6

Understanding Serial Execution Plans

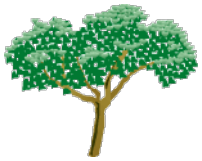
Objectives

After completing this lesson, you should be able to:

- Gather execution plans
- Display execution plans
- Interpret execution plans

What Is an Execution Plan?

- The execution plan of a SQL statement is composed of small building blocks called row sources for serial execution plans.
- The combination of row sources for a statement is called the execution plan.
- By using parent-child relationships, the execution plan can be displayed in a tree-like structure (text or graphical).



Reviewing the Execution Plan

By reviewing execution plans, you should be able to assess if the suboptimal plan is caused by the optimizer's wrong assumptions, calculations, or other factors:

- Drive from the table that has the most selective filter.
- Check to confirm the following:
  - The driving table has the best filter.
  - The fewest number of rows are returned to the next step.
  - The join method is appropriate for the number of rows returned.
  - Views are correctly used.
  - There are any unintentional Cartesian products.
  - Tables are accessed efficiently.

Where to Find Execution Plans

- `PLAN_TABLE` (Oracle SQL Developer or SQL*Plus)
- `V$SQL_PLAN` (Library Cache)
- `V$SQL_PLAN_MONITOR` (11*g*)
- `DBA_HIST_SQL_PLAN` (AWR)
- `STATS$SQL_PLAN` (Statspack)
- SQL management base (SQL plan baselines)
- SQL tuning set
- Trace files generated by `DBMS_MONITOR`
- Event 10053 trace file
- Process state dump trace file since 10*g*R2

Viewing Execution Plans

- The `EXPLAIN PLAN` command followed by:
  - `SELECT from PLAN_TABLE`
  - `DBMS_XPLAN.DISPLAY()`
- Oracle SQL*Plus Autotrace: `SET AUTOTRACE ON`
- `DBMS_XPLAN.DISPLAY_CURSOR()`
- `DBMS_XPLAN.DISPLAY_AWR()`
- `DBMS_XPLAN.DISPLAY_SQLSET()`
- `DBMS_XPLAN.DISPLAY_SQL_PLAN_BASELINE()`

The `EXPLAIN PLAN` Command: Overview

- Generates an optimizer execution plan
- Stores the plan in `PLAN_TABLE`
- Does not execute the statement itself

The `EXPLAIN PLAN` Command: Syntax

```
>>-- EXPLAIN PLAN --+-------------------------------+-->
                    |  SET STATEMENT_ID             |
                    |      = 'text'                 |

>--+-------------------------------------------------+-->
   |  INTO your plan table                           |

>-------------- FOR statement ---------------------->>
```

The EXPLAIN PLAN Command: Example

```
SQL> EXPLAIN PLAN
  2  SET STATEMENT_ID = 'demo01' FOR
  3  SELECT e.last_name, d.department_name
  4  FROM hr.employees e, hr.departments d
  5  WHERE e.department_id = d.department_id;

Explained.

SQL>
```

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

PLAN_TABLE

- `PLAN_TABLE`:
  - Is automatically created to hold the `EXPLAIN PLAN` output
  - You can create your own using `utlxplan.sql`.
  - Advantage: SQL is not executed.
  - Disadvantage: May not be the actual execution plan
- `PLAN_TABLE` is hierarchical.
- Hierarchy is established with the `ID` and `PARENT_ID` columns.

