collects data about high-load SQL
- Precalculates useful data
  - Cache hit ratios
  - Transaction statistics
- Uses permanent tables owned by the `PERFSTAT` user to store performance statistics
- Separates data collection from report generation
- Uses snapshots to compare performance at different times

Using Dynamic Performance Views

- Select a slow performing period of time to identify high-load SQL.
- Gather operating system and Oracle statistics
- Identify the SQL statements that use the most resources.

V$SQLAREA View

Column	Description
SQL_TEXT	First thousand characters of the SQL text
SORTS	Sum of the number of sorts that were done for all the child cursors
EXECUTIONS	Total number of executions, totaled over all the child cursors
DISK_READS	Sum of the number of disk reads over all child cursors
CPU_TIME	CPU time (in microseconds) used by this cursor for parsing/executing/fetching
ELAPSED_TIME	Elapsed time (in microseconds) used by this cursor for parsing, executing, and fetching

Querying the `V$SQLAREA` View

```
SELECT sql_text,  disk_reads , sorts,
       cpu_time, elapsed_time
FROM   v$sqlarea
WHERE upper(sql_text) like '%PROMOTIONS%'
ORDER BY sql_text;
```

Investigating Full Table Scan Operations

```
SELECT name, value FROM v$sysstat
WHERE name LIKE '%table scan%';

NAME                                              VALUE
--------------------------------------------- --------
table scans (short tables)                       217842
table scans (long tables)                          3040
table scans (rowid ranges)                          254
table scans (cache partitions)                        7
table scans (direct read)                           213
table scan rows gotten                         40068909
table scan blocks gotten                        1128681
```

Summary

In this lesson, you should have learned about the different methods of identifying high-load SQL:

- ADDM
- Top SQL
- Statspack
- Dynamic performance views

10

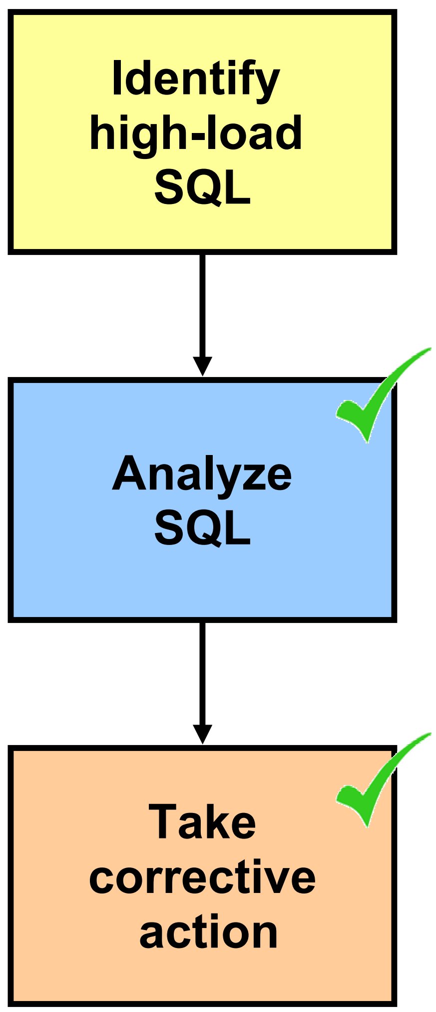
Automatic SQL Tuning

Objectives

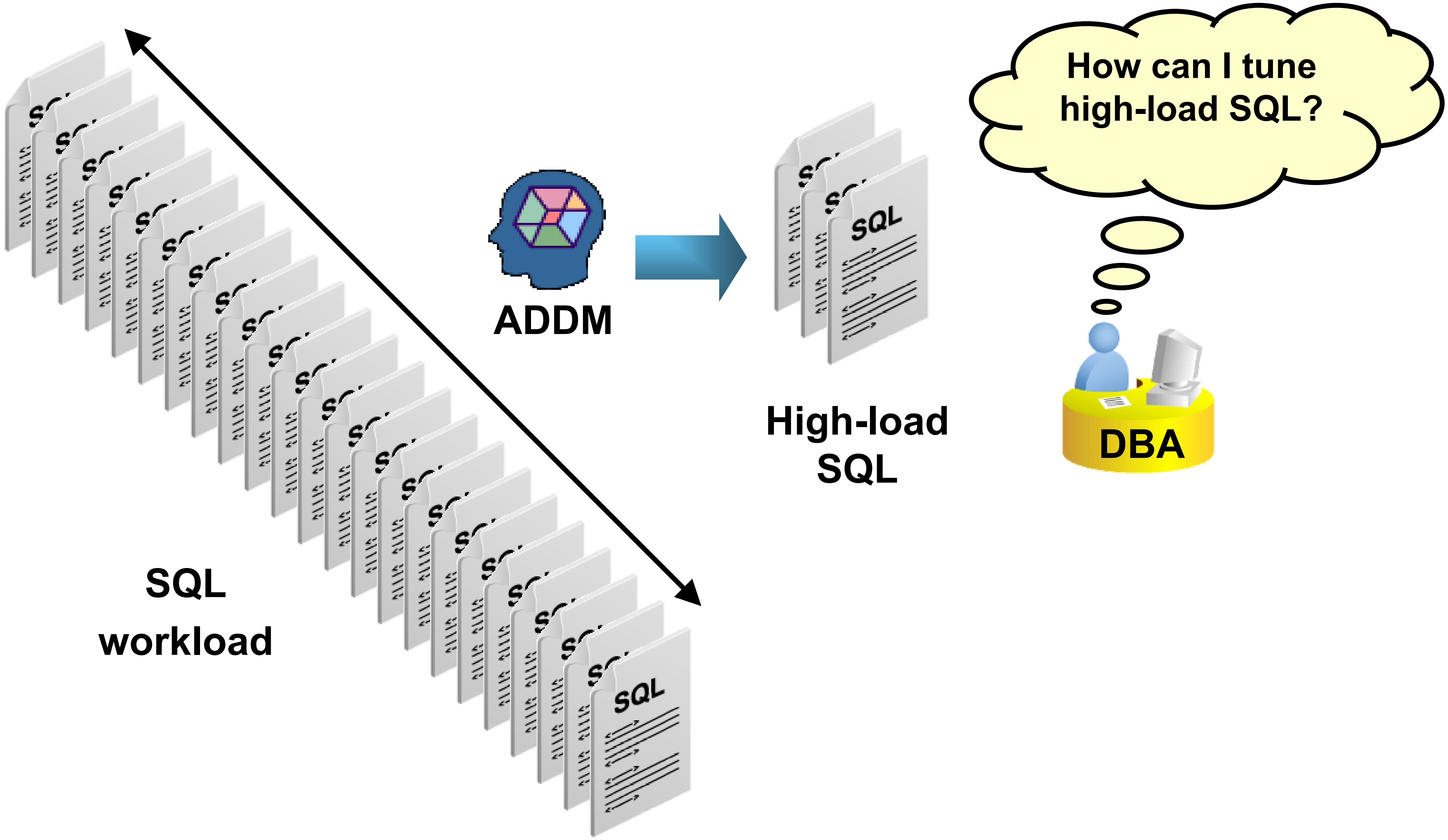
After completing this lesson, you should be able to do the following:

- Describe automatic SQL tuning
- Describe the Automatic Workload Repository
- Use Automatic Database Diagnostic Monitor
- View the cursor cache
- Perform automatic SQL tuning
- Use the SQL Tuning Advisor
- Use the SQL Access Advisor

SQL Tuning Process: Overview



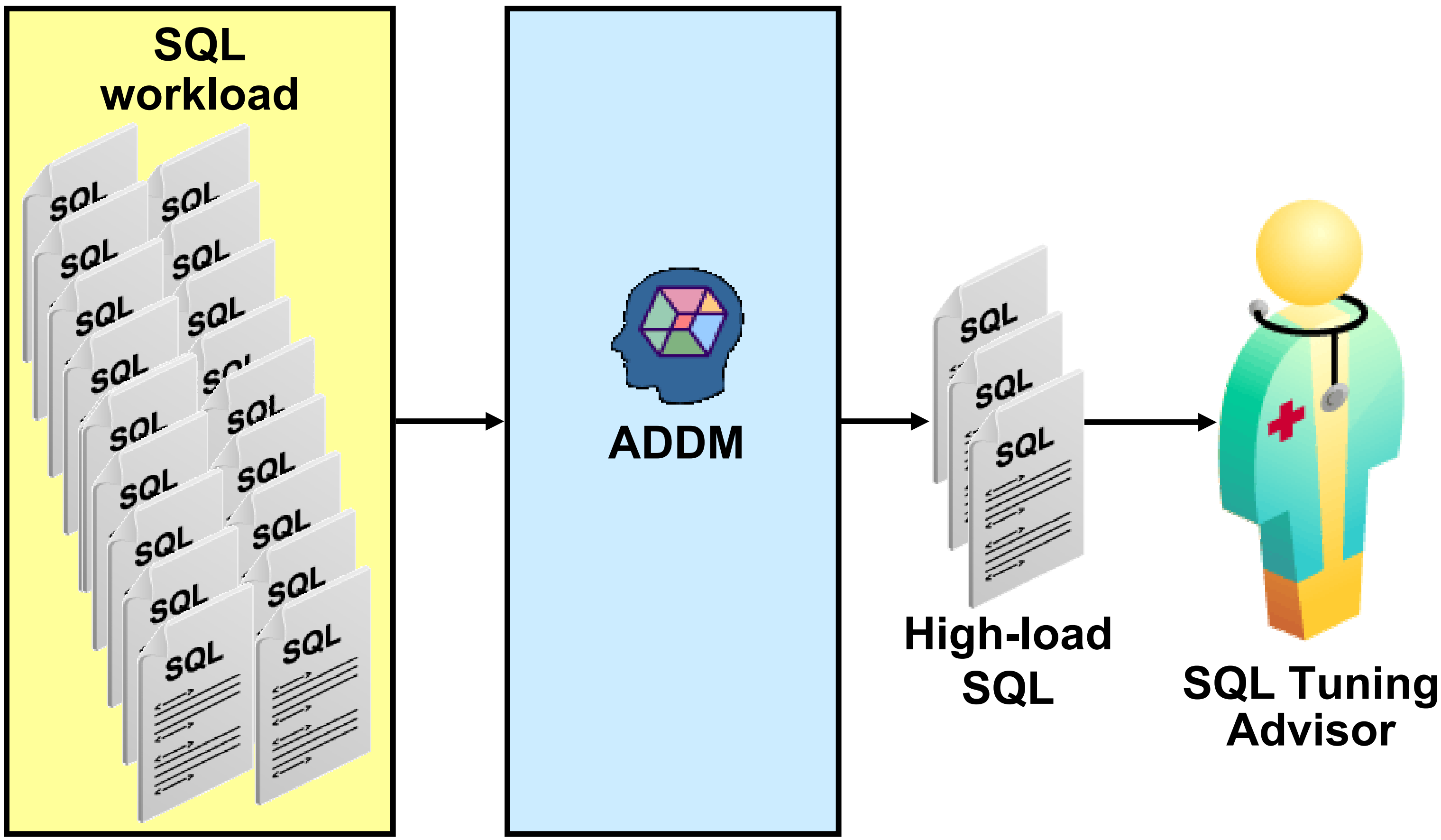
Automatic SQL Tuning



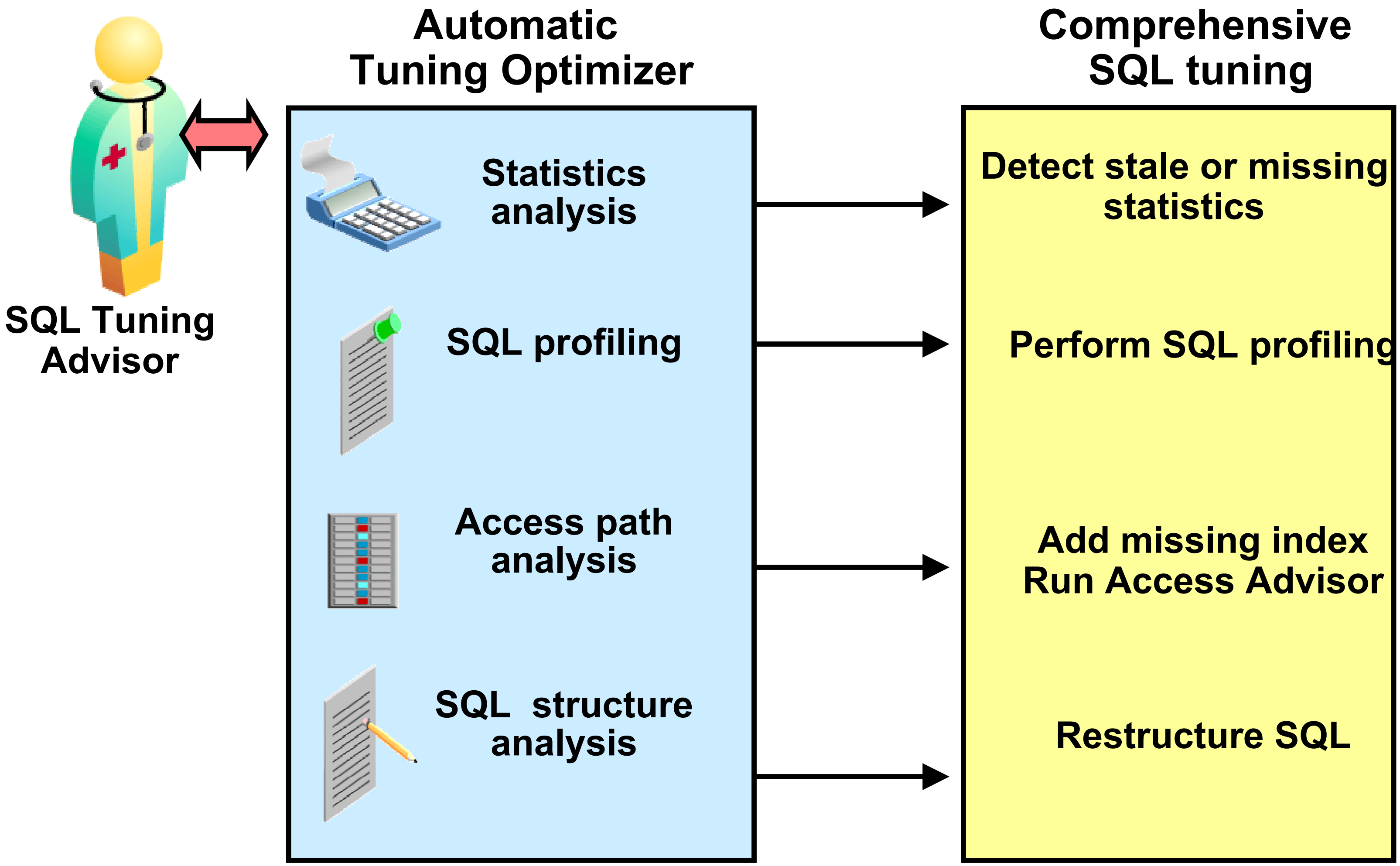
Automatic Tuning Optimizer

- Is the query optimizer running in tuning mode
- Performs verification steps
- Performs exploratory steps

