```
select /*+ full(dep) full(loc) */
       emp.last_name, job.job_title, loc.city
  from jobs job,
       employees emp,
       departments dep,
       locations loc
 where job.job_id = emp.job_id
   and emp.department_id = dep.department_id
   and dep.location_id = loc.location_id
   and (emp.email = 'HBROWN' or job.job_id = 'HR_REP');
```

```
LAST_NAME       JOB_TITLE                           CITY
--------------- ----------------------------------- --------------------
Jacobs          Human Resources Representative      London
Brown           Public Relations Representative     Munich

2 rows selected.
```

Shh! We Have a [SQL] Plan

```
SQL_ID 6um9z82ayj75t, child number 0
Plan hash value: 1743992561

------------------------------------------------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                       | Name          | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time     | A-Rows |    A-Time    | Buffers |  OMem |  1Mem | Used-Mem |
------------------------------------------------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                |               |      1 |        |       |    12 (100)|            |      2 |00:00:00.01 |      21 |       |       |          |
|*  1 |  HASH JOIN                      |               |      1 |      7 |   511 |    12   (9)| 00:00:01   |      2 |00:00:00.01 |      21 |  1106K|  1106K|  536K (0)|
|*  2 |   HASH JOIN                     |               |      1 |      7 |   427 |     9  (12)| 00:00:01   |      2 |00:00:00.01 |      14 |  1106K|  1106K|  553K (0)|
|   3 |    MERGE JOIN                   |               |      1 |      7 |   378 |     6  (17)| 00:00:01   |      2 |00:00:00.01 |       8 |       |       |          |
|   4 |     TABLE ACCESS BY INDEX ROWID| JOBS          |      1 |     19 |   513 |     2   (0)| 00:00:01   |     19 |00:00:00.01 |       2 |       |       |          |
|   5 |      INDEX FULL SCAN            | JOB_ID_PK     |      1 |     19 |       |     1   (0)| 00:00:01   |     19 |00:00:00.01 |       1 |       |       |          |
|*  6 |     FILTER                      |               |     19 |        |       |            |            |      2 |00:00:00.01 |       6 |       |       |          |
|*  7 |      SORT JOIN                  |               |     19 |    107 |  2889 |     4  (25)| 00:00:01   |    107 |00:00:00.01 |       6 | 15360 | 15360 |14336  (0)|
|   8 |       TABLE ACCESS FULL         | EMPLOYEES     |      1 |    107 |  2889 |     3   (0)| 00:00:01   |    107 |00:00:00.01 |       6 |       |       |          |
|   9 |    TABLE ACCESS FULL            | DEPARTMENTS   |      1 |     27 |   189 |     3   (0)| 00:00:01   |     27 |00:00:00.01 |       6 |       |       |          |
|  10 |   TABLE ACCESS FULL             | LOCATIONS     |      1 |     23 |   276 |     3   (0)| 00:00:01   |     23 |00:00:00.01 |       7 |       |       |          |
------------------------------------------------------------------------------------------------------------------------------------------------------------------

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

   1 - access("DEP"."LOCATION_ID"="LOC"."LOCATION_ID")
   2 - access("EMP"."DEPARTMENT_ID"="DEP"."DEPARTMENT_ID")
   6 - filter(("EMP"."EMAIL"='HBROWN' OR "JOB"."JOB_ID"='HR_REP'))
   7 - access("JOB"."JOB_ID"="EMP"."JOB_ID")
       filter("JOB"."JOB_ID"="EMP"."JOB_ID")
```