Displaying from PLAN_TABLE: Typical

```
SQL> EXPLAIN PLAN SET STATEMENT_ID = 'demo01' FOR SELECT * FROM emp
  2  WHERE ename = 'KING';

Explained.

SQL> SET LINESIZE 130
SQL> SET PAGESIZE 0
SQL> select * from table(DBMS_XPLAN.DISPLAY());

Plan hash value: 3956160932
---------------------------------------------------------------------------
| Id  | Operation         | Name | Rows  | Bytes | Cost (%CPU)| Time     |
---------------------------------------------------------------------------
|   0 | SELECT STATEMENT  |      |     1 |    37 |     3   (0)| 00:00:01 |
|*  1 |  TABLE ACCESS FULL| EMP  |     1 |    37 |     3   (0)| 00:00:01 |
---------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   1 - filter("ENAME"='KING')
```

Displaying from PLAN_TABLE: ALL

```
SQL> select * from table(DBMS_XPLAN.DISPLAY(null,null,'ALL'));

Plan hash value: 3956160932
---------------------------------------------------------------------------
| Id  | Operation         | Name | Rows  | Bytes | Cost (%CPU)| Time     |
---------------------------------------------------------------------------
|   0 | SELECT STATEMENT  |      |     1 |    37 |     3   (0)| 00:00:01 |
|*  1 |  TABLE ACCESS FULL| EMP  |     1 |    37 |     3   (0)| 00:00:01 |
---------------------------------------------------------------------------
Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------
   1 - SEL$1 / EMP@SEL$1
Predicate Information (identified by operation id):
---------------------------------------------------
   1 - filter("ENAME"='KING')
Column Projection Information (identified by operation id):
-----------------------------------------------------------
 1 - "EMP"."EMPNO"[NUMBER,22], "ENAME"[VARCHAR2,10], "EMP"."JOB"[VARCHAR2,9],
     "EMP"."MGR"[NUMBER,22], "EMP"."HIREDATE"[DATE,7], "EMP"."SAL"[NUMBER,22],
     "EMP"."COMM"[NUMBER,22], "EMP"."DEPTNO"[NUMBER,22]
```

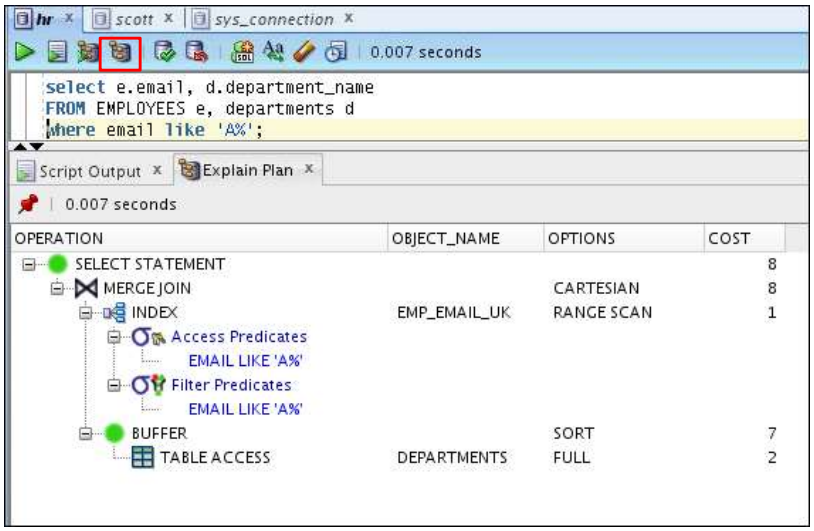
The EXPLAIN PLAN Command

```
→→ EXPLAIN PLAN ──┬──────────────────────────┬──────────────→
                  └─ SET STATEMENT_ID ───────┘
                       = 'text'

→──┬──────────────────────────────────┬──────────────────────→
   └─ INTO your plan table ───────────┘

→──────────── FOR statement ──────────────→→
```

Displaying from PLAN_TABLE: ADVANCED

```
select plan_table_output from table(DBMS_XPLAN.DISPLAY(null,null,'ADVANCED
 -PROJECTION -PREDICATE -ALIAS'));
Plan hash value: 3956160932
-----------------------------------------------------------------------------
| Id  | Operation         | Name | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------
|   0 | SELECT STATEMENT  |      |     1 |    37 |     3   (0)| 00:00:01 |
|   1 |  TABLE ACCESS FULL| EMP  |     1 |    37 |     3   (0)| 00:00:01 |
-----------------------------------------------------------------------------
Outline Data
-------------
  /*+
      BEGIN_OUTLINE_DATA
      FULL(@"SEL$1" "EMP"@"SEL$1")
      OUTLINE_LEAF(@"SEL$1")
      ALL_ROWS
      DB_VERSION('11.1.0.6')
      OPTIMIZER_FEATURES_ENABLE('11.1.0.6')
      IGNORE_OPTIM_EMBEDDED_HINTS
      END_OUTLINE_DATA
  */
```