SQL Tuning Advisor



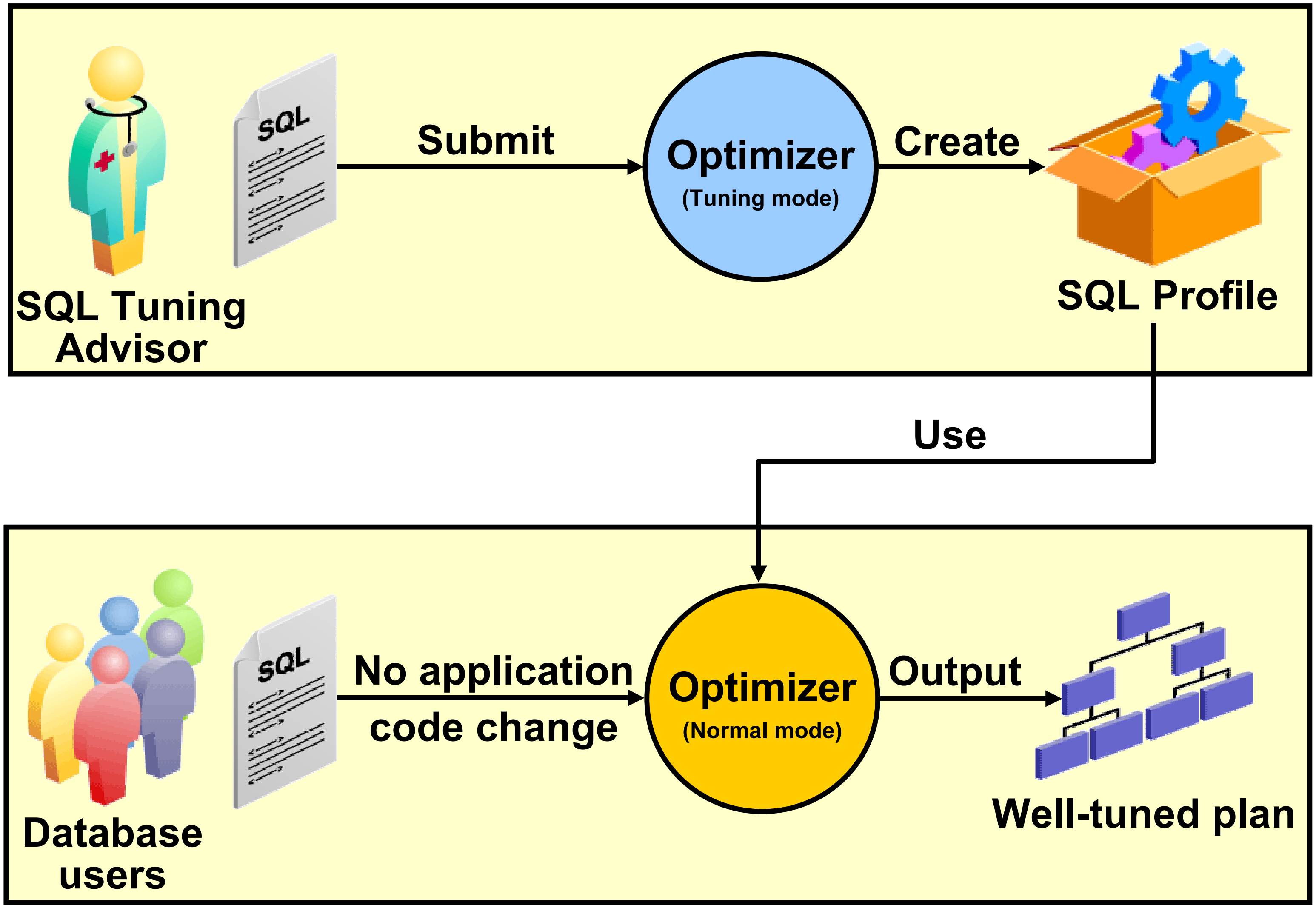
SQL Tuning Advisor Analysis



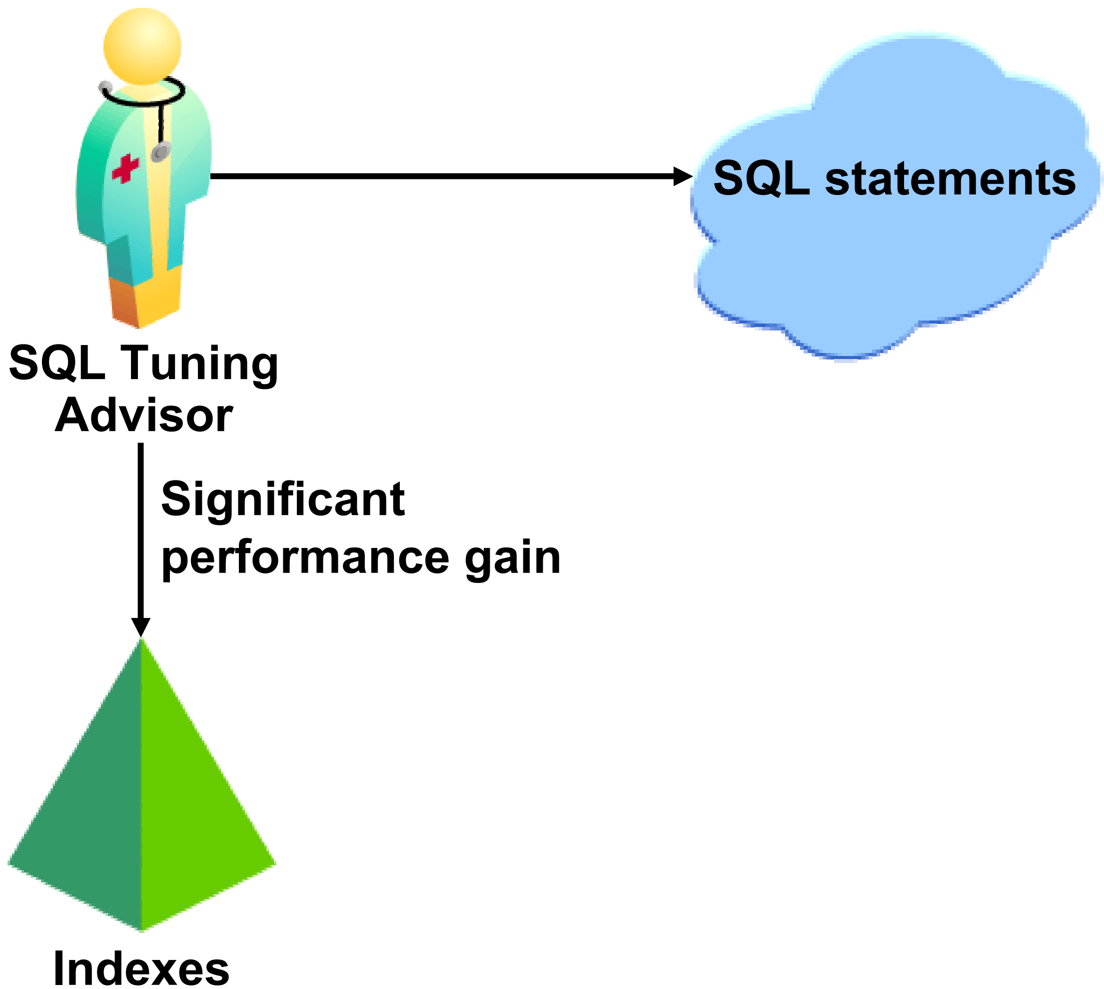
Statistics Analysis


```
DBMS_STATS.GATHER_TABLE_STATS(
        ownname=>'SH', tabname=>'CUSTOMERS',
   estimate_percent=>
   DBMS_STATS.AUTO_SAMPLE_SIZE);
```