Agenda

I. Introduction

II. Retrieving and Displaying Plans

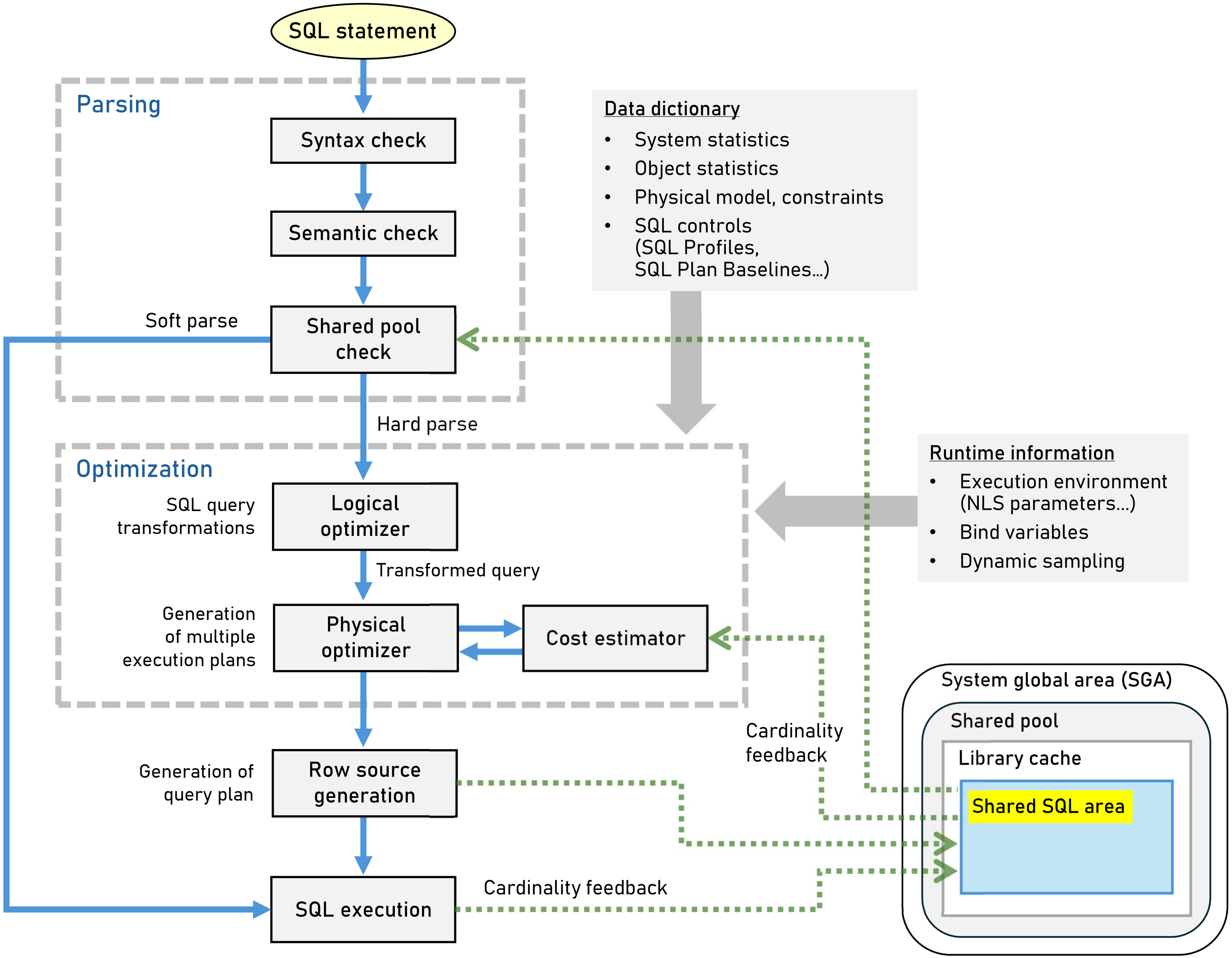
III. Understanding SQL Plans

IV. Demos

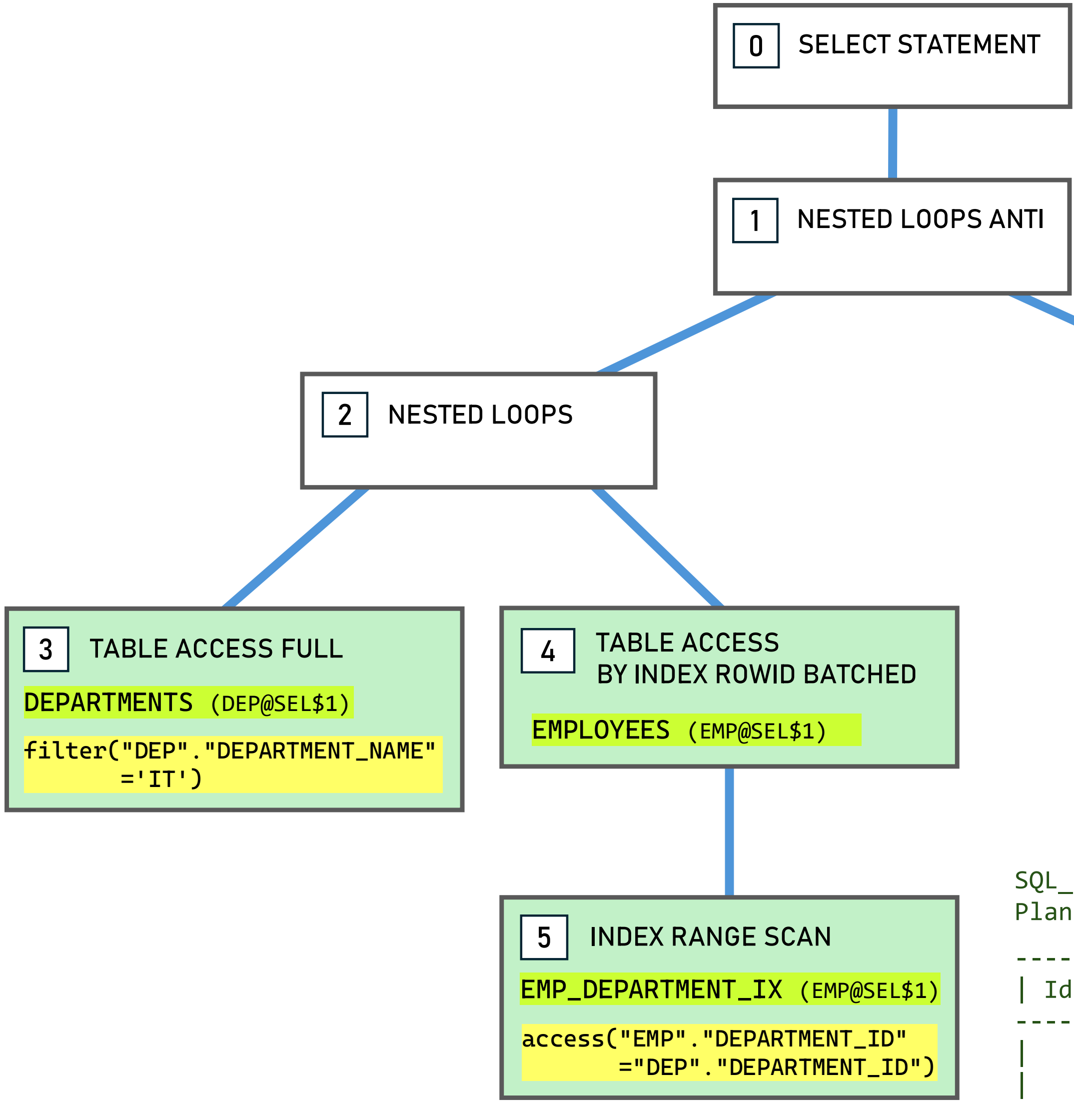
```
-----------------------------------------------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                                  | Name             | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   | A-Rows |   A-Time   | Buffers | Reads  |
-----------------------------------------------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                           |                  |      1 |        |       |     8 (100)|          |      2 |00:00:00.01 |      16 |      1 |
|   1 |  VIEW                                      | VW_ORE_8CFACDC3  |      1 |      2 |   100 |     8   (0)| 00:00:01 |      2 |00:00:00.01 |      16 |      1 |
|   2 |   UNION-ALL                                |                  |      1 |        |       |            |          |      2 |00:00:00.01 |      16 |      1 |
|   3 |    NESTED LOOPS                            |                  |      1 |      1 |    73 |     4   (0)| 00:00:01 |      1 |00:00:00.01 |       8 |      1 |
|   4 |     NESTED LOOPS                           |                  |      1 |      1 |    61 |     3   (0)| 00:00:01 |      1 |00:00:00.01 |       6 |      1 |
|   5 |      NESTED LOOPS                          |                  |      1 |      1 |    54 |     2   (0)| 00:00:01 |      1 |00:00:00.01 |       4 |      0 |
|   6 |       TABLE ACCESS BY INDEX ROWID          | EMPLOYEES        |      1 |      1 |    27 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|*  7 |        INDEX UNIQUE SCAN                   | EMP_EMAIL_UK     |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|   8 |       TABLE ACCESS BY INDEX ROWID          | JOBS             |      1 |      1 |    27 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|*  9 |        INDEX UNIQUE SCAN                   | JOB_ID_PK        |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|  10 |      TABLE ACCESS BY INDEX ROWID           | DEPARTMENTS      |      1 |      1 |     7 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      1 |
|* 11 |       INDEX UNIQUE SCAN                    | DEPT_ID_PK       |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      1 |
|  12 |     TABLE ACCESS BY INDEX ROWID            | LOCATIONS        |      1 |      1 |    12 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|* 13 |      INDEX UNIQUE SCAN                     | LOC_ID_PK        |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|  14 |    NESTED LOOPS                            |                  |      1 |      1 |    73 |     4   (0)| 00:00:01 |      1 |00:00:00.01 |       8 |      0 |
|  15 |     NESTED LOOPS                           |                  |      1 |      1 |    73 |     4   (0)| 00:00:01 |      1 |00:00:00.01 |       7 |      0 |
|  16 |      NESTED LOOPS                          |                  |      1 |      1 |    61 |     3   (0)| 00:00:01 |      1 |00:00:00.01 |       6 |      0 |
|  17 |       NESTED LOOPS                         |                  |      1 |      1 |    54 |     2   (0)| 00:00:01 |      1 |00:00:00.01 |       4 |      0 |
|  18 |        TABLE ACCESS BY INDEX ROWID         | JOBS             |      1 |      1 |    27 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|* 19 |         INDEX UNIQUE SCAN                  | JOB_ID_PK        |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|* 20 |        TABLE ACCESS BY INDEX ROWID BATCHED | EMPLOYEES        |      1 |      1 |    27 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|* 21 |         INDEX RANGE SCAN                   | EMP_JOB_IX       |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|  22 |       TABLE ACCESS BY INDEX ROWID          | DEPARTMENTS      |      1 |      1 |     7 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       2 |      0 |
|* 23 |        INDEX UNIQUE SCAN                   | DEPT_ID_PK       |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|* 24 |      INDEX UNIQUE SCAN                     | LOC_ID_PK        |      1 |      1 |       |     0   (0)|          |      1 |00:00:00.01 |       1 |      0 |
|  25 |     TABLE ACCESS BY INDEX ROWID            | LOCATIONS        |      1 |      1 |    12 |     1   (0)| 00:00:01 |      1 |00:00:00.01 |       1 |      0 |
-----------------------------------------------------------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SET$2A13AF86   / VW_ORE_8CFACDC3@SEL$8CFACDC3
   2 - SET$2A13AF86
   3 - SET$2A13AF86_1
   6 - SET$2A13AF86_1 / EMP@SET$2A13AF86_1
   7 - SET$2A13AF86_1 / EMP@SET$2A13AF86_1
   8 - SET$2A13AF86_1 / JOB@SET$2A13AF86_1
   9 - SET$2A13AF86_1 / JOB@SET$2A13AF86_1
  10 - SET$2A13AF86_1 / DEP@SET$2A13AF86_1
  11 - SET$2A13AF86_1 / DEP@SET$2A13AF86_1
  12 - SET$2A13AF86_1 / LOC@SET$2A13AF86_1
  13 - SET$2A13AF86_1 / LOC@SET$2A13AF86_1
  14 - SET$2A13AF86_2
  18 - SET$2A13AF86_2 / JOB@SET$2A13AF86_2
  19 - SET$2A13AF86_2 / JOB@SET$2A13AF86_2
  20 - SET$2A13AF86_2 / EMP@SET$2A13AF86_2
  21 - SET$2A13AF86_2 / EMP@SET$2A13AF86_2
  22 - SET$2A13AF86_2 / DEP@SET$2A13AF86_2
  23 - SET$2A13AF86_2 / DEP@SET$2A13AF86_2
  24 - SET$2A13AF86_2 / LOC@SET$2A13AF86_2
  25 - SET$2A13AF86_2 / LOC@SET$2A13AF86_2
```