Explain Plan Using Oracle SQL Developer



Quiz

An `EXPLAIN PLAN` command executes the statement and inserts the plan used by the optimizer into a table.

a. True
b. False

Quiz

Which of the following is NOT true about a `PLAN_TABLE`?

a. The `PLAN_TABLE` is automatically created to hold the `EXPLAIN PLAN` output.
b. You cannot create your own `PLAN_TABLE`.
c. The actual SQL command is not executed.
d. The plan in the `PLAN_TABLE` may not be the actual execution plan.

AUTOTRACE

- Is an Oracle SQL*Plus and SQL Developer facility
- Was introduced with Oracle 7.3
- Needs a `PLAN_TABLE`
- Needs the `PLUSTRACE` role to retrieve statistics from some `V$` views
- Produces the execution plan and statistics by default after running the query
- May not be the execution plan used by the optimizer when using bind peeking (recursive `EXPLAIN PLAN`)

The AUTOTRACE Syntax

```
                                  ┌─ OFF ─────────┐
──►► SET AUTOTRACE ──────────────┼─ ON ──────────┼──►
                                  └─ TRACE[ONLY] ─┘

──►────────────────────────────────────────────────►►
                                  ┌─ EXPLAIN ─┐
                                  └─ STATISTICS ─┘

──►► SHOW AUTOTRACE ──────────────────────────────►►
```

AUTOTRACE: Examples

- To start tracing statements using AUTOTRACE:

```
SQL> set autotrace on
```

- To only display the execution plan without execution:

```
SQL> set autotrace traceonly explain
```

- To display rows and statistics:

```
SQL> set autotrace on statistics
```

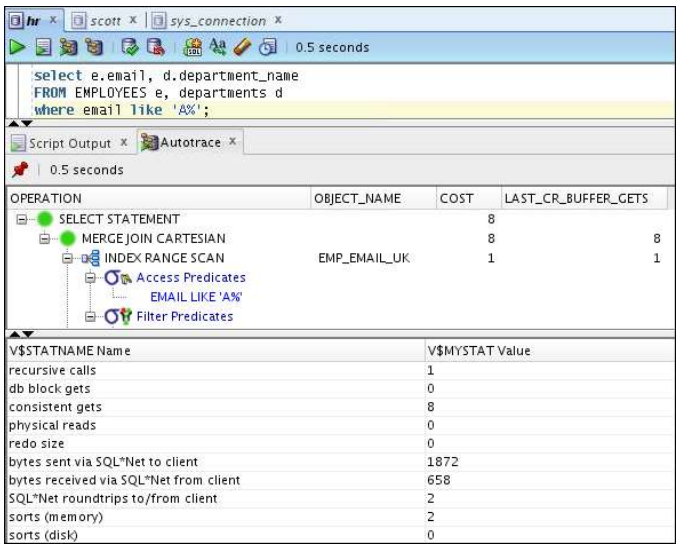
- To get only the plan and the statistics (suppress rows):

```
SQL> set autotrace traceonly
```

AUTOTRACE: Statistics

```
SQL> show autotrace
autotrace OFF
SQL> set autotrace traceonly statistics
SQL> SELECT * FROM oe.products;

288 rows selected.

Statistics
----------------------------------------------------------
       1334  recursive calls
          0  db block gets
        686  consistent gets
        394  physical reads
          0  redo size
     103919  bytes sent via SQL*Net to client
        629  bytes received via SQL*Net from client
         21  SQL*Net roundtrips to/from client
         22  sorts (memory)
          0  sorts (disk)
        288  rows processed
```