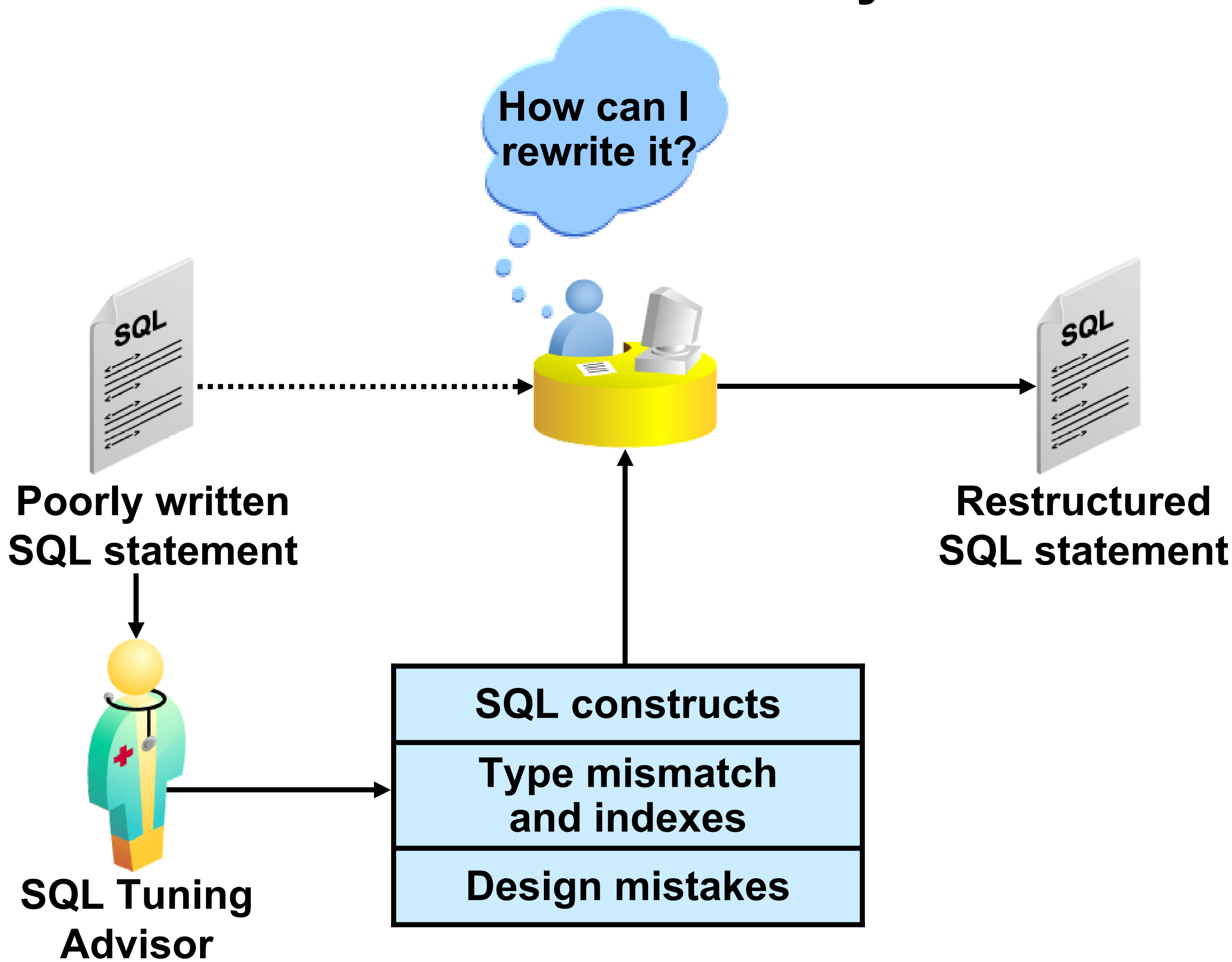
SQL Profiling



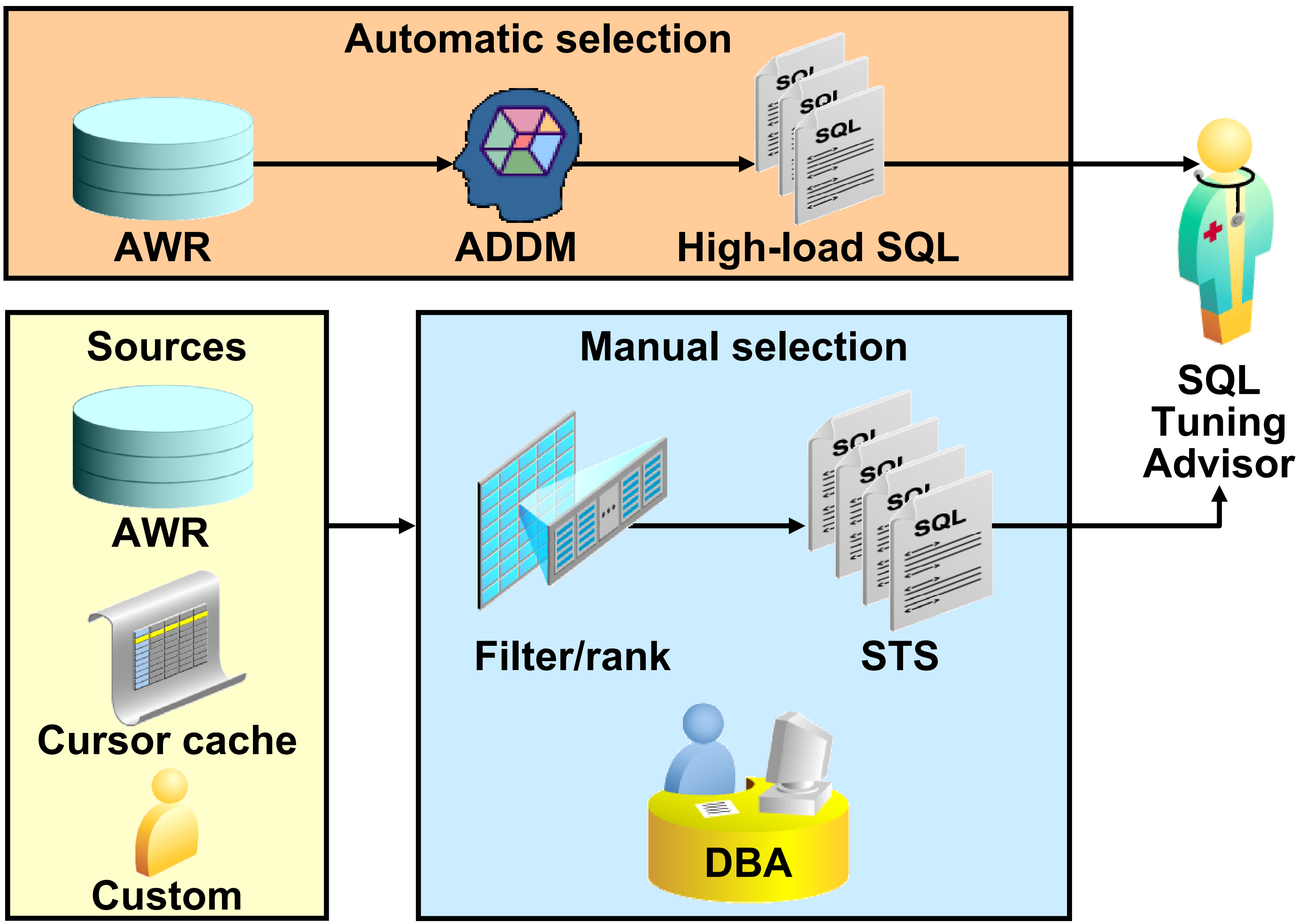
SQL Access Path Analysis



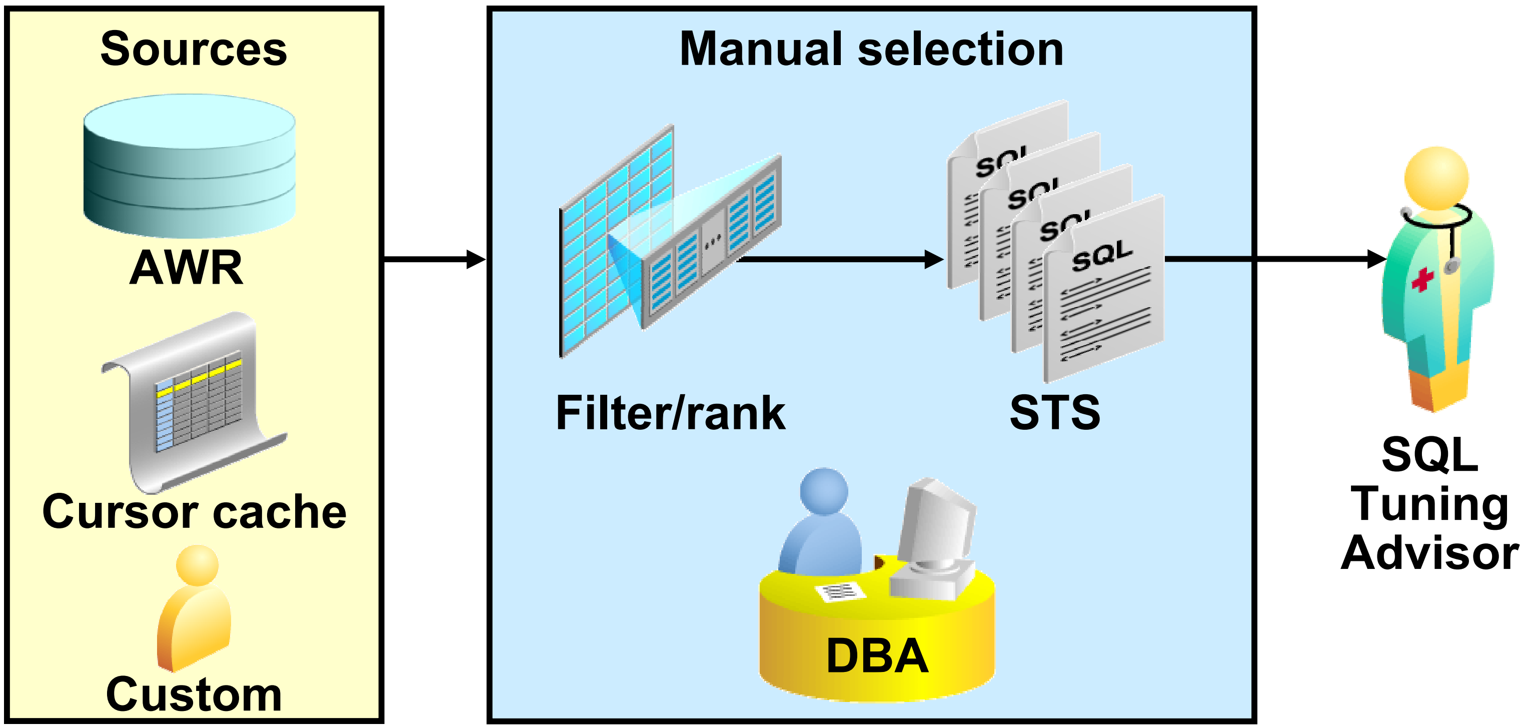
SQL Structure Analysis



SQL Tuning Advisor: Usage Model



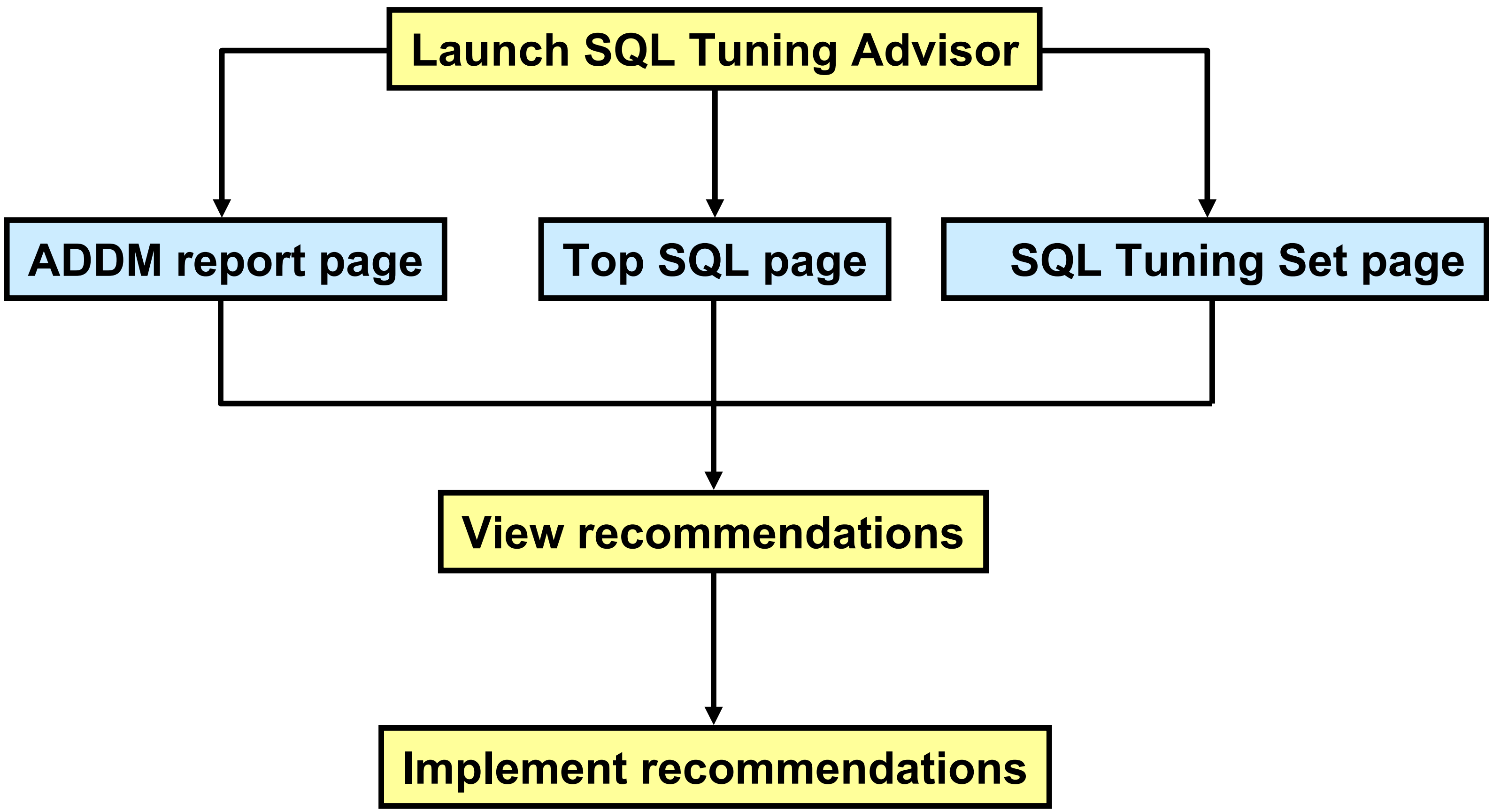
SQL Tuning Set



SQL Tuning Views

- **Advisor information views:**
  - `DBA_ADVISOR_TASKS`
  - `DBA_ADVISOR_FINDINGS`
  - `DBA_ADVISOR_RECOMMENDATIONS`
  - `DBA_ADVISOR_RATIONALE`
- **SQL tuning information views:**
  - `DBA_SQLTUNE_STATISTICS`
  - `DBA_SQLTUNE_BINDS`
  - `DBA_SQLTUNE_PLANS`
- **SQL Tuning Set views:**
  - `DBA_SQLSET`, `DBA_SQLSET_BINDS`
  - `DBA_SQLSET_STATEMENTS`
  - `DBA_SQLSET_REFERENCES`
- **SQL Profile view:** `DBA_SQL_PROFILES`