Part #1: Introduction

Overview of SQL processing



A plan is a tree of row source operations




```
select emp.employee_id,
       emp.first_name, emp.last_name
  from departments dep,
       employees emp
 where dep.department_name = 'IT'
   and emp.department_id = dep.department_id
   and not exists
       ( select 1 from employees sub
          where sub.manager_id = emp.employee_id );
```

```
SQL_ID 74dt9au6977k8, child number 0
Plan hash value: 2491633195

-----------------------------------------------------------------
| Id  | Operation                            | Name             |
-----------------------------------------------------------------
|   0 | SELECT STATEMENT                     |                  |
|   1 |  NESTED LOOPS ANTI                   |                  |
|   2 |   NESTED LOOPS                       |                  |
|*  3 |    TABLE ACCESS FULL                 | DEPARTMENTS      |
|   4 |    TABLE ACCESS BY INDEX ROWID BATCHED| EMPLOYEES       |
|*  5 |     INDEX RANGE SCAN                 | EMP_DEPARTMENT_IX|
|*  6 |   INDEX RANGE SCAN                   | EMP_MANAGER_IX   |
-----------------------------------------------------------------
```

SQL plan operations & options

```
select distinct operation, options from v$sql_plan union
select distinct operation, options from dba_hist_sql_plan
 order by 1, 2;
```

Only a limited subset of all operations and options can fit on this slide!

OPERATION	OPTIONS
FILTER	
COUNT	STOPKEY
INLIST ITERATOR	

OPERATION	OPTIONS
VIEW	
VIEW PUSHED PREDICATE	

OPERATION	OPTIONS
CONCATENATION	
UNION-ALL	
UNION ALL PUSHED PREDICATE	
MINUS	

OPERATION	OPTIONS
TABLE ACCESS	FULL
TABLE ACCESS	BY INDEX ROWID
TABLE ACCESS	BY INDEX ROWID BATCHED
TABLE ACCESS	BY LOCAL INDEX ROWID
TABLE ACCESS	BY LOCAL INDEX ROWID BATCHED
TABLE ACCESS	BY GLOBAL INDEX ROWID BATCHED
TABLE ACCESS	BY USER ROWID

OPERATION	OPTIONS
FAST DUAL	
XMLTABLE EVALUATION	
RESULT CACHE	
SEQUENCE	
FIXED TABLE	FULL
EXTERNAL TABLE ACCESS	FULL
COLLECTION ITERATOR	PICKLER FETCH

OPERATION	OPTIONS
PARTITION RANGE	SINGLE
PARTITION RANGE	ITERATOR
PARTITION RANGE	ALL
PARTITION RANGE	AND
PARTITION RANGE	SUBQUERY
PARTITION LIST	SINGLE
PARTITION LIST	ITERATOR
PARTITION LIST	ALL
PARTITION LIST	SUBQUERY
PARTITION HASH	SINGLE
PARTITION HASH	INLIST
PARTITION HASH	ALL
PARTITION HASH	SUBQUERY

OPERATION	OPTIONS
INDEX	UNIQUE SCAN
INDEX	RANGE SCAN
INDEX	RANGE SCAN DESCENDING
INDEX	RANGE SCAN (MIN/MAX)
INDEX	FULL SCAN
INDEX	FAST FULL SCAN
INDEX	FULL SCAN (MIN/MAX)
INDEX	SAMPLE FAST FULL SCAN
INDEX	SKIP SCAN

OPERATION	OPTIONS
BITMAP INDEX	SINGLE VALUE
BITMAP INDEX	RANGE SCAN
BITMAP INDEX	FULL SCAN
BITMAP INDEX	FAST FULL SCAN
BITMAP AND	
BITMAP OR	
BITMAP MERGE	
BITMAP MINUS	
BITMAP CONVERSION	FROM ROWIDS
BITMAP CONVERSION	TO ROWIDS

OPERATION	OPTIONS
CONNECT BY	NO FILTERING WITH START-WITH
CONNECT BY	WITH FILTERING
CONNECT BY	WITH FILTERING (UNIQUE)
CONNECT BY	WITHOUT FILTERING
CONNECT BY PUMP	
UNION ALL (RECURSIVE WITH)	DEPTH FIRST
UNION ALL (RECURSIVE WITH)	BREADTH FIRST
RECURSIVE WITH PUMP	