AUTOTRACE by Using SQL Developer



Quiz

A user needs to be granted some specialized privileges to generate AUTOTRACE statistics.

a. True
b. False

Using the V$SQL_PLAN View

- V$SQL_PLAN provides a way of examining the execution plan for cursors that are still in the library cache.
- V$SQL_PLAN is very similar to PLAN_TABLE:
  - PLAN_TABLE shows a theoretical plan that can be used if this statement were to be executed.
  - V$SQL_PLAN contains the actual plan used.
- It contains the execution plan of every cursor in the library cache (including child).
- Link to V$SQL:
  - ADDRESS, HASH_VALUE, and CHILD_NUMBER

The V$SQL_PLAN Columns

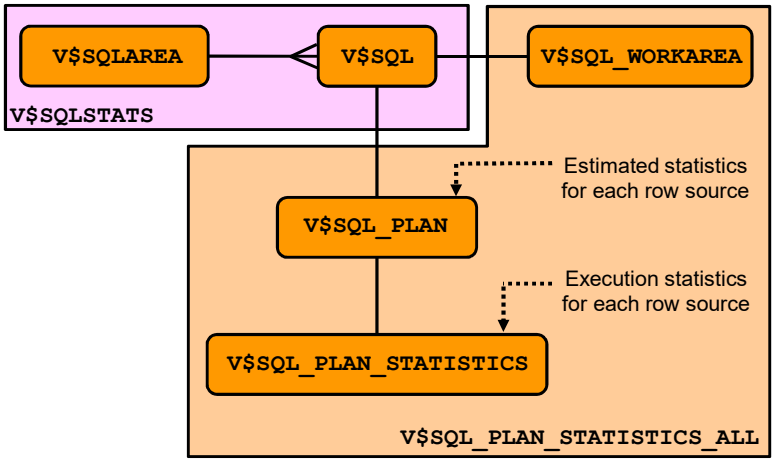
HASH_VALUE	Hash value of the parent statement in the library cache
ADDRESS	Address of the handle to the parent for this cursor
CHILD_NUMBER	Child cursor number using this execution plan
POSITION	Order of processing for all operations that have the same PARENT_ID
PARENT_ID	ID of the next execution step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

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

The V$SQL_PLAN_STATISTICS View

- V$SQL_PLAN_STATISTICS provides actual execution statistics:
  - STATISTICS_LEVEL set to ALL
  - The GATHER_PLAN_STATISTICS hint
- V$SQL_PLAN_STATISTICS_ALL enables side-by-side comparisons of the optimizer estimates with the actual execution statistics.

Links Between Important Dynamic Performance Views



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.
```

Automatic Workload Repository

- Collects, processes, and maintains performance statistics for problem-detection and self-tuning purposes
- Includes the following statistics:
  - 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:

```
SQL> exec DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT ('ALL');
```

- Dropping snapshots:

```
SQL> exec DBMS_WORKLOAD_REPOSITORY.DROP_SNAPSHOT_RANGE -
    (low_snap_id => 22, high_snap_id => 32, dbid => 3310949047);
```

- Managing snapshot settings:

```
SQL> exec DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS -
     (retention => 43200, interval => 30, dbid => 3310949047);
```

Important 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

Comparing the Execution Plans by Using AWR

- Identify a problem SQL statement and Retrieve SQL_ID.