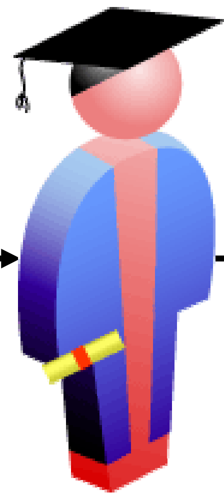
Enterprise Manager: Usage Model



SQL Access Advisor

SQL workload

```
Select …
Select …
Select …
…
```



SQL Access Advisor

Recommendations

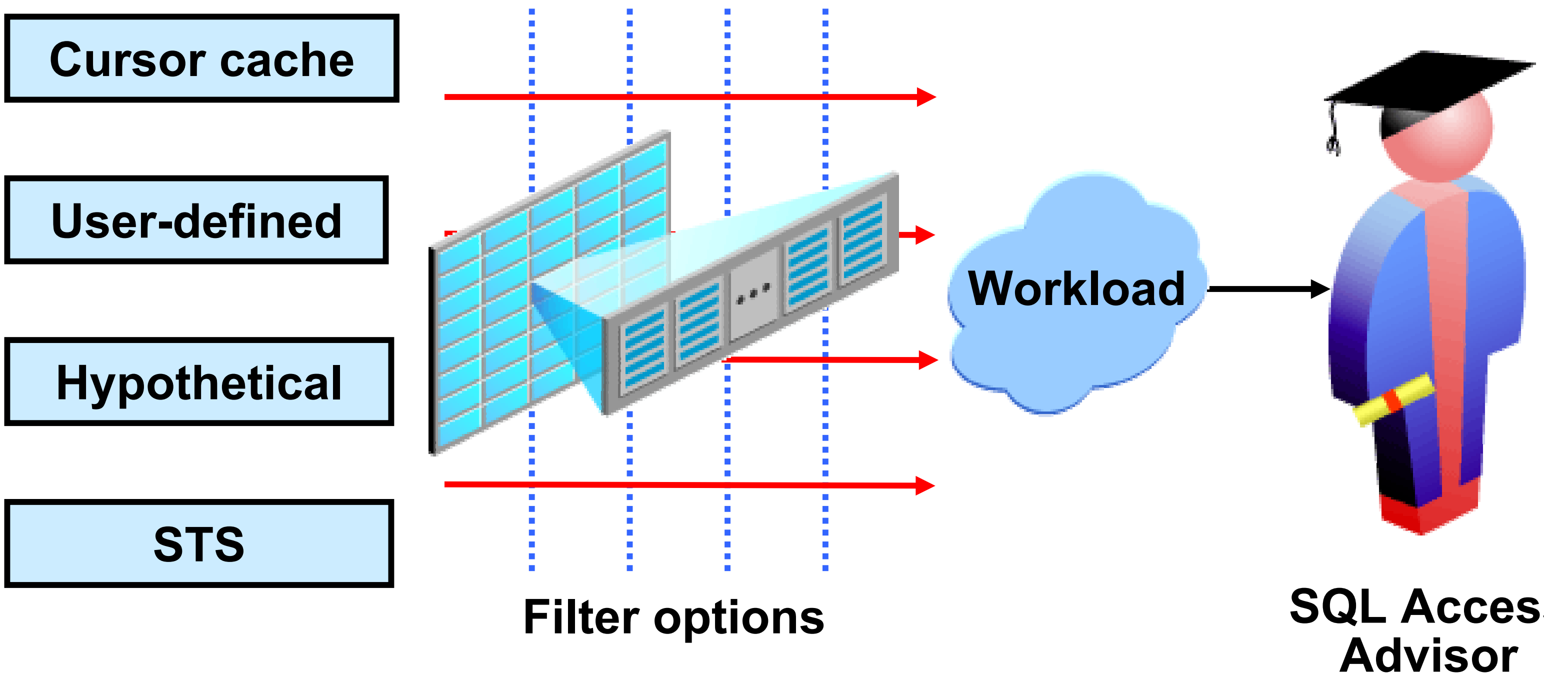
Create index …
Drop index…
Create materialized view …

SQL Access Advisor: Features

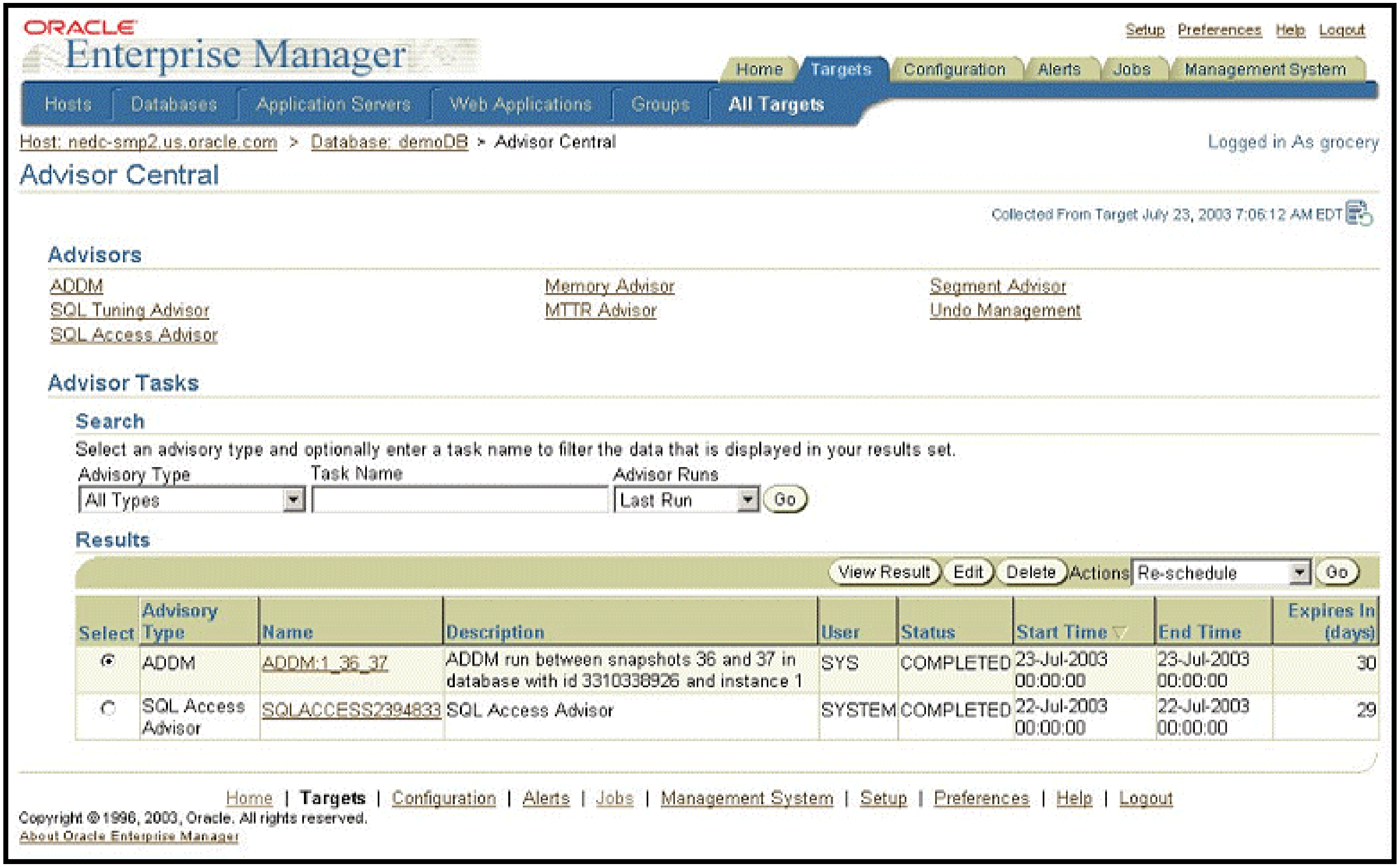
Using the SQL Access Advisor Wizard or API, you can do the following:

- Recommend creation or removal of materialized views and indexes
- Manage workloads
- Mark, update, and remove recommendations

SQL Access Advisor: Usage Model



SQL Access Advisor: User Interface



SQL Tuning Advisor and SQL Access Advisor

Analysis Types	Advisor
Statistics	SQL Tuning Advisor
SQL Profile	SQL Tuning Advisor
SQL Structure	SQL Tuning Advisor
Access Path: Indexes	SQL Tuning/Access Advisor
Access Path: Materialized Views	SQL Access Advisor
Access Path: Materialized View Logs	SQL Access Advisor

Summary

In this lesson, you should have learned how to:

- Describe the Automatic Workload Repository
- Use Automatic Database Diagnostic Monitor
- View the cursor cache
- Perform automatic SQL tuning
- Use the SQL Tuning Advisor
- Use the SQL Access Advisor

11

Index Usage

Objectives

After completing this lesson, you should be able to do the following:

- Identify index types
- Identify basic access methods
- Monitor index usage

Indexing Guidelines

- You should create indexes only as needed.
- Creating an index to tune a specific statement could affect other statements.
- It is best to drop unused indexes.
- `EXPLAIN PLAN` can be used to determine if an index is being used by the optimizer.

Types of Indexes

- Unique and nonunique indexes
- Composite indexes
- Index storage techniques:
  - B*-tree
    - Normal
    - Reverse key
    - Descending
    - Function based
  - Bitmap
  - Domain indexes
  - Key compression

When to Index

Index	Do Not Index
Keys frequently used in search or query expressions	Keys and expressions with few distinct values except bitmap indexes in data warehousing
Keys used to join tables	Frequently updated columns
High-selectivity keys	Columns used only with functions or expressions unless creating function-based indexes
Foreign keys	Columns based only on query performance

Effect of DML Operations on Indexes

- Inserts result in the insertion of an index entry in the appropriate block. (Block splits might occur.)
- Delete rows result in a deletion of the index entry. (Empty blocks become available.)
- Updates to the key columns result in a logical delete and an insert to the index.

Indexes and Constraints

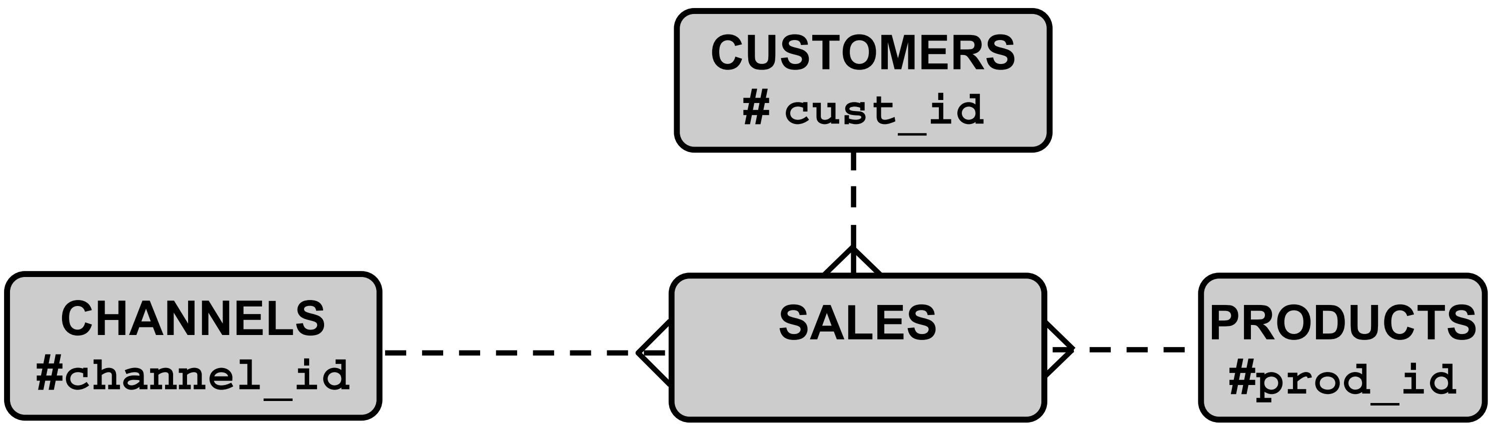
The Oracle Server implicitly creates or uses B*-tree indexes when you define the following:

- Primary key constraints
- Unique key constraints

```
CREATE TABLE new_channels
 ( channel_id CHAR(1)
  CONSTRAINT channels_channel_id_pk PRIMARY KEY
  , channel_desc VARCHAR2(20)
  CONSTRAINT channels_channel_desc_nn  NOT NULL
  , channel_class VARCHAR2(20)
  , channel_total VARCHAR2(13)
 );
```

Indexes and Foreign Keys

- Indexes are not created automatically.
- There are locking implications to DML activity on parent-child tables.



Basic Access Methods

- Full table scans:
  - Can use multiblock I/O
  - Can be parallelized
- Index scans:
  - Allow index access only
  - Are followed by access by `ROWID`
- Fast-full index scans:
  - Can use multiblock I/O
  - Can be parallelized

Identifying Unused Indexes

- The Oracle Database provides the capability to gather statistics about the usage of an index.
- Benefits include:
  - Space conservation
  - Improved performance by eliminating unnecessary overhead during DML operations

Enabling and Disabling the Monitoring of Index Usage

- To start monitoring the usage of an index:

```
ALTER INDEX customers_pk MONITORING USAGE;
```

- To stop monitoring the usage of an index:

```
ALTER INDEX customers_pk NOMONITORING USAGE;
```

- `V$OBJECT_USAGE` contains information about the usage of an index.

Index Tuning Using the SQL Access Advisor

The SQL Access Advisor:

- Determines which indexes are required
- Recommends a set of indexes
- Is invoked from
  - Advisor Central in Oracle Enterprise Manager
  - Run through the `DBMS_ADVISOR` package APIs
- Uses a workload such as:
  - Current contents of the SQL cache
  - A user-defined set of SQL statements
  - A SQL Tuning Set
  - Hypothetical workload
- Generates a set of recommendations
- Provides an implementation script

Summary

In this lesson, you should have learned about the following:

- Indexes
  - Index types
  - DML operations and indexes
  - Indexes and constraints
- Monitoring indexes
  - Index usage monitoring

12

Using Different Indexes

Objectives

After completing this lesson, you should be able to do the following:

- Use composite indexes
- Use bitmap indexes
- Use bitmap join indexes
- Identify bitmap index operations
- Create function-based indexes
- Use index-organized tables

Composite Indexes

Here are some features of the index displayed below.