OPERATION	OPTIONS
HASH	UNIQUE
HASH	GROUP BY
HASH	GROUP BY PIVOT
SORT	UNIQUE
SORT	UNIQUE STOPKEY
SORT	GROUP BY
SORT	GROUP BY NOSORT
SORT	GROUP BY ROLLUP
SORT	ORDER BY
SORT	ORDER BY STOPKEY
WINDOW	BUFFER
WINDOW	SORT
WINDOW	SORT PUSHED RANK
WINDOW	CHILD PUSHED RANK

OPERATION	OPTIONS
NESTED LOOPS	
NESTED LOOPS	ANTI
NESTED LOOPS	OUTER
NESTED LOOPS	SEMI
HASH JOIN	
HASH JOIN	SEMI
HASH JOIN	ANTI
HASH JOIN	ANTI NA
HASH JOIN	OUTER
HASH JOIN	FULL OUTER
HASH JOIN	RIGHT SEMI
HASH JOIN	RIGHT ANTI
HASH JOIN	RIGHT OUTER
HASH JOIN	BUFFERED
HASH JOIN	OUTER BUFFERED
HASH JOIN	RIGHT OUTER BUFFERED
JOIN FILTER	CREATE
JOIN FILTER	USE
PART JOIN FILTER	CREATE
MERGE JOIN	
MERGE JOIN	ANTI
MERGE JOIN	CARTESIAN
MERGE JOIN	OUTER
MERGE JOIN	SEMI
SORT	JOIN
BUFFER	SORT
BUFFER	SORT (REUSE)

OPERATION	OPTIONS
PX COORDINATOR	
PX BLOCK	ITERATOR
PX RECEIVE	
PX SEND	QC (ORDER)
PX SEND	QC (RANDOM)
PX SEND	BROADCAST
PX SEND	HASH
PX SEND	HYBRID HASH
PX SEND	RANGE
PX SEND	ROUND-ROBIN

```
select loc.city, dep.department_name
  from ( select location_id, city
           from locations
          where city in ('Whitehorse', 'Toronto')
       ) loc
  full outer join
       ( select department_id, location_id, department_name
           from departments
          where department_id in (20, 230)
       ) dep
       on dep.location_id = loc.location_id;


SQL_ID faskun742dmdj, child number 0
Plan hash value: 2763787302

-----------------------------------------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                           | Name        | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   | A-Rows |   A-Time   | Buffers | Reads  |
-----------------------------------------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |             |      1 |        |       |     4 (100)|          |      3 |00:00:00.01 |       7 |      1 |
|   1 |  VIEW                               | VW_FOJ_0    |      1 |      2 |    68 |     4   (0)| 00:00:01 |      3 |00:00:00.01 |       7 |      1 |
|*  2 |   HASH JOIN FULL OUTER              |             |      1 |      2 |   120 |     4   (0)| 00:00:01 |      3 |00:00:00.01 |       7 |      1 |
|   3 |    VIEW                             |             |      1 |      2 |    60 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       3 |      1 |
|   4 |     INLIST ITERATOR                 |             |      1 |        |       |            |          |      2 |00:00:00.01 |       3 |      1 |
|   5 |      TABLE ACCESS BY INDEX ROWID BATCHED| LOCATIONS   |      2 |      2 |    24 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       3 |      1 |
|*  6 |       INDEX RANGE SCAN              | LOC_CITY_IX |      2 |      2 |       |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       2 |      1 |
|   7 |    VIEW                             |             |      1 |      2 |    60 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      0 |
|   8 |     INLIST ITERATOR                 |             |      1 |        |       |            |          |      2 |00:00:00.01 |       4 |      0 |
|   9 |      TABLE ACCESS BY INDEX ROWID    | DEPARTMENTS |      2 |      2 |    38 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      0 |
|* 10 |       INDEX UNIQUE SCAN             | DEPT_ID_PK  |      2 |      2 |       |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       2 |      0 |
-----------------------------------------------------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SEL$1 / from$_subquery$_005@SEL$4
   2 - SEL$1
   3 - SEL$2 / LOC@SEL$1
   4 - SEL$2
   5 - SEL$2 / LOCATIONS@SEL$2
   6 - SEL$2 / LOCATIONS@SEL$2
   7 - SEL$3 / DEP@SEL$1
   8 - SEL$3
   9 - SEL$3 / DEPARTMENTS@SEL$3
  10 - SEL$3 / DEPARTMENTS@SEL$3

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

   2 - access("DEP"."LOCATION_ID"="LOC"."LOCATION_ID")
   6 - access(("CITY"='Toronto' OR "CITY"='Whitehorse'))
  10 - access(("DEPARTMENT_ID"=20 OR "DEPARTMENT_ID"=230))
```

Part #2: Retrieving and Displaying Plans

Method #1: EXPLAIN PLAN

Syntax:

```
EXPLAIN PLAN [ set statement_id = 'identifier' ] [ INTO [schema.]plan_table_name ]
    FOR sql_statement;
```

Semantics: `sql_statement` is <u>not</u> run; instead, `EXPLAIN PLAN`:

- generates a plan for that statement
- inserts the plan details into SYS.PLAN_TABLE$, aka "PUBLIC".PLAN_TABLE (or into the specified plan table)

```
select * from table(dbms_xplan.display('PLAN_TABLE', 'identifier', 'display_fmt'));
```

Prints a tabular representation of the plan, with details according to `display_fmt`

Method #2: retrieve and display actual plans

- Cursors still available in the cursor cache
  - Retrieve the `sql_id` and `child_number`
  - Print the plan details using:
    ```
    select * from table(dbms_xplan.display_cursor('sql_id', child_number, 'display_fmt'));
    ```
- Special case: latest cursor in *this* session:
  ```
  select * from table(dbms_xplan.display_cursor(null, null, 'display_fmt'));
  ```
- Plans stored in the AWR (*)
  - Retrieve the `sql_id` (and, possibly, the plan `hash_value`)
  - Print the plan details using:
    ```
    select * from table(dbms_xplan.display_awr('sql_id', hash_value, null, 'display_fmt'));
    ```
    db_id; null = current database id

(*) Requires the Advanced Diagnostics Pack license

Plan-related tables & views

- *Predicted plans* from EXPLAIN PLAN: PLAN_TABLE
- *Actual plans* from the cursor cache: V$SQL_PLAN_STATISTICS_ALL
- *Actual plans* from the AWR: DBA_HIST_SQL_PLAN (*)

Requirements

- EXPLAIN PLAN: privileges to run the target statement
  + READ or SELECT on *all* underlying tables (otherwise ORA-01039 is raised)
- Plans from the cursor cache: READ / SELECT grants on the following:
  - V$SQL
  - V$SQL_PLAN_STATISTICS_ALL
  - V$SESSION (columns sql_id, child_number, prev_sql_id, prev_child_number)
  - Plus, possibly: V$ACTIVE_SESSION_HISTORY (*), etc.
- Plans from the AWR(*): READ / SELECT grants on the following:
  - DBA_HIST_SQLTEXT
  - DBA_HIST_SQL_PLAN
  - Plus, possibly: DBA_HIST_SQLSTAT, DBA_HIST_ACTIVE_SESS_HISTORY, DBA_HIST_SNAPSHOT, etc.