```
select sql_id, sql_text
from v$SQL  where sql_text  like '%example%';

SQL_ID        SQL_TEXT
------------- ------------------------------------------
454rug2yva18w select /* example */ * from …
```

- Retrieve all execution plans stored for a particular SQL_ID.

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

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 |
|   3 |   TABLE ACCESS FULL| EMPLOYEES   |   107 |  7276 |     3   (0)| 00:00:01 |
-------------------------------------------------------------------------------
```

Generating SQL Reports from AWR Data

```
SQL> @$ORACLE_HOME/rdbms/admin/awrsqrpt

Specify the Report Type …
Would you like an HTML report, or a plain text report?
Specify the number of days of snapshots to choose from
Specify the Begin and End Snapshot Ids …
Specify the SQL Id …
Enter value for sql_id: dvza55c7zu0yv
Specify the Report Name …
```

WORKLOAD REPOSITORY SQL Report

Snapshot Period Summary

DB Name	DB Id	Instance	Inst num	Startup Time	Release	RAC
ORCL	1249102530	orcl	1	14-Jun-10 02:06	11.2.0.1.0	NO

	Snap Id	Snap Time	Sessions	Cursors/Session
Begin Snap:	218	17-Jun-10 22:00:47	43	6.3
End Snap:	226	18-Jun-10 04:21:15	40	6.4
Elapsed:		380.47 (mins)		
DB Time:		5.54 (mins)		

SQL ID: dvza55c7zu0yv

- 1st Capture and Last Capture Snap IDs refer to Snapshot IDs within the snapshot range
- SELECT sql_id, sql_text from DBA_HIST_SQLTEXT where sql_text like '%sa...

#	Plan Hash Value	Total Elapsed Time(ms)	Executions	1st Capture Snap ID	Last Capture Snap ID
1	1258587641	429	1	226	226

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Plan 1(PHV: 1258587641)

- Plan Statistics
- Execution Plan

Quiz

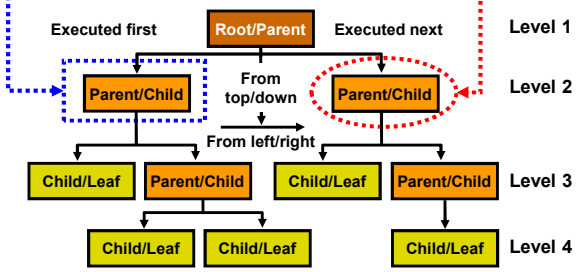
After monitoring is initiated, an entry is added to the _____view. This entry tracks key performance metrics collected for the execution.

a. V$SQL_MONITOR
b. V$PLAN_MONITOR
c. ALL_SQL_MONITOR
d. ALL_SQL_PLAN_MONITOR

Interpreting a Serial Execution Plan

```
id= 1 (pid= )                root/parent
id= 2 (pid=1) (pos=1)          parent/child
id= 3 (pid=2) (pos=1)            child/leaf
id= 4 (pid=2) (pos=2)          parent/child
id= 5 (pid=4) (pos=1)            child/leaf
id= 6 (pid=4) (pos=2)            child/leaf
id= 7 (pid=1) (pos=2)          parent/child
id= 8 (pid=7) (pos=1)            child/leaf
id= 9 (pid=7) (pos=2)          parent/child
id=10 (pid=9) (pos=1)            child/leaf
```

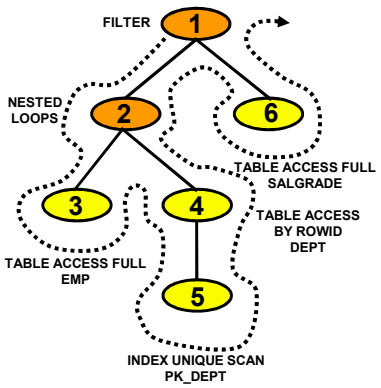
Transform it into a tree.