- **Combinations of columns that are leading portions of the index:**
  - `cust_last_name`
  - `cust_last_name cust_first_name`
  - `cust_last_name cust_first_name cust_gender`
- **Combinations of columns that are *not* leading portions of the index:**
  - `cust_first_name cust_gender`
  - `cust_first_name`
  - `cust_gender`

```
CREATE INDEX cust_last_first_gender_idx
ON customers (cust_last_name,
              cust_first_name, cust_gender);
```

Composite Index Guidelines

- Create a composite index on keys that are used together frequently in `WHERE` clauses.
- Create the index so that the keys used in `WHERE` clauses make up a leading portion.
- Put the most frequently queried column in the leading part of the index.
- Put the most restrictive column in the leading part of the index.

Skip Scanning of Indexes

- Index skip scanning enables access through a composite index when the prefix column is not part of the predicate.
- Skip scanning is supported by:
  - Cluster indexes
  - Descending scans
  - `CONNECT BY` clauses
- Skip scanning is not supported by reverse key or bitmap indexes.

Bitmap Index

- Compared with regular B*-tree indexes, bitmap indexes are faster and use less space for low-cardinality columns.
- Each bitmap index comprises storage pieces called *bitmaps*.
- Each bitmap contains information about a particular value for each of the indexed columns.
- Bitmaps are compressed and stored in a B*-tree structure.

When to Use Bitmap Indexes

Use bitmap indexes for:

- Columns with low cardinality
- Columns that are frequently used in:
  - Complex `WHERE` clause conditions
  - Group functions (such as `COUNT` and `SUM`)
- Very large tables
- DSS systems with many ad hoc queries and few concurrent DML changes

Advantages of Bitmap Indexes

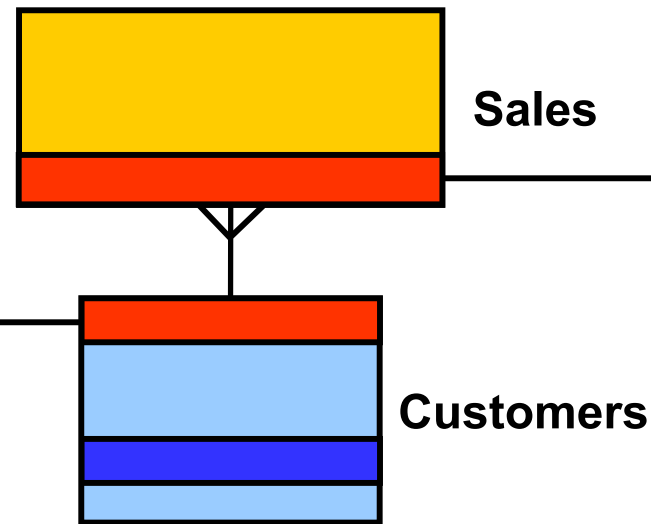
When used appropriately, bitmap indexes provide:

- Reduced response time for many ad hoc queries
- Substantial reduction of space usage compared to other indexing techniques
- Dramatic performance gains

Bitmap Index Guidelines

- **Reduce bitmap storage by:**
  - **Declaring columns `NOT NULL` when possible**
  - **Using fixed-length data types when feasible**
  - **Using the command:**
    `ALTER TABLE … MINIMIZE RECORDS_PER_BLOCK`
- **Improve bitmap performance by increasing the value of `PGA_AGGREGATE_TARGET`.**

Bitmap Join Index




```
CREATE BITMAP INDEX cust_sales_bji
ON      sales(c.cust_city)
FROM    sales s, customers c
WHERE   c.cust_id = s.cust_id;
```

Bitmap Join Index

- No join with the `CUSTOMERS` table is needed.
- Only the index and the `SALES` table are used to evaluate the following query:

```
SELECT SUM(s.amount_sold)
FROM   sales s, customers c
WHERE  s.cust_id =
       c.cust_id
AND    c.cust_city = 'Sully';
```

Bitmap Join Index: Advantages and Disadvantages

- Advantages
  - Good performance for join queries; space-efficient
  - Especially useful for large-dimension tables in star schemas
- Disadvantages
  - More indexes are required: Up to one index per dimension-table column rather than one index per dimension table is required.
  - Maintenance costs are higher: Building or refreshing a bitmap join index requires a join.

Function-Based Index

```
CREATE INDEX FBI_UPPER_LASTNAME
  ON CUSTOMERS(upper(cust_last_name));
```

```
ALTER SESSION
 SET QUERY_REWRITE_ENABLED = TRUE;
```

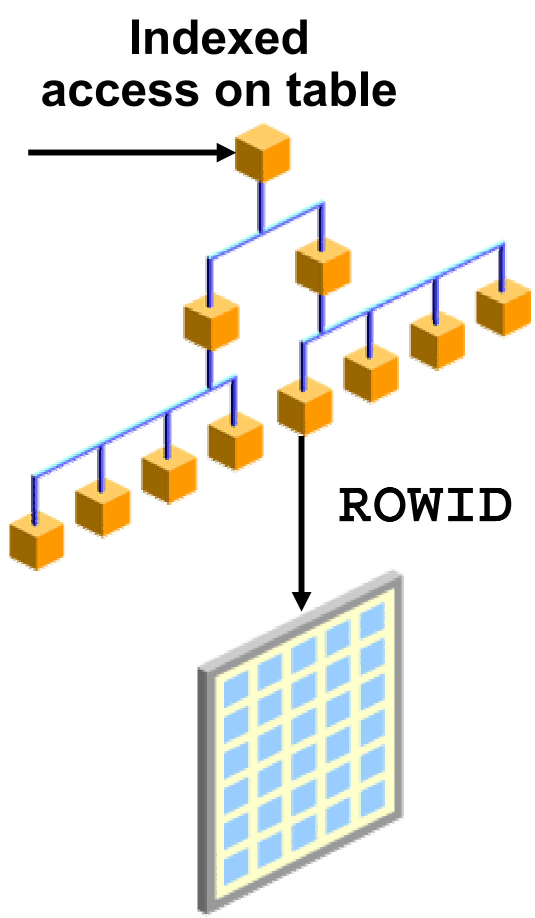
```
SELECT *
 FROM   customers
 WHERE  UPPER(cust_last_name) = 'SMITH';
```

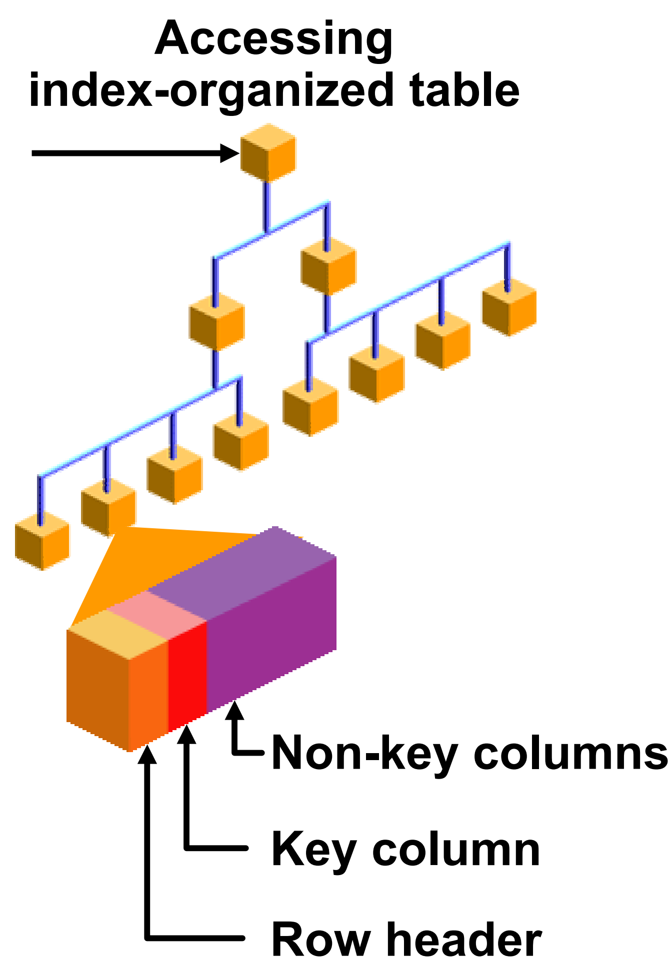
Function-Based Indexes: Usage

Function-based indexes:

- Materialize computational-intensive expressions
- Facilitate non-case-sensitive searches
- Provide a simple form of data compression
- Can be used for an NLS sort index

Index-Organized Tables: Overview





Index-Organized Tables: Characteristics

Index-organized tables:

- Must have a primary key
- Cannot contain `LONG` columns
- Can be rebuilt
- Can be accessed by either primary key or leading columns

Advantages and Disadvantages of IOTs

- Advantages
  - IOTs provide fast key-based access for queries involving exact match and range searches.
  - DML causes only updates to index structure.
  - Storage requirements are reduced.
  - IOTs are useful in:
    - Applications that retrieve data based on a primary key
    - Applications that involve content-based information
- Disadvantages
  - Not suitable for queries that do not use the primary key in a predicate

Summary

In this lesson, you should have learned about:

- Composite indexes
- Bitmap indexes
- Bitmap join indexes
- Function-based indexes
- Index-organized tables

13

Optimizer Hints

Objectives

After completing this lesson, you should be able to specify hints for:

- Optimizer mode
- Query transformation
- Access path
- Join orders
- Join methods

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Optimizer Hints: Overview

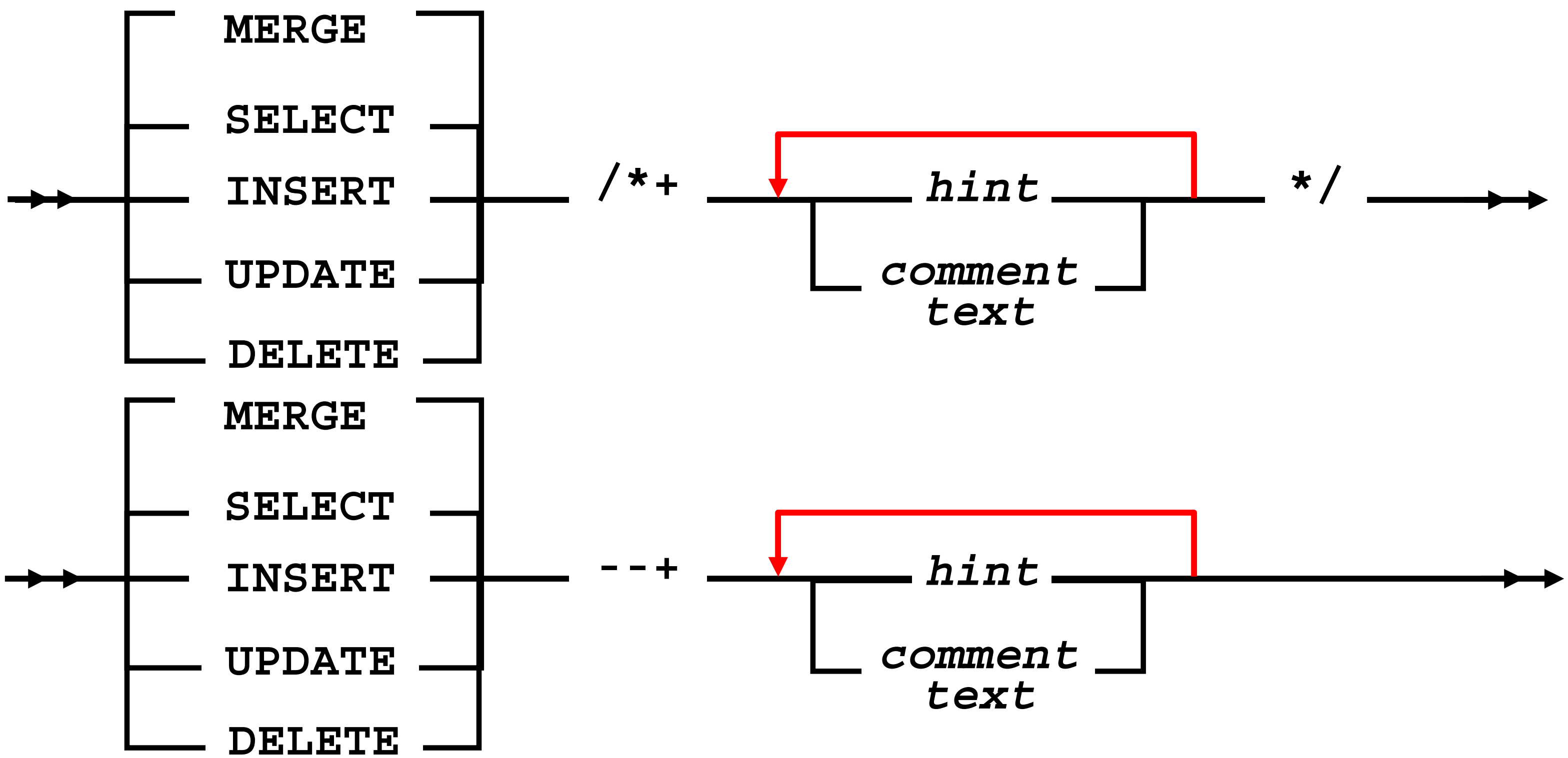
Optimizer hints:

- Are used to alter execution plans
- Influence optimizer decisions
- Provide a mechanism to instruct the optimizer to choose a certain query execution plan

Types of Hints

Single-table hints	**Specified on one table or view**
Multitable hints	**Specify more than one table or view**
Query block hints	**Operate on a single query block**
Statement hints	**Apply to the entire SQL statement**

Specifying Hints



Rules for Hints

- Place hints immediately after the first SQL keyword of a statement block.
- Each statement block can have only one hint comment, but it can contain multiple hints.
- Hints apply to only the statement block in which they appear.
- If a statement uses aliases, hints must reference aliases rather than table names.