EXPLAIN PLAN requires high privileges on the application's data.

Access to actual plans from the cursor cache or the AWR(*) requires DBA-level (viewing) privileges.

(*) Requires the Advanced Diagnostics Pack license

EXPLAIN PLAN vs actual plans—which method should you use?

"EXPLAIN PLAN *lies*": the plan generated by EXPLAIN PLAN can be different from actual plans, due to EXPLAIN PLAN limitations:

- EXPLAIN PLAN does not use *bind peeking*
  Therefore, it always assumes VARCHAR data type, possibly using different type conversions than in reality
  And it cannot use column histograms at all, possibly resulting in a wholly different plan shape

- EXPLAIN PLAN requires privileges to run the target statement, plus READ / SELECT privileges on *all* underlying tables, creating opportunities for view merging that might otherwise not happen

- EXPLAIN PLAN always uses the *latest* published statistics,
  as opposed to statistics *at the time* when the actual cursor was created

- *Et caetera*… (adaptive plans?)

Bottom line: you mostly want to use *actual* plans, especially in SQL tuning activities.

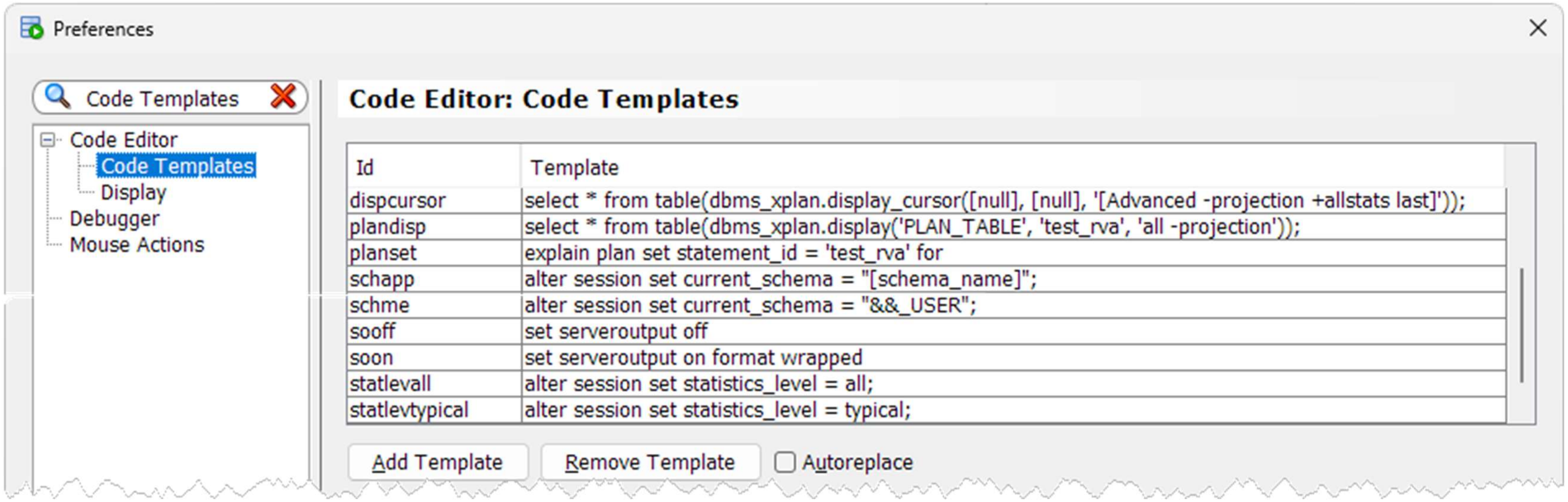
EXPLAIN PLAN still has its uses:

- For quick checking—or demonstration purposes—without actually running a statement
- As a workaround for `dbms_xplan.display_cursor` not being able to correctly render complex predicates—yielding meaningless expressions such as `filter( IS NULL)`

But you should be aware of the limitations.

Remark: the TKPROF utility uses EXPLAIN PLAN in the Execution Plan section, possibly resulting in a mismatch with the Row Source Operation section, which uses actual plan execution statistics from the trace file.

SQL Dev. tip: use code templates to save typing



(Stored in: %APPDATA%\SQL Developer\CodeTemplate.xml)

Choose Ids which are:

i. easy to remind & type

And:

ii. which work well with auto-completion (so you just type a prefix, then Alt + Space)

Id	Template
schapp	alter session set current_schema = "[schema_name]";
schme	alter session set current_schema = "&&_USER";
sooff	set serveroutput off
soon	set serveroutput on format wrapped
statlevall	alter session set statistics_level = all;
statlevtypical	alter session set statistics_level = typical;
planset	explain plan set statement_id = 'test_rva' for
plandisp	select * from table(dbms_xplan.display('PLAN_TABLE', 'test_rva', 'all -projection'));
dispcursor	select * from table(dbms_xplan.display_cursor([null], [null], '[Advanced -projection -qbregistry +allstats last]'));

DB ≥ 19c

Demo: EXPLAIN PLAN

```
set pagesize 50000

variable JOB_ID varchar2(10)
exec :JOB_ID := 'SA_REP';

variable
print JOB_ID
```

Defining bind variables is unnecessary for EXPLAIN PLAN: it will *always* ignore the values and assume varchar2 bind type

```
explain plan set statement_id = 'test #1' for
select count(*)
  from hr.employees emp
 where emp.job_id = :JOB_ID
   and emp.hire_date > date '2010-01-01';
```

Include most useful information, without column projections

```
select * from table(dbms_xplan.display('PLAN_TABLE', 'test #1', 'All -projection'));
```

Estimated by the SQL Optimizer

```
 Plan hash value: 2830499944

 ---------------------------------------------------------------------------------------------
 | Id  | Operation                    | Name        | Rows  | Bytes | Cost (%CPU)| Time     |
 ---------------------------------------------------------------------------------------------
 |   0 | SELECT STATEMENT             |             |     1 |    17 |     2   (0)| 00:00:01 |
 |   1 |  SORT AGGREGATE              |             |     1 |    17 |            |          |
 |*  2 |   TABLE ACCESS BY INDEX ROWID| EMPLOYEES   |     6 |   102 |     2   (0)| 00:00:01 |
 |*  3 |    INDEX RANGE SCAN          | EMP_JOB_IX  |     6 |       |     1   (0)| 00:00:01 |
 ---------------------------------------------------------------------------------------------

 Query Block Name / Object Alias (identified by operation id):
 -------------------------------------------------------------

    1 - SEL$1
    2 - SEL$1 / EMP@SEL$1
    3 - SEL$1 / EMP@SEL$1

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

    2 - filter("EMP"."HIRE_DATE">TO_DATE(' 2010-01-01 00:00:00',
               'syyyy-mm-dd hh24:mi:ss'))
    3 - access("EMP"."JOB_ID"=:JOB_ID)
```

Note: there *is* a pending transaction in the session at this stage, because EXPLAIN PLAN has inserted rows into the PLAN_TABLE.