Execution Plan Interpretation: Example 1

```
SELECT /*+ RULE */ ename,job,sal,dname
FROM emp,dept
WHERE dept.deptno=emp.deptno and not exists(SELECT *
                                            FROM salgrade
                                            WHERE emp.sal between losal and hisal);
```

```
-----------------------------------------------
| Id  | Operation                      | Name     |
-----------------------------------------------
|   0 | SELECT STATEMENT               |          |
|*  1 |  FILTER                        |          |
|   2 |   NESTED LOOPS                 |          |
|   3 |    TABLE ACCESS FULL           | EMP      |
|   4 |    TABLE ACCESS BY INDEX ROWID| DEPT     |
|*  5 |     INDEX UNIQUE SCAN          | PK_DEPT  |
|*  6 |   TABLE ACCESS FULL            | SALGRADE |
-----------------------------------------------

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

   1 - filter( NOT EXISTS
    (SELECT 0 FROM "SALGRADE" "SALGRADE" WHERE
     "HISAL">=:B1 AND "LOSAL"<=:B2))
   5 - access("DEPT"."DEPTNO"="EMP"."DEPTNO")
   6 - filter("HISAL">=:B1 AND "LOSAL"<=:B2)
```



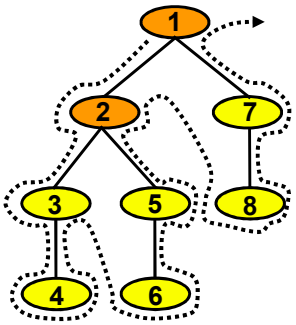
Execution Plan Interpretation: Example 1

```
SQL> alter session set statistics_level=ALL;

Session altered.

SQL> select /*+ RULE to make sure it reproduces 100% */ ename,job,sal,dname
from emp,dept where dept.deptno = emp.deptno and not exists (select * from salgrade
where emp.sal between losal and hisal);

no rows selected

SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL IOSTATS
LAST'));

SQL_ID  274019myw3vuf, child number 0
-------------------------------------
…
Plan hash value: 1175760222
--------------------------------------------------------------------------------
| Id  | Operation                      | Name     | Starts | A-Rows | Buffers |
--------------------------------------------------------------------------------
|*  1 |  FILTER                        |          |      1 |      0 |      61 |
|   2 |   NESTED LOOPS                 |          |      1 |     14 |      25 |
|   3 |    TABLE ACCESS FULL           | EMP      |      1 |     14 |       7 |
|   4 |    TABLE ACCESS BY INDEX ROWID| DEPT     |     14 |     14 |      18 |
|*  5 |     INDEX UNIQUE SCAN          | PK_DEPT  |     14 |     14 |       4 |
|*  6 |   TABLE ACCESS FULL            | SALGRADE |     12 |     12 |      36 |
--------------------------------------------------------------------------------
…
```

Execution Plan Interpretation: Example 2

```
SQL> select /*+ USE_NL(d) use_nl(m) */ m.last_name as dept_manager
  2  ,       d.department_name
  3  ,       l.street_address
  4  from    hr.employees m   join
  5          hr.departments d on (d.manager_id = m.employee_id)
  6          natural join
  7          hr.locations l
  8  where   l.city = 'Seattle';
```

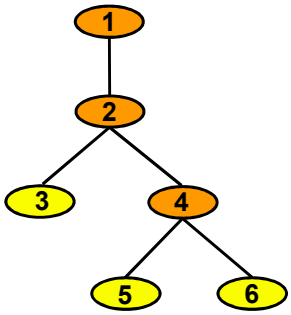
```
0   SELECT STATEMENT
1 0   NESTED LOOPS
2 1    NESTED LOOPS
3 2     TABLE ACCESS BY INDEX ROWID LOCATIONS
4 3      INDEX RANGE SCAN           LOC_CITY_IX
5 2     TABLE ACCESS BY INDEX ROWID DEPARTMENTS
6 5      INDEX RANGE SCAN           DEPT_LOCATION_IX
7 1    TABLE ACCESS BY INDEX ROWID  EMPLOYEES
8 7     INDEX UNIQUE SCAN           EMP_EMP_ID_PK
```