Hint Recommendations

- **Use hints carefully because they imply a high maintenance load.**
- **Be aware of the performance impact of hard-coded hints when they become less valid.**

Optimizer Hint Syntax: Example

```
UPDATE /*+ INDEX(p PRODUCTS_PROD_CAT_IX)*/
products p
SET   p.prod_min_price =
        (SELECT
         (pr.prod_list_price*.95)
         FROM products pr
         WHERE p.prod_id = pr.prod_id)
WHERE p.prod_category = 'Men'
AND   p.prod_status = 'available, on stock'
/
```

Hint Categories

There are hints for:

- Optimization approaches and goals
- Access paths
- Query transformations
- Join orders
- Join operation
- Parallel execution

Optimization Goals and Approaches

`ALL_ROWS`	**Chooses cost-based approach with a goal of best throughput**
`FIRST_ROWS(n)`	**Instructs Oracle Server to optimize an individual SQL statement for fast response**

Hints for Access Paths

`FULL`	Performs a full table scan
`ROWID`	Accesses a table by `ROWID`
`INDEX`	Scans an index in ascending order
`INDEX_ASC`	Scans an index in ascending order
`INDEX_COMBINE`	Explicitly chooses a bitmap access path

Hints for Access Paths

`INDEX_JOIN`	**Instructs the optimizer to use an index join as an access path**
`INDEX_DESC`	**Chooses an index scan for the specified table**
`INDEX_FFS`	**Performs a fast-full index scan**
`NO_INDEX`	**Disallows using a set of indexes**
`AND_EQUAL`	**Merges single-column indexes**

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INDEX_COMBINE Hint: Example

```
SELECT --+INDEX_COMBINE(CUSTOMERS)
       cust_last_name
FROM   SH.CUSTOMERS
WHERE ( CUST_GENDER= 'F' AND
CUST_MARITAL_STATUS =  'single')
OR     CUST_YEAR_OF_BIRTH BETWEEN '1917'
AND '1920';
```

INDEX_COMBINE Hint: Example

```
Execution Plan
---------------------------------------------------
0   SELECT STATEMENT Optimizer=CHOOSE (Cost=491
     Card=10481
         Bytes =167696)
1    0   TABLE ACCESS (BY INDEX ROWID) OF 'CUSTOMERS'
             (Cost=491 …)
2    1     BITMAP CONVERSION (TO ROWIDS)
3    2       BITMAP OR
4    3         BITMAP AND
5    4           BITMAP INDEX (SINGLE VALUE) OF
                   'CUST_MARITAL_BIX'
6    4           BITMAP INDEX (SINGLE VALUE) OF
                   'CUST_GENDER_BIX'
7    3         BITMAP MERGE
8    7           BITMAP INDEX (RANGE SCAN) OF
                   'CUST_YOB_BIX'
```

Hints for Query Transformation

USE_CONCAT	**Rewrites** OR **into** UNION ALL **and disables** INLIST **processing**
NO_EXPAND	**Prevents** OR **expansions**

Hints for Query Transformation

`MERGE`	Merges a view for each query
`NO_MERGE`	Prevents merging of mergeable views
`STAR_TRANSFORMATION`	Makes the optimizer use the best plan in which the transformation can be used
`FACT`	Indicates that the hinted table should be considered as a fact table
`NO_FACT`	Indicates that the hinted table should not be considered as a fact table

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Hints for Join Orders

`ORDERED`	Causes the Oracle Server to join tables in the order in which they appear in the `FROM` clause
`LEADING`	Uses the specified table as the first table in the join order

Hints for Join Operations

`USE_NL`	Joins the specified table using a nested loop join
`NO_USE_NL`	Does not use nested loops to perform the join
`USE_MERGE`	Joins the specified table using a sort-merge join
`NO_USE_MERGE`	Does not perform sort-merge operations for the join
`USE_HASH`	Joins the specified table using a hash join
`NO_USE_HASH`	Does not use hash join

Other Hints

`APPEND`	Enables direct-path `INSERT`
`NOAPPEND`	Enable regular `INSERT`
`ORDERED_PREDICATES`	Forces the optimizer to preserve the order of predicate evaluation
`CURSOR_SHARING_EXACT`	Prevents replacing literals with bind variables
`DYNAMIC_SAMPLING`	Controls dynamic sampling to improve server performance

Hints for Suppressing Index Usage

Hint	Description
`NO_INDEX`	Disallows use of any indexes
`FULL`	Forces a full table scan
`INDEX` or `INDEX_COMBINE`	Forces the optimizer to use a specific index or a set of listed indexes

Hints and Views

- Do not use hints in views.
- Use view-optimization techniques:
  - Statement transformation
  - Results accessed like a table
- Hints can be used on mergeable views and nonmergeable views.

Hints for View Processing

`MERGE`	**Merges complex views or subqueries with the surrounding query**
`NO_MERGE`	**Does not merge mergeable views**

Global and Local Hints

- Extended hint syntax enables the specifying of (global) hints through views
- References a table name in the hint with a dot notation

```
CREATE view city_view AS
SELECT *
FROM   customers c
WHERE  cust_city like 'S%';

SELECT /*+ index(v.c cust_credit_limit_idx) */
    v.cust_last_name, v.cust_credit_limit
FROM   city_view v
WHERE  cust_credit_limit > 5000;
```

Specifying a Query Block in a Hint

```
Explain plan for
 SELECT employee_id, last_name
 FROM hr.employees e
 WHERE last_name = 'Smith';

SELECT PLAN_TABLE_OUTPUT
FROM TABLE(DBMS_XPLAN.DISPLAY(NULL, NULL,
           'ALL'));
```

1

```
SELECT /*+ QB_NAME(qb) FULL(@qb e) */
        employee_id, last_name
FROM hr.employees e
WHERE employee_id = 100;
```

2

Specifying a Full Set of Hints

```
SELECT /*+ LEADING(e2 e1) USE_NL(e1) INDEX(e1
       emp_emp_id_pk) USE_MERGE(j) FULL(j) */
    e1.first_name, e1.last_name, j.job_id,
     sum(e2.salary) total_sal
FROM hr.employees e1, hr.employees e2,
hr.job_history j
WHERE e1.employee_id = e2.manager_id
AND e1.employee_id = j.employee_id
AND e1.hire_date = j.start_date
GROUP BY e1.first_name, e1.last_name, j.job_id
ORDER BY total_sal;
```

Summary

In this lesson, you should have learned how to:

- Set the optimizer mode
- Use optimizer hint syntax
- Determine access-path hints
- Analyze hints and their impact on views

14

Materialized Views

Objectives

After completing this lesson, you should be able to do the following:

- Identify the characteristics and benefits of materialized views
- Use materialized views to enable query rewrites
- Verify the properties of materialized views
- Perform refreshes on materialized views

Materialized Views

A materialized view:

- Is a precomputed set of results
- Has its own data segment and offers:
  - Space management options
  - Use of its own indexes
- Is useful for:
  - Expensive and complex joins
  - Summary and aggregate data

If Materialized Views Are Not Used

```
SELECT c.cust_id, SUM(amount_sold)
FROM   sales s, customers c
WHERE  s.cust_id = c.cust_id
GROUP BY c.cust_id;
```

```
CREATE TABLE cust_sales_sum AS
SELECT c.cust_id, SUM(amount_sold) AS amount
FROM   sales s, customers c
WHERE  s.cust_id = c.cust_id
GROUP BY c.cust_id;
```

```
SELECT * FROM cust_sales_sum;
```

Benefits of Using Materialized Views

```
CREATE MATERIALIZED VIEW cust_sales_mv
ENABLE QUERY REWRITE AS
SELECT c.cust_id, SUM(amount_sold) AS amount
FROM   sales s, customers c
WHERE  s.cust_id = c.cust_id
GROUP BY c.cust_id;
```

```
SELECT c.cust_id, SUM(amount_sold)
FROM   sales s, customers c
WHERE  s.cust_id = c.cust_id
GROUP BY c.cust_id;
```

```
Execution Plan
----------------------------------------------------------
  0       SELECT STATEMENT Optimizer=ALL_ROWS (Cost=6 …)

  1     0   MAT_VIEW REWRITE ACCESS (FULL) OF 'CUST_SALES_MV' (MAT_VIEW
             REWRITE) (Cost=6 …)
```

How Many Materialized Views?

- One materialized view for multiple queries:
  - One materialized view can be used to satisfy multiple queries
  - Less disk space is needed
  - Less time is needed for maintenance
- Query rewrite chooses the materialized view to use.
- One materialized view per query:
  - Is not recommended because it consumes too much disk space
  - Improves one query's performance

Creating Materialized Views: Syntax Options

```
CREATE MATERIALIZED VIEW mview_name
    [TABLESPACE ts_name]
    [PARALLEL (DEGREE n)]
    [BUILD {IMMEDIATE|DEFERRED}]
    [{ REFRESH {FAST|COMPLETE|FORCE}
    [{ON COMMIT|ON DEMAND}]
     | NEVER REFRESH } ]
    [{ENABLE|DISABLE} QUERY REWRITE]

AS SELECT … FROM …
```

Creating Materialized Views: Example

```
CREATE MATERIALIZED VIEW cost_per_year_mv
ENABLE QUERY REWRITE
AS
SELECT   t.week_ending_day
,        t.calendar_year
,        p.prod_subcategory
,        sum(c.unit_cost) AS dollars
FROM     costs c
,        times t
,        products p
WHERE    c.time_id = t.time_id
AND      c.prod_id = p.prod_id
GROUP BY t.week_ending_day
,        t.calendar_year
,        p.prod_subcategory;

Materialized view created.
```

Types of Materialized Views

- **Materialized views with aggregates**

```
CREATE MATERIALIZED VIEW cust_sales_mv AS
SELECT c.cust_id, s.channel_id,
       SUM(amount_sold) AS amount
FROM   sales s, customers c
WHERE  s.cust_id = c.cust_id
GROUP BY c.cust_id, s.channel_id;
```

- **Materialized views containing only joins**

```
CREATE MATERIALIZED VIEW sales_products_mv AS
SELECT s.time_id, p.prod_name
FROM sales s, products p
WHERE s.prod_id = p.prod_id;
```

Refresh Methods

- You can specify how you want your materialized views to be refreshed from the detail tables by selecting one of four options:
  - `COMPLETE`
  - `FAST`
  - `FORCE`
  - `NEVER`
- You can view the `REFRESH_METHOD` in the `ALL_MVIEWS` data dictionary view.

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Refresh Modes

- Manual refresh
  - Specify `ON DEMAND` option
  - By using the `DBMS_MVIEW` package
- Automatic refresh Synchronous
  - Specify `ON COMMIT option`
  - Upon commit of changes to the underlying tables but independent of the committing transaction
- Automatic refresh Asynchronous
  - Specify using `START WITH` and `NEXT` clauses
  - Defines a refresh interval for the materialized view
- `REFRESH_MODE` in `ALL_MVIEWS`

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Manual Refresh with DBMS_MVIEW

- For ON DEMAND refresh only
- Three procedures with the DBMS_MVIEW package:
  - REFRESH
  - REFRESH_ALL_MVIEWS
  - REFRESH_DEPENDENT

Materialized Views: Manual Refresh

Specific materialized views:

```
Exec DBMS_MVIEW.REFRESH('cust_sales_mv');
```

Materialized views based on one or more tables:

```
VARIABLE fail NUMBER;
exec DBMS_MVIEW.REFRESH_DEPENDENT(-
:fail,'CUSTOMERS,SALES');
```

All materialized views due for refresh:

```
VARIABLE fail NUMBER;
exec DBMS_MVIEW.REFRESH_ALL_MVIEWS(:fail);
```

Query Rewrites

- If you want to use a materialized view instead of the base tables, a query must be rewritten.
- Query rewrites are transparent to applications.
- Query rewrites do not require special privileges on the materialized view.
- A materialized view can be enabled or disabled for query rewrites.

Query Rewrites

- Use `EXPLAIN PLAN` or `AUTOTRACE` to verify that query rewrites occur.
- Check the query response:
  - Fewer blocks are accessed.
  - Response time should be significantly better.