Demo: dbms_xplan.display_cursor

```
set pagesize 50000
alter session set statistics_level = all;
set serveroutput off

variable JOB_ID varchar2(10)
exec :JOB_ID := 'SA_REP';

set feedback only

select count(*)
  from hr.employees emp
 where emp.job_id = :JOB_ID
   and emp.hire_date > date '2010-01-01';
```

Statistics level must be "all", in order to collect *actual* plan statistics
(Note: inherent overhead due to per-row source counting & timing)

Prevents SQL Dev from reading the dbms_output buffer after each statement
(thereby ruining prev_sql_id, prev_child_number in v$session)

Turns off the display of query result data
(useful if testing large SELECTs)

Use prev_sql_id, prev_child_number from v$session

Include *actual* plan statistics (*if available*) in the readout

```
select * from table(dbms_xplan.display_cursor(null, null, 'All -projection +peeked_binds +allstats last'));
```

Actual (A) — Estimated (E) — Actual (A)

```
SQL_ID  b0x08w3bzxjdv, child number 0
-------------------------------------
Plan hash value: 1756381138

--------------------------------------------------------------------------------------------------------------
| Id  | Operation           | Name      | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   | A-Rows |   A-Time   | Buffers |
--------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT    |           |      1 |        |       |     3 (100)|          |      1 |00:00:00.01 |       6 |
|   1 |  SORT AGGREGATE     |           |      1 |      1 |    17 |            |          |      1 |00:00:00.01 |       6 |
|*  2 |   TABLE ACCESS FULL| EMPLOYEES |      1 |     30 |   510 |     3   (0)| 00:00:01 |     30 |00:00:00.01 |       6 |
--------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SEL$1
   2 - SEL$1 / EMP@SEL$1

Peeked Binds (identified by position):
--------------------------------------

   1 - :1 (VARCHAR2(30), CSID=873): 'SA_REP'

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

   2 - filter(("EMP"."JOB_ID"=:JOB_ID AND "EMP"."HIRE_DATE"
              >TO_DATE(' 2010-01-01 00:00:00', 'syyyy-mm-dd hh24:mi:ss')))
```

<u>Important</u>: always pay attention to the "Notes" section, if there is one.

```
SQL_ID dcnc91w8z6s9d, child number 0
Plan hash value: 2945430922

-----------------------------------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                             | Name           | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   | A-Rows |   A-Time   | Buffers | Reads  |
-----------------------------------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                      |                |      1 |        |       |     9 (100)|          |      2 |00:00:00.01 |      20 |      2 |
|   1 |  NESTED LOOPS                         |                |      1 |      1 |    48 |     6   (0)| 00:00:01 |      2 |00:00:00.01 |      20 |      2 |
|   2 |   NESTED LOOPS                        |                |      1 |      2 |    48 |     6   (0)| 00:00:01 |      2 |00:00:00.01 |      18 |      2 |
|   3 |    NESTED LOOPS                       |                |      1 |      2 |    74 |     4   (0)| 00:00:01 |      2 |00:00:00.01 |       8 |      2 |
|   4 |     TABLE ACCESS BY INDEX ROWID BATCHED | EMPLOYEES    |      1 |      2 |    44 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      1 |
|*  5 |      INDEX SKIP SCAN                  | EMP_NAME_IX    |      1 |      2 |       |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       2 |      1 |
|   6 |     TABLE ACCESS BY INDEX ROWID       | EMPLOYEES      |      2 |      1 |    15 |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      1 |
|*  7 |      INDEX UNIQUE SCAN                | EMP_EMP_ID_PK  |      2 |      1 |       |     0   (0)|          |      2 |00:00:00.01 |       2 |      1 |
|*  8 |    INDEX UNIQUE SCAN                  | EMP_EMP_ID_PK  |      2 |      1 |       |     0   (0)|          |      2 |00:00:00.01 |      10 |      0 |
|   9 |     NESTED LOOPS SEMI                 |                |      2 |      1 |    23 |     3   (0)| 00:00:01 |      2 |00:00:00.01 |       8 |      0 |
|* 10 |      TABLE ACCESS BY INDEX ROWID BATCHED| EMPLOYEES    |      2 |      1 |    15 |     2   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      0 |
|* 11 |       INDEX SKIP SCAN                 | EMP_NAME_IX    |      2 |      1 |       |     1   (0)| 00:00:01 |      3 |00:00:00.01 |       2 |      0 |
|* 12 |      TABLE ACCESS BY INDEX ROWID      | EMPLOYEES      |      2 |      6 |    48 |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       4 |      0 |
|* 13 |       INDEX UNIQUE SCAN               | EMP_EMP_ID_PK  |      2 |      1 |       |     0   (0)|          |      2 |00:00:00.01 |       2 |      0 |
|  14 |   TABLE ACCESS BY INDEX ROWID         | EMPLOYEES      |      2 |      1 |    11 |     1   (0)| 00:00:01 |      2 |00:00:00.01 |       2 |      0 |
-----------------------------------------------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SEL$1
   4 - SEL$1        / JAM1@SEL$1
   5 - SEL$1        / JAM1@SEL$1
   6 - SEL$1        / MGR1@SEL$1
   7 - SEL$1        / MGR1@SEL$1
   8 - SEL$1        / MGR2@SEL$1
   9 - SEL$BE5C8E5F
  10 - SEL$BE5C8E5F / JAM2@SEL$2
  11 - SEL$BE5C8E5F / JAM2@SEL$2
  12 - SEL$BE5C8E5F / MID@SEL$3
  13 - SEL$BE5C8E5F / MID@SEL$3
  14 - SEL$1        / MGR2@SEL$1

Peeked Binds (identified by position):
--------------------------------------

   1 - (VARCHAR2(30), CSID=873): 'Julia'

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

   5 - access("JAM1"."FIRST_NAME"=:EMP_FIRST_NAME)
       filter("JAM1"."FIRST_NAME"=:EMP_FIRST_NAME)
   7 - access("MGR1"."EMPLOYEE_ID"="JAM1"."MANAGER_ID")
   8 - access("MGR2"."EMPLOYEE_ID"="MGR1"."MANAGER_ID")
       filter( IS NOT NULL)
  10 - filter("JAM2"."EMPLOYEE_ID"<>:B1)
  11 - access("JAM2"."FIRST_NAME"=:B1)
       filter("JAM2"."FIRST_NAME"=:B1)
  12 - filter("MID"."MANAGER_ID"=:B1)
  13 - access("JAM2"."MANAGER_ID"="MID"."EMPLOYEE_ID")
```

Part #3: Understanding SQL Plans

Christian Antognini's classification of plan operations

In Troubleshooting Oracle Performance(*), Antognini defined 4 Categories of Plan operations.