Execution Plan Interpretation: Example 3

```
select /*+ ORDERED USE_HASH(b) SWAP_JOIN_INPUTS(c) */ max(a.i)
from t1 a, t2 b, t3 c
where a.i = b.i and a.i = c.i;
```

```
0   SELECT STATEMENT
1     SORT AGGREGATE
2 1    HASH JOIN
3 2     TABLE ACCESS FULL T3
4 2     HASH JOIN
5 4      TABLE ACCESS FULL T1
6 4      TABLE ACCESS FULL T2
```



Expand All | Collapse All

Operation	Object	Order
SELECT STATEMENT		7
SORT AGGREGATE		6
HASH JOIN		5
TABLE ACCESS FULL	T3	1
HASH JOIN		4
TABLE ACCESS FULL	T1	2
TABLE ACCESS FULL	T2	3

Join order is: T1 - T2 - T3

Execution Plan Interpretation: Example 4

```
select /*+ GATHER_PLAN_STATISTICS */ *
from oe.inventories where
warehouse_id = 1;

select plan_table_output
  from table(dbms_xplan.display_cursor(format=> 'allstats last'));

PLAN_TABLE_OUTPUT
-----------------------------------------------------------------------------------------------------
SQL_ID  6260b91rbnn4n, child number 0
-------------------------------------
select /*+ GATHER_PLAN_STATISTICS */ * from oe.inventories where
warehouse_id = 1

Plan hash value: 791134270

-----------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name         | Starts | E-Rows | A-Rows |   A-Time   | Buffers |
-----------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |              |      1 |        |     36 |00:00:00.01 |       9 |
|   1 |  TABLE ACCESS BY INDEX ROWID| INVENTORIES  |      1 |    124 |     36 |00:00:00.01 |       9 |
|*  2 |   INDEX RANGE SCAN           | INVENTORY_IX |      1 |    124 |     36 |00:00:00.01 |       5 |
-----------------------------------------------------------------------------------------------------

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

   2 - access("WAREHOUSE_ID"=1)
```

Compare actual rows returned by each operation (A-Rows) with the Optimizer estimate (E-Rows)

Reading More Complex Execution Plans

```
SELECT owner , segment_name , segment_type
FROM dba_extents
WHERE file_id = 1
AND   123213 BETWEEN block_id AND block_id + blocks -1;
```

Expand All | Collapse All

Operation	Object	Order	Rows	Bytes	Cost	CPU (%)	Time
SELECT STATEMENT		113			2,834	100	
VIEW	SYS.DBA_EXTENTS	112	2	140	2,834	0	0:0:35
UNION-ALL		111					
NESTED LOOPS		56	1	214	1,391	0	0:0:17
NESTED LOOPS		110	1	196	1,442	0	0:0:18

Collapse using indentation
and
focus on operations consuming most resources.

Looking Beyond Execution Plans

- An execution plan alone cannot tell you whether a plan is good or not.
- It may need additional testing and tuning:
  - SQL Tuning Advisor
  - SQL Access Advisor
  - SQL Performance Analyzer
  - SQL Monitoring
  - Tracing

Quiz

```
SELECT * FROM oe.inventories WHERE warehouse_id = 1;

-----------------------------------------------------------------------------------------
| Id  | Operation                    | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |              |   124 |  1240 |     3   (0)| 00:00:01 |
|   1 |  TABLE ACCESS BY INDEX ROWID| INVENTORIES  |   124 |  1240 |     3   (0)| 00:00:01 |
|*  2 |   INDEX RANGE SCAN           | INVENTORY_IX |   124 |       |     2   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------

SELECT count(*) FROM oe.inventories WHERE warehouse_id = 1;

COUNT(*)
--------
      36
```

Q1. According to the execution plan, is the number of rows returned in step 2 quite accurate?

Q2. What is the selectivity of the predicate and computed cardinality (total rows in the table: 1112 rows, NDV: 9)?

Q3. Has the optimizer made a good estimation?

Summary

In this lesson, you should have learned how to:

- Gather execution plans
- Display execution plans
- Interpret execution plans

Practice 6: Overview

This practice covers the following topics:

- Using different techniques to extract execution plans
- Using SQL monitoring