Enabling and Controlling Query Rewrites

- Query rewrites are available with cost-based optimization only.

```
QUERY_REWRITE_ENABLED = {true|false|force}
QUERY_REWRITE_INTEGRITY =
{enforced|trusted|stale_tolerated}
```

- The following optimizer hints influence query rewrites:
  - `REWRITE`
  - `NOREWRITE`
  - `REWRITE_OR_ERROR`

Query Rewrite: Example

```
EXPLAIN PLAN FOR
SELECT   t.week_ending_day
,        t.calendar_year
,        p.prod_subcategory
,        sum(c.unit_cost) AS dollars
FROM     costs c
,        times t
,        products p
WHERE    c.time_id = t.time_id
  ...
```

```
Execution Plan
-----------------------------------------------------------------------
   0      SELECT STATEMENT Optimizer=ALL_ROWS (Cost…)
   1    0   MAT_VIEW REWRITE ACCESS (FULL) OF 'costs_per_year_mv' (
             MAT_VIEW REWRITE) (Cost…)
```

Query Rewrite: Example

```
SELECT    t.week_ending_day
,         t.calendar_year
,         p.prod_subcategory
,         sum(c.unit_cost) AS dollars
FROM      costs c, times t, products p
WHERE     c.time_id = t.time_id
AND       c.prod_id = p.prod_id
AND       t.calendar_year = '1999'
GROUP BY t.week_ending_day, t.calendar_year
,         p.prod_subcategory
HAVING    sum(c.unit_cost) > 10000;
```

```
SELECT    week_ending_day
,         prod_subcategory
,         dollars
FROM      cost_per_year_mv
WHERE     calendar_year = '1999'
AND       dollars > 10000;
```

Verifying Query Rewrite

```
CREATE MATERIALIZED VIEW cust_orders_mv
ENABLE QUERY REWRITE AS
SELECT c.customer_id, SUM(order_total) AS amt
FROM   oe.orders s, oe.customers c
WHERE  s.customer_id = c.customer_id
GROUP BY c.customer_id;
```

```
SELECT /*+ REWRITE_OR_ERROR */ c.customer_id,
SUM(order_total)AS amt
FROM   oe.orders s, oe.customers c
WHERE  s.customer_id = c.customer_id
GROUP BY c.customer_id;
```

```
ORA-30393: a query block in the statement did
not rewrite
```

SQL Access Advisor

For a given workload, the SQL Access Advisor:

- Recommends creating the appropriate:
  - Materialized views
  - Materialized view logs
  - Indexes
- Provides recommendations to optimize for :
  - Fast refresh
  - Query rewrite
- Can be run:
  - From Oracle Enterprise Manager by using the SQL Access Advisor Wizard
  - By invoking the `DBMS_ADVISOR` package

Using the DBMS_MVIEW Package

DBMS_MVIEW methods

- EXPLAIN_MVIEW
- EXPLAIN_REWRITE
- TUNE_MVIEW

Tuning Materialized Views for Fast Refresh and Query Rewrite

```
DBMS_ADVISOR.TUNE_MVIEW (
        task_name IN OUT VARCHAR2,
        mv_create_stmt IN [CLOB | VARCHAR2]
                                  );
```

Results of `Tune_MVIEW`

- `IMPLEMENTATION` recommendations
  - `CREATE MATERIALIZED VIEW LOG` statements
  - `ALTER MATERIALIZED VIEW LOG FORCE` statements
  - One or more `CREATE MATERIALIZED VIEW` statements
- `UNDO` recommendations
  - `DROP MATERIALIZED VIEW` statements

DBMS_MVIEW.EXPLAIN_MVIEW Procedure

- Accepts:
  - Materialized view name
  - SQL statement
- Advises what is and what is not possible:
  - For an existing materialized view
  - For a potential materialized view before you create it
- Stores results in MV_CAPABILITIES_TABLE (relational table) or in a VARRAY
- utlxmv.sql must be executed as the current user to create MV_CAPABILITIES_TABLE.

Explain Materialized View: Example

```
EXEC dbms_mview.explain_mview (
      'cust_sales_mv', '123');
```

```
SELECT capability_name, possible, related_text,msgtxt
FROM mv_capabilities_table
WHERE statement_id = '123' ORDER BY seq;
```

```
CAPABILITY_NAME    P RELATED_TE MSGTXT
------------------ - ---------- --------------------
...
REFRESH_COMPLETE   Y
REFRESH_FAST       N
REWRITE            N
PCT_TABLE          N SALES      no partition key or
                                PMARKER in select
                                list
PCT_TABLE          N CUSTOMERS  relation is not a
                                partitioned
                                table
...
```

Designing for Query Rewrite

Query rewrite considerations:

- Constraints
- Outer joins
- Text match
- Aggregates
- Grouping conditions
- Expression matching
- Date folding
- Statistics

Materialized View Hints

`REWRITE`	Rewrites a query in terms of materialized views
`REWRITE_OR_ERROR`	Forces an error if a query rewrite is not possible
`NO_REWRITE`	Disables query rewrite for the query block

Summary

In this lesson, you should have learned how to:

- Create materialized views
- Enable query rewrites using materialized views

D

Data Warehouse Tuning Considerations

Objectives

After completing this lesson, you should understand the following:

- Star transformations
- Basics of parallel execution
- Types of parallelism
- Parallel query
- Parallelizing SQL statements
- Viewing parallel queries with `EXPLAIN PLAN`

Star Transformation

With the star transformation, you can:

- Execute star queries efficiently, especially in the following cases:
  - Number of dimension tables is large.
  - Fact table is sparse.
  - Not all dimensions have constraining predicates.
- Set the `STAR_TRANSFORMATION_ENABLED` initialization parameter
- Use the `STAR_TRANSFORMATION` hint

Star Transformation: Example

```
SELECT s.amount_sold, p.prod_name
,      ch.channel_desc
FROM   sales s, products p
,      channels ch, customers c
WHERE  s.prod_id= p.prod_id
AND    s.channel_id = ch.channel_id
AND    s.cust_id = c.cust_id
AND    ch.channel_id in ('I','P','S')
AND    c.cust_city = 'Asten'
AND    p.prod_id > 40000;
```

Steps in Execution

The Oracle Server processes the query by carrying out the following steps:

1. Use a bitmap index to identify row sets for sales in channels I, P, or S. Combine these with a bitmap `OR` operation.
2. Use a bitmap for rows corresponding to sales in the city of Asten.
3. Use a bitmap for rows with product ID greater than 40,000.
4. Combine these three bitmaps into a single bitmap with the bitmap `AND` operation.
5. Use this final bitmap to access rows that satisfy all the conditions from the fact table.
6. Join these rows from the fact table to the dimension tables.

Introduction to Parallel Execution

Parallel execution improves processing for:

- Queries requiring large table scans, joins, or partitioned index scans
- Creation of large indexes
- Creation of large tables
- Bulk inserts, updates, merges, and deletes
- Large sorts

When to Implement Parallel Execution

- DSS and data warehousing environments
- OLTP systems
  – During batch processing
  – During schema maintenance operations

Operations That Can Be Parallelized

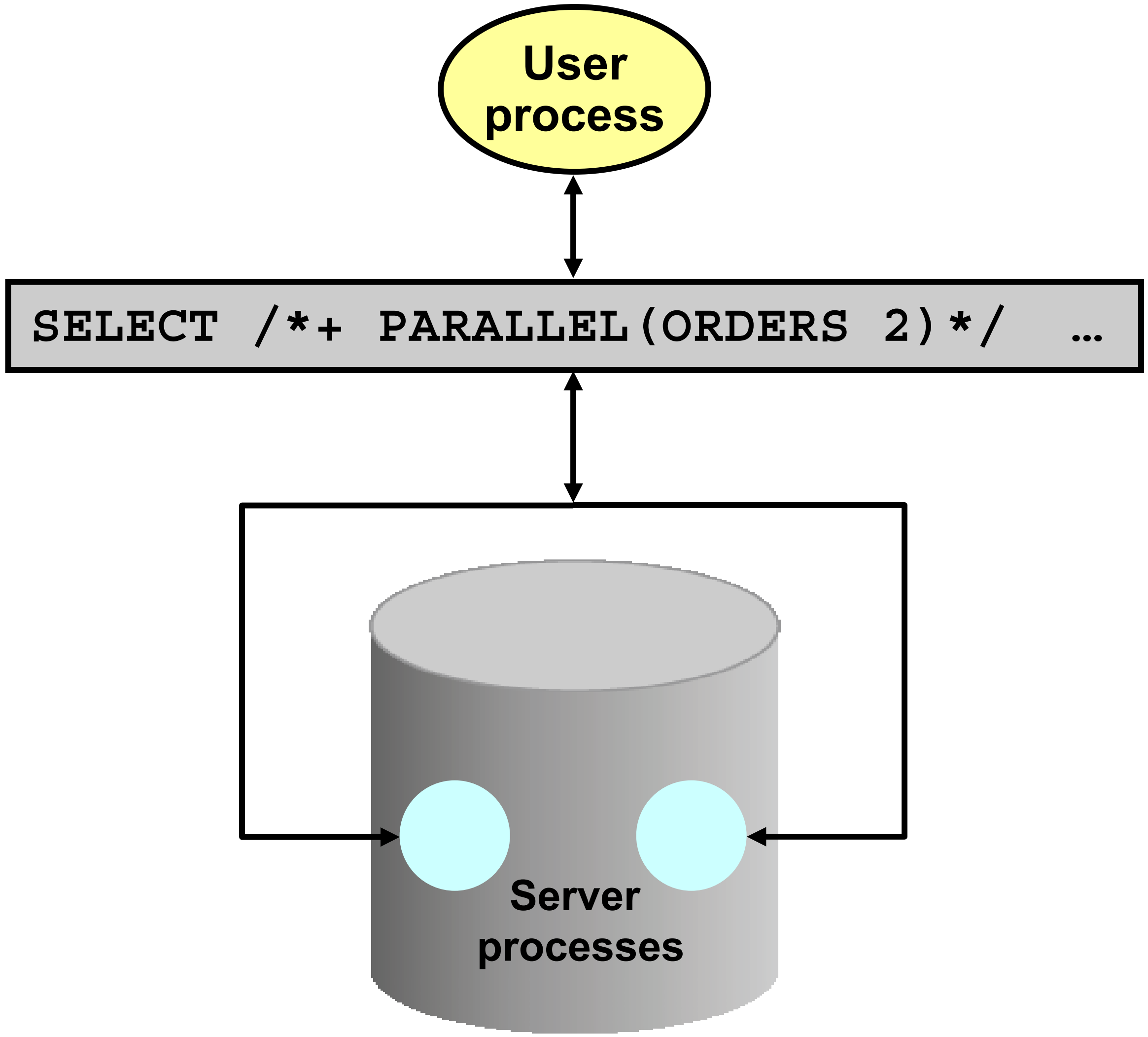
- Access methods
- Join methods
- DDL
- DML
- Miscellaneous SQL operations
- Query
- SQL*Loader

How Parallel Execution Works

The query coordinator:

- Parses the query and determines the degree of parallelism
- Allocates one or two sets of slaves
- Controls the query and sends instructions to the PQ slaves
- Determines which tables or indexes need to be scanned by the PQ slaves
- Produces the final output to the user

Degree of Parallelism



Parallelization Rules for SQL Statements

- A parallel query looks at every table and index in the statement.
- The basic rule is to pick the table or index with the largest DOP.
- For parallel DML, the reference object that determines the DOP is the table being modified by a DML operation.
- If the parallel DML statement includes a subquery, the subquery's DOP is the same as the DML operation.
- For parallel DDL, the reference object that determines the DOP is the table, index, or partition that is being created, rebuilt, split, or moved.
- If the parallel DDL statement includes a subquery, the subquery's DOP is the same as the DDL operation.

When to Parallelize a `SELECT` Statement

- A parallel hint
  - The query includes a parallel hint specification.
  - The schema objects have a `PARALLEL` declaration.
- One or more tables specified in the query require one of the following:
  - A full table scan
  - An index range scan
  - Absence of scalar subqueries are in the `SELECT` list.

Parallel DML

```
UPDATE /*+ PARALLEL(SALES,4) */ SALES
 SET PROD_MIN_PRICE = PROD_MIN_PRICE *1.10
```

```
 ALTER SESSION FORCE PARALLEL DML
```

```
INSERT /*+ PARALLEL(new_emp,2) */ INTO new_emp
SELECT /*+ PARALLEL(employees,4) */ * FROM
employees;
```

The DOP used is 2, as specified in the `INSERT` hint

Parallel DDL

Use default DOP

```
ALTER TABLE employees PARALLEL;
```

Use DOP of 4

```
ALTER TABLE employees PARALLEL 4;
```

Session override

```
ALTER SESSION FORCE PARALLEL DDL
```

Parallelization Rules

- **Priority 1: `PARALLEL` hint**
- **Priority 2: `PARALLEL` clause or `ALTER SESSION FORCE PARALLEL` …**
- **Priority 3: `PARALLEL` declaration while creating objects**

Displaying Parallel Explain Plans

```
--------------------------------------------------------------------------------------------
|Id | Operation                    |Name      |Rows   |Bytes  |Cost   |    TQ |IN-OUT|PQ Distrib|
--------------------------------------------------------------------------------------------
|  0 | SELECT STATEMENT            |          |    41 |  1066 |     4 |       |      |          |
|  1 |  PX COORDINATOR             |          |       |       |       |       |      |          |
|  2 |   PX SEND QC (RANDOM)       |:TQ10001  |    41 |  1066 |     4 |Q1,01  | P->S |QC (RAND) |
|  3 |    SORT GROUP BY            |          |    41 |  1066 |     4 |Q1,01  | PCWP |          |
|  4 |     PX RECEIVE              |          |    41 |  1066 |     4 |Q1,01  | PCWP |          |
|  5 |      PX SEND HASH           |:TQ10000  |    41 |  1066 |     4 |Q1,00  | P->P | HASH     |
|  6 |       SORT GROUP BY         |          |    41 |  1066 |     4 |Q1,00  | PCWP |          |
|  7 |        PX BLOCK ITERATOR    |          |    41 |  1066 |     1 |Q1,00  | PCWC |          |
|  8 |         TABLE ACCESS FULL   |EMP2      |    41 |  1066 |     1 |Q1,00  | PCWP |          |
--------------------------------------------------------------------------------------------
```

Disabling Parallel Execution

```
ALTER SESSION DISABLE PARALLEL DML;
```

```
ALTER TABLE employees NOPARALLEL;
```

Hints for Parallel Execution

- **PARALLEL**
- **NO_PARALLEL**
- **PQ_DISTRIBUTE**
- **PARALLEL_INDEX**
- **NO_PARALLEL_INDEX**

Summary

In this lesson, you should have learned how to do the following:

- Describe parallel execution
- Describe the types of parallelism
- Use parallel query
- Parallelize SQL statements
- View parallel queries with `EXPLAIN PLAN`

E

Optimizer Plan Stability

Objectives

After completing this lesson, you should be able to do the following:

- Identify the purpose and benefits of optimizer plan stability
- Create stored outlines
- Use stored outlines
- Edit stored outlines
- Maintain stored outlines

Optimizer Plan Stability

- Enables well-tuned applications to force the use of the desired SQL access path
- Maintains consistent execution plans through database changes
- Is implemented using stored outlines consisting of hints
- Groups stored outlines in categories

Plan Equivalence

- Plans are maintained through:
  - New Oracle Database versions
  - New statistics on objects
  - Initialization parameter changes
  - Database reorganizations
  - Schema changes
- Plan equivalence can control execution plans for third-party applications.