Category of plan operations	Definition	Examples
Stand-alone	Single child operations, which start their child operation only once. Many operations belong in that category.	VIEW COUNT STOPKEY SORT UNIQUE/ORDER BY/GROUP BY HASH UNIQUE/GROUP BY … Single-child FILTER
Iterative	Single child operations, which may start their child operation repeatedly (or not at all)	INLIST ITERATOR PARTITION LIST/RANGE/HASH ITERATOR
Unrelated-combine	Operations with 2 (or more) child operations, which run their child operations only once, in turn, independantly of one another	HASH JOIN MERGE JOIN UNION ALL
Related-combine	Operations with 2 (or more) child operations, in which processing is driven by rows from one of the children, and the other child operations are called repeatedly, using the current row of the driving child as input	NESTED LOOPS FILTER with multiple children CONNECT BY WITH FILTERING UNION ALL (RECURSIVE WITH)

This is a model—there are exceptions, and special cases—but a most helpful one.

(*) Troubleshooting Oracle Performance, 2nd Edition [*link*]
Christian Antognini, Apress, 2014
ISBN-13 (softcover): 978-1-4302-5758-5 / ISBN-13 (electronic): 978-1-4302-5759-2

HASH JOIN pseudo-code *(high-level, simplified perspective)*

```
HASH JOIN
  CHILD_ROW_SOURCE_1  ← driving/build row source, or "left" input    alias: r1   columns: (c1, c2, … , cn)
  CHILD_ROW_SOURCE_2  ← probe row source, or "right" input           alias: r2   columns: (c1, c2, … , cm)
```

with join conditions as follows:

$$\left.\begin{array}{ll} & r_1.c_{h_1} = r_2.c_{j_1} \\ \text{and} & r_1.c_{h_2} = r_2.c_{j_2} \\ \dots & \\ \text{and} & r_1.c_{h_k} = r_2.c_{j_k} \end{array}\right\} \textit{equality conditions}$$

$$\left.\begin{array}{ll} \text{and} & \textit{expression}(\, r_1.c_{h_{k+1}}, \dots ,\ r_1.c_{h_p} \\ & \quad ,\ r_2.c_{j_{k+1}}, \dots ,\ r_2.c_{j_q}\ ) \end{array}\right\} \textit{non-equality conditions}$$

```
Start CHILD_ROW_SOURCE_1
For each row r1 = (c1, c2, … , cn) from CHILD_ROW_SOURCE_1 Loop  -- build loop
    insert r1 into the hash table using (r1.ch1, … , r1.chk) as the hash key
End loop  -- CHILD_ROW_SOURCE_1 has been fully processed
If CHILD_ROW_SOURCE_1 returned at least 1 row Then
    Start CHILD_ROW_SOURCE_2
    For each row r2 = (c1, c2, … , cm) from CHILD_ROW_SOURCE_2 Loop  -- probe loop
        For each row r1 matching (r2.cj1, … , r2.cjk) in the hash table /* access conditions */ Loop
            /* evaluate non-equality conditions: filter conditions */
            If expression(r1.chk+1, … , r1.chp, r2.cjk+1, … , r2.cjq ) is true Then
                Yield the combined row rj = (r1.c1, … , r1.cn, r2.c1, … , r2.cm) to the parent operation (*)
            End If
        End Loop
    End Loop
End If
```

(*) Actually, only projected columns are passed to the parent operation

Key points:

- CHILD_ROW_SOURCE_1 and _2 are started only once (per start of the parent), and processed independently, in turn
- The hash table (in workarea) is built from CHILD_ROW_SOURCE_1: rows from CHILD_ROW_SOURCE_2 are not buffered (*iff* the hash join can be processed fully in memory)
- The hash key is formed of equi-joined columns; non-equality join conditions are always used as *filter* conditions, and evaluated by *iterating* on rows matching the probe key in the hash table—if there are too many such rows, a lot of CPU time could go into that
- The optimizer may swap join inputs, depending on (estimated) memory requirements of using either as the build row source

NESTED LOOPS pseudo-code *(high-level, simplified perspective)*

```
NESTED LOOPS
 CHILD_ROW_SOURCE_1  ← driving row source (or "outer" row source)   alias: r1  columns: (c1, c2, … , cn)
 CHILD_ROW_SOURCE_2  ← inner row source (or "probe" row source)     alias: r2  columns: (c1, c2, … , cm)
```

with join conditions defined on columns $(c_{h_1}, c_{h_2}, \dots, c_{h_p})$ of r_1, and $(c_{j_1}, c_{j_2}, \dots, c_{j_q})$ of r_2

```
Start CHILD_ROW_SOURCE_1
For each row r1 = (c1, c2, … , cn) from CHILD_ROW_SOURCE_1 Loop -- outer loop
    Start CHILD_ROW_SOURCE_2, given (r1.ch1, r1.ch2, … , r1.chp)
    /*
      CHILD_ROW_SOURCE_2 uses the values of columns from the
      current row r1 in join access/filter conditions in order
      to find all rows r2 joining with r1
     */
    For each row r2 = (c1, c2, … , cm) from CHILD_ROW_SOURCE_2 Loop -- inner loop
       /*
        Rows from CHILD_ROW_SOURCE_2 are joined to the
        current row from CHILD_ROW_SOURCE_1
        */
       Yield the combined row rj = (r1.c1, … , r1.cn, r2.c1, … , r2.cm) to the parent operation (*)
    End Loop
End loop
```

(*) Actually, only projected columns are passed to the parent operation

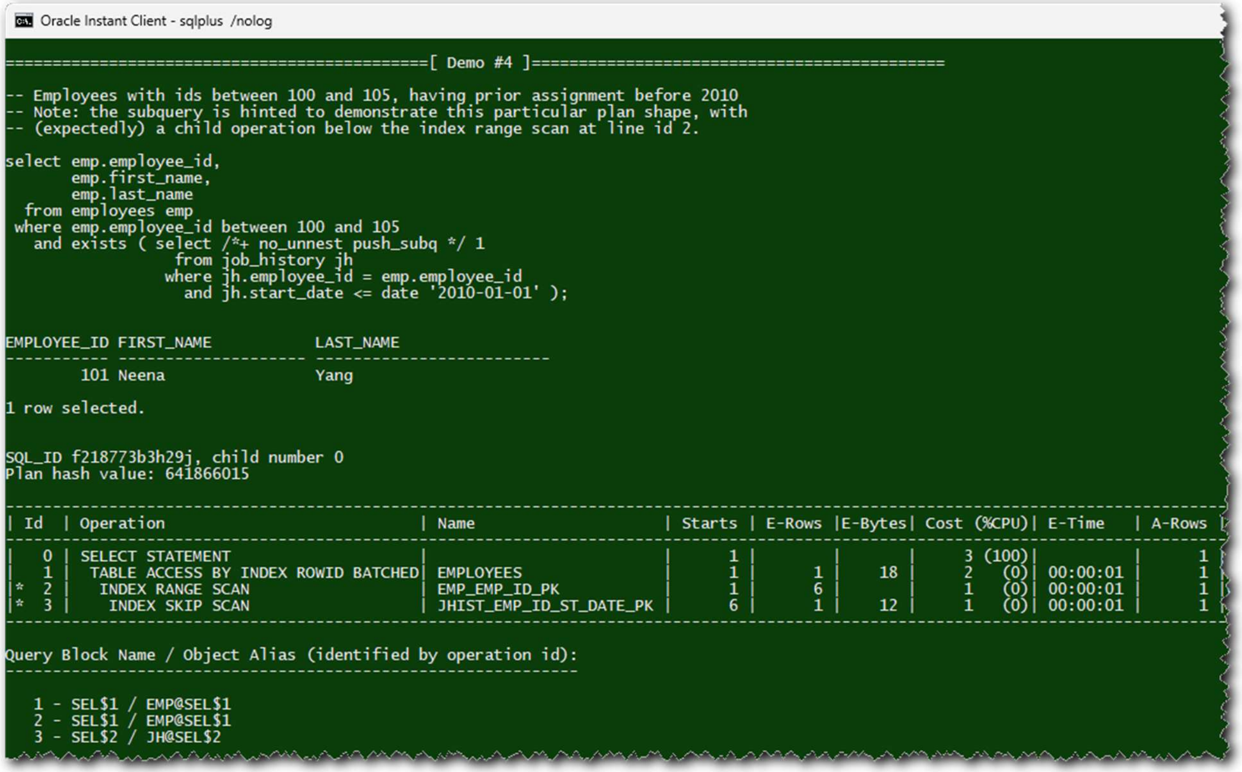
Key points:

- CHILD_ROW_SOURCE_1 is started once per start of its parent
- CHILD_ROW_SOURCE_2 is started as many times as CHILD_ROW_SOURCE_1 supplies a row to be joined with
- CHILD_ROW_SOURCE_2 uses join columns from the "outer row" as input
- Join access/filter conditions are processed by CHILD_ROW_SOURCE_2

```
merge into
      ( select emp.employee_id, emp.job_id, emp.salary
          from employees emp
      ) tgt
using ( select sal.employee_id, sal.salary_incr_pct
          from &_USER..salary_raises sal
      ) src
   on ( tgt.employee_id = src.employee_id )
 when matched then update
          set tgt.salary = tgt.salary * (1 + src.salary_incr_pct / 100)
        where ( select job.max_salary from jobs job
                 where job.job_id = tgt.job_id ) >=
                        tgt.salary * (1 + src.salary_incr_pct / 100);

1 row merged.


SQL_ID 44srjbwp278ra, child number 0
Plan hash value: 3955867600

-----------------------------------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                      | Name          | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   |IN-OUT| A-Rows |   A-Time    | Buffers |
-----------------------------------------------------------------------------------------------------------------------------------------------------
|   0 | MERGE STATEMENT                |               |      1 |        |       |     5 (100)|          |      |      0 |00:00:00.01 |      12 |
|   1 |  MERGE                         | EMPLOYEES     |      1 |        |       |            |          |      |      0 |00:00:00.01 |      12 |
|   2 |   VIEW                         |               |      1 |        |       |            |          |      |      3 |00:00:00.01 |       7 |
|   3 |    NESTED LOOPS                |               |      1 |      3 |   111 |     5   (0)| 00:00:01 |      |      3 |00:00:00.01 |       7 |
|   4 |     NESTED LOOPS               |               |      1 |      3 |   111 |     5   (0)| 00:00:01 |      |      3 |00:00:00.01 |       4 |
|   5 |      TABLE ACCESS FULL         | SALARY_RAISES |      1 |      3 |    24 |     2   (0)| 00:00:01 |      |      3 |00:00:00.01 |       2 |
|*  6 |      INDEX UNIQUE SCAN         | EMP_EMP_ID_PK |      3 |      1 |       |     0   (0)|          |      |      3 |00:00:00.01 |       2 |
|   7 |     TABLE ACCESS BY INDEX ROWID| EMPLOYEES     |      3 |      1 |    29 |     1   (0)| 00:00:01 |      |      3 |00:00:00.01 |       3 |
|   8 |   TABLE ACCESS BY INDEX ROWID  | JOBS          |      2 |      1 |    12 |     1   (0)| 00:00:01 | PCWP |      2 |00:00:00.01 |       4 |
|*  9 |    INDEX UNIQUE SCAN           | JOB_ID_PK     |      2 |      1 |       |     0   (0)|          | PCWP |      2 |00:00:00.01 |       2 |
-----------------------------------------------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SEL$76AA3327
   3 - SEL$8984BF49
   5 - SEL$8984BF49 / SAL@SEL$4
   6 - SEL$8984BF49 / EMP@SEL$3
   7 - SEL$8984BF49 / EMP@SEL$3
   8 - SEL$6        / JOB@SEL$6
   9 - SEL$6        / JOB@SEL$6

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

   6 - access("EMP"."EMPLOYEE_ID"="SAL"."EMPLOYEE_ID")
   9 - access("JOB"."JOB_ID"=:B1)
```

Part #4: Demos

Demo SQL scripts


Oracle Instant Client - sqlplus /nolog

```
============================================[ Demo #4 ]============================================

-- Employees with ids between 100 and 105, having prior assignment before 2010
-- Note: the subquery is hinted to demonstrate this particular plan shape, with
-- (expectedly) a child operation below the index range scan at line id 2.

select emp.employee_id,
       emp.first_name,
       emp.last_name
  from employees emp
 where emp.employee_id between 100 and 105
   and exists ( select /*+ no_unnest push_subq */ 1
                  from job_history jh
                 where jh.employee_id = emp.employee_id
                   and jh.start_date <= date '2010-01-01' );


EMPLOYEE_ID FIRST_NAME           LAST_NAME
----------- -------------------- -------------------------
        101 Neena                Yang

1 row selected.


SQL_ID f218773b3h29j, child number 0
Plan hash value: 641866015

------------------------------------------------------------------------------------------------------------------------
| Id  | Operation                            | Name                     | Starts | E-Rows |E-Bytes| Cost (%CPU)| E-Time   | A-Rows |
------------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                     |                          |      1 |        |       |     3 (100)|          |      1 |
|   1 |  TABLE ACCESS BY INDEX ROWID BATCHED| EMPLOYEES                |      1 |      1 |    18 |     2   (0)| 00:00:01 |      1 |
|*  2 |   INDEX RANGE SCAN                   | EMP_EMP_ID_PK            |      1 |      6 |       |     1   (0)| 00:00:01 |      1 |
|*  3 |    INDEX SKIP SCAN                   | JHIST_EMP_ID_ST_DATE_PK |      6 |      1 |    12 |     1   (0)| 00:00:01 |      1 |
------------------------------------------------------------------------------------------------------------------------

Query Block Name / Object Alias (identified by operation id):
-------------------------------------------------------------

   1 - SEL$1 / EMP@SEL$1
   2 - SEL$1 / EMP@SEL$1
   3 - SEL$2 / JH@SEL$2
```

Source code : link

Requirements

- HR schema, from the Oracle Database Sample Schemas 23c [download link; installation instructions]
- A user with DML rights on HR's tables, plus READ/SELECT on a few v$ views

Principles

The demo consists in 4 SQL*Plus scripts intended for a live demo:

- A simple query is run
- The corresponding plan (from the cursor cache) is shown, possibly with a comment or two
- The script pauses before continuing with the next example
- Repeat…

See the README [link] for details.