Creating Stored Outlines

- **For all statements during a session:**

```
SQL> ALTER SESSION
  2  SET create_stored_outlines = OTLN1;
SQL> SELECT ... ;
SQL> SELECT ... ;
```

- **For a specific statement:**

```
SQL> CREATE OR REPLACE OUTLINE CU_CO_JOIN
  2  FOR CATEGORY OTLN1 ON
  3      SELECT co.country_name,
  4      cu.cust_city, cu.cust_last_name
  5      FROM   countries co
  6      JOIN customers cu ON
 ...
```

Using Stored Outlines

- Set `USE_STORED_OUTLINES` to `TRUE` or to a category name:

```
SQL> ALTER SESSION
  2  SET use_stored_outlines = OTLN1;
SQL> SELECT ...
```

- You can set `CREATE_STORED_OUTLINES` and `USE_STORED_OUTLINES` at two levels:
  - `ALTER SYSTEM`
  - `ALTER SESSION`

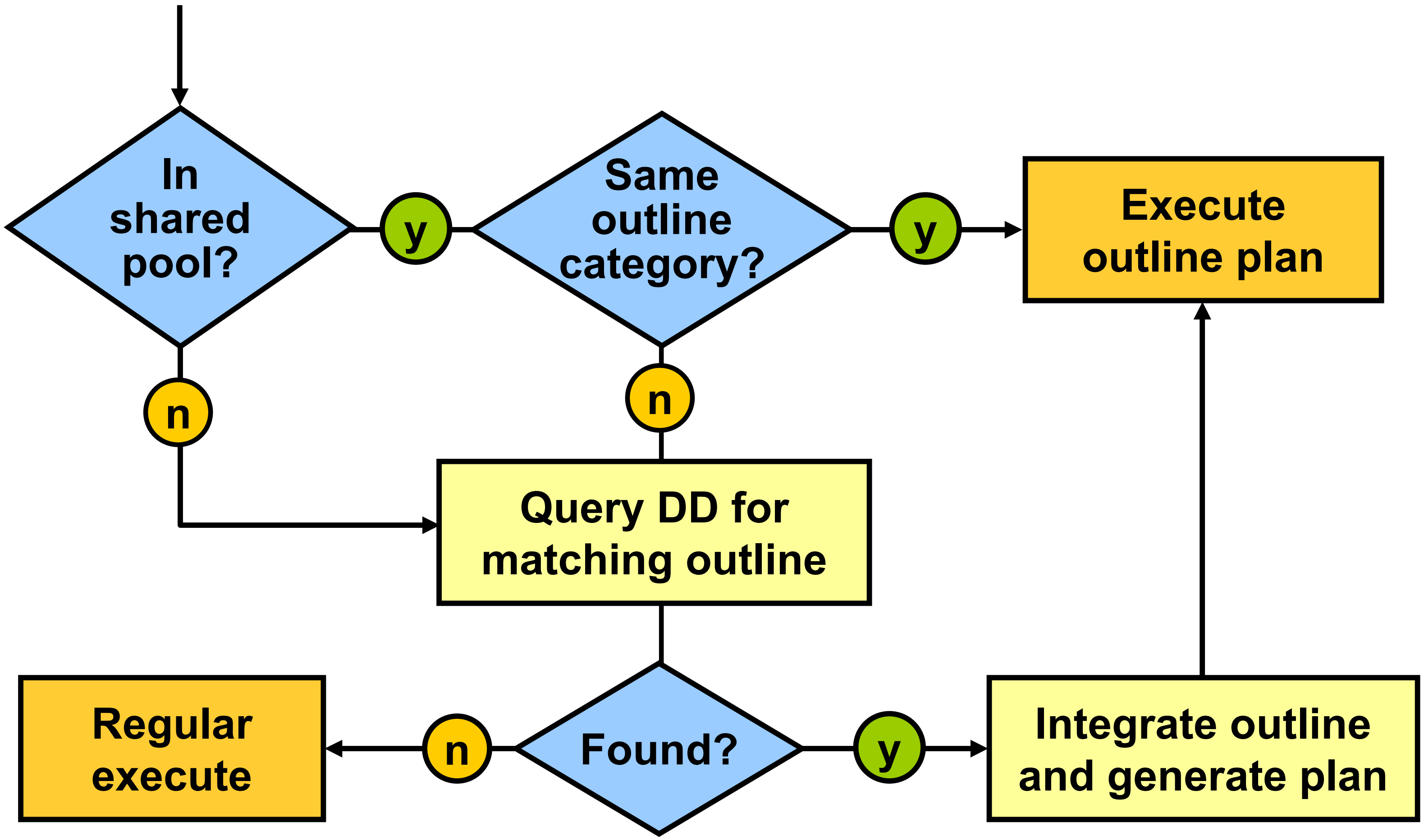
Data Dictionary Information

```
SQL> SELECT name, category, used
  2  ,      sql_text
  3  FROM   user_outlines;
```

```
SQL> SELECT node, hint
  2  FROM   user_outline_hints
  3  WHERE  name = ...;
```

```
SQL> SELECT sql_text, outline_category
  2  FROM   v$sql
  3  WHERE  ...;
```

Execution Plan Logic



Maintaining Stored Outlines

- Use `DBMS_OUTLN` to:
  - Drop unused outlines
  - Drop categories of outlines
  - Rename a category
- Use `ALTER OUTLINE` to:
  - Rename an outline
  - Rebuild an outline
  - Change the category of an outline
- Outlines are stored in the `OUTLN` schema.

Maintaining Stored Outlines

```
SQL> BEGIN
       dbms_outln.drop_unused;
       dbms_outln.update_by_cat
         ('default','otln1');
       dbms_outln.drop_by_cat('otln1');
     END;
```

Public Versus Private Outlines

- Public outlines
  - Default setting when creating outlines
  - Stored in the `OUTLN` schema
  - Used when `USE_STORED_OUTLINES` is set to `TRUE` or a category
- Private outlines
  - Stored in the user's schema for the duration of the session
  - Can be edited
  - Used when `USE_PRIVATE_OUTLINES` is set to `TRUE` or a category
  - Changes can be saved as public outlines.

Outline Editing: Overview

- Stored outlines can be edited.
- Users can tune execution plans without having to change the application.
- This is possible by editing the content of the saved plan.

Outline Editing: Overview

- Outline is cloned in a staging area.
- Outline is edited in the user's session.
- When satisfied with the result, the editor can publicize the result to the user community.

Editable Attributes

- Join order
- Join methods
- Access methods
- Distributed execution plans
- Distribution methods for parallel query execution
- Query rewrite
- View and subquery merging

Editing Stored Outlines

To edit and use private outlines:

1. **Create the outline tables in the current schema.**
2. **Copy the selected outline to a private outline.**
3. **Edit the outline that is stored as a private outline.**
4. **To use the private outline, set the `USE_PRIVATE_OUTLINE` parameter.**
5. **To allow public access to the new stored outline, overwrite the stored outline.**
6. **Reset `USE_PRIVATE_OUTLINE` to `FALSE`.**

Outlines: Administration and Security

- **Privileges required for cloning outlines**
  - `SELECT_CATALOG_ROLE`
  - `CREATE ANY OUTLINE`
  - `EXECUTE` **privilege on** `DBMS_OUTLN_EDIT`
- `DBMS_OUTLN_EDIT.CREATE_EDIT_TABLES`
  - **Creates required temporary tables in user’s schema for cloning and editing outlines**

Outlines: Administration and Security

- The `OUTLINE_SID` is available in the `V$SQL` fixed view.
- `OUTLINE_SID` identifies the session ID from which the outline was retrieved.

Configuration Parameters

`USE_PRIVATE_OUTLINES` **is a session parameter that controls the use of private outlines instead of public outlines.**

```
ALTER SESSION SET use_private_outlines =
 [TRUE | FALSE | category_name ];
```

- `TRUE` **enables the use of private outlines in the** `DEFAULT` **category.**
- `FALSE` **disables use of private outlines.**
- `category_name` **enables use of private outlines in the named category.**

Cloning Outlines

The `CREATE OUTLINE` command can be used to clone outlines:

```
CREATE [OR REPLACE]
  [PUBLIC | PRIVATE] OUTLINE [outline name]
  [FROM [PUBLIC | PRIVATE] source_outline_name]
  [FOR CATEGORY category_name] [ON statement]
```

Example

```
CREATE OR REPLACE OUTLINE public_outline2
FROM public_outline1 FOR CATEGORY cat2;
```

SQL Profiles

- SQL Profiles
  - Are an alternative to using hints
  - Consist of auxiliary stored statistics that are specific to a statement
  - Contain execution history information about the SQL statement that the Automatic Tuning Optimizer uses to set optimizer parameter settings
- A SQL Profile, after being accepted, is stored persistently in the data dictionary.
- Information about SQL Profiles can be obtained from the `DBA_SQL_PROFILES` view.

Summary

In this lesson, you should have learned how to:

- Use stored outlines to ensure execution-plan consistency
- Create outlines for a session or a single statement
- Organize outlines in categories
- Enable or disable using outlines or categories of outlines
- Maintain outlines with the `DBMS_OUTLN` package or the `ALTER OUTLINE` command

F

Statspack

Objectives

After completing this lesson, you should be able to do the following Use Statspack.

Overview of Statspack

Statspack

- collects data about high-resource SQL.
- precalculates many useful data
  - cache hit ratios
  - rates
  - transaction statistics
- Uses permanent tables owned by the PERFSTAT user to store performance statistics.
- Separates data collection from report generation
- Can be automated

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Statspack Mechanism

- The `PERFSTAT` user is created automatically at installation.
- `PERFSTAT` owns all objects needed by the Statspack package and has query privileges on the V$ views
- A snapshot is a single collection of performance data, identified by a snapshot ID, which is generated at the time the snapshot is taken.
- The performance report uses start and end snapshot IDs and then calculates activity on the instance between the two snapshots

Taking a Statistics Snapshot

```
SQL> variable snap number;
SQL> begin
  2 :snap := statspack.snap;
  3  end;
  4  /
PL/SQL procedure successfully completed.
```

Automatic Statistics Gathering

- You need to take multiple snapshots over a period of time for comparison
- To automate the collection at regular intervals use the Oracle `DBMS_JOB` procedure to schedule snapshots.
- The script `SPAUTO.SQL` schedules a snapshot every hour, on the hour.

Generating a Performance Report

The Statspack package includes two reports.

- **`SPREPORT.SQL`**
  - **Covers all aspects of instance performance**
  - **Calculates and prints ratios and differences for all statistics between the two snapshots**
  - **Prompts for :**

    The beginning snapshot ID

    The ending snapshot ID

    The name of the report text file to be created
- **`SPREPSQL.SQL`**
  - **Displays statistics, the complete SQL text, and information on any SQL plans associated with that statement.**

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Snapshot Levels

Level	Description
>= 0	General performance statistics
>= 5	Additional data: SQL statements
>= 6	Additional Data: SQL Plans and SQL Plan Usage
>= 7	Additional data: Segment Level Statistics
>= 10	Additional Statistics: Parent and Child Latches

Snapshot Levels

Level	Description
>= 0	General performance statistics
>= 5	Additional data: SQL statements
>= 6	Additional Data: SQL Plans and SQL Plan Usage
>= 7	Additional data: Segment Level Statistics
>= 10	Additional Statistics: Parent and Child Latches

Altering Snapshot Defaults

```
SQL> EXECUTE STATSPACK.SNAP(i_snap_level=>10,
                i_modify_parameter=>'true');
```

```
SQL> EXECUTE STATSPACK.MODIFY_STATSPACK_PARAMETER
      (i_snap_level=>10, i_buffer_gets_th=>10000,
       i_disk_reads_th=>1000);
```

```
SQL> EXECUTE STATSPACK.SNAP(i_snap_level=>6);
```

Removing Statspack Data

- **Use the `SPPURGE.SQL` script**
- **Deletes snapshots that fall between the begin and end snapshot IDs you specify**

Summary

In this lesson, you should have learned about the use of Statspack in statistics gathering.