# Session 521

# A Look under the Hood of CBO

# The 10053 Event

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# Which Plan is better?

a)

```
   cost     card operation
------- -------- ------------------------------------------------------------
  2,979      446 SELECT STATEMENT
  2,979      446   SORT ORDER BY
                     FILTER
  2,955      446       HASH JOIN
     10   13,679         TABLE ACCESS FULL E
  2,901   49,755         HASH JOIN
    737    8,629           HASH JOIN
      5       45             HASH JOIN
      3        6               TABLE ACCESS FULL A
      1       15               TABLE ACCESS FULL D
    731  316,380             TABLE ACCESS FULL B
  1,953  239,142           TABLE ACCESS FULL C
```

b)

```
   cost     card operation
------- -------- ------------------------------------------------------------
    792        1 SELECT STATEMENT
    792        1   SORT ORDER BY
                     FILTER
    790        1       HASH JOIN
    760       83         HASH JOIN
    758       11           NESTED LOOPS
    749        1             HASH JOIN
      3        6               TABLE ACCESS FULL A
    731   28,762               TABLE ACCESS FULL B
      9  239,142             TABLE ACCESS BY INDEX ROWID C
      4  239,142               INDEX RANGE SCAN C_IX0
      1       15           TABLE ACCESS FULL D
     10   13,679         TABLE ACCESS FULL E
```

# Agenda

- Overview
- Trace contents
- Table, Index and Column Statistics
- Cost Calculations
  - Single Table Access Costs
  - Join Costs

# Event 10053

Event 10053 details the choices made by the CBO in evaluating the execution path for a query

Event 10053 externalizes the information that the optimizer uses in generating a plan for a query

# Setting Event 10053

for your own session

on:

```
alter session set events
 '10053 trace name context forever[, level {1|2}]'
```

off:

```
alter session set events
 '10053 trace name context off'
```

# Setting Event 10053

for another session

on:

```
sys.dbms_system.set_ev
    (<sid>, <serial#>, 10053, {1|2}, '')
```

off:

```
sys.dbms_system.set_ev
    (<sid>, <serial#>, 10053, 0, '')
```

# Trace Generation

When the statement is parsed by the CBO

❶ the statement is parsed

and

❷ the statement is parsed by the CBO

# Quiz

- Q When is a statement parsed by the rule based optimizer rather than the cost based optimizer?
- Q When is a statement parsed by the cost based optimizer rather than the rule based optimizer?
- Q How do you guarantee that a SQL statement gets parsed in order to generate a 10053 trace but avoid that it actually gets executed?

# Trace Contents

- Query
- Parameters used by the optimizer
- Base Statistical Information
- Base Table Access Cost
- Join Order and Method Computations
- Recosting for special features

# Parameters used by the Optimizer

DB_FILE_MULTIBLOCK_READ_COUNT

HASH_AREA_SIZE

HASH_MULTIBLOCK_IO_COUNT

OPTIMIZER_FEATURES_ENABLE

OPTIMIZER_INDEX_CACHING

OPTIMIZER_INDEX_COST_ADJ

OPTIMIZER_PERCENT_PARALLEL

SORT_AREA_SIZE

# Table Statistics

Table stats  Table: EMP  Alias: EMP
TOTAL ::  CDN: 855  NBLKS:  12  SCAN_CST:
1  AVG_ROW_LEN:  40

# Index Statistics

INDEX#: 34612 COL#: 2
TOTAL :: LVLS: 1 #LB: 305 #DK: 16528
LB/K: 1 DB/K: 3 CLUF: 62374

INDEX#: 15865 COL#: 25 3 2
TOTAL :: LVLS: 2 #LB: 543 #DK: 56995
LB/K: 1 DB/K: 1 CLUF: 97075

# Base Access Plans

2 Table Scan

3 Index Unique

4 Index Range

5 Index And-Equal

23 index fast full scan

# Single Table Access Path

Column: ENAME Col#: 2 Table: EMP Alias: EMP
NDV: 14 NULLS: 0 DENS: 1.6667e-001

TABLE: EMP ORIG CDN: 855
CMPTD CDN: 143

BEST_CST: 1.00 PATH: 2 Degree: 1

**142.5 = 855 * 1.6667e$^{-001}$**

**CMPTD CDN = ORIG CDN * FF**

# Table Scan Cost

Table stats  Table: [redacted] Alias: D
TOTAL :: CDN: 115630  NBLKS: 4339
SCAN_CST: 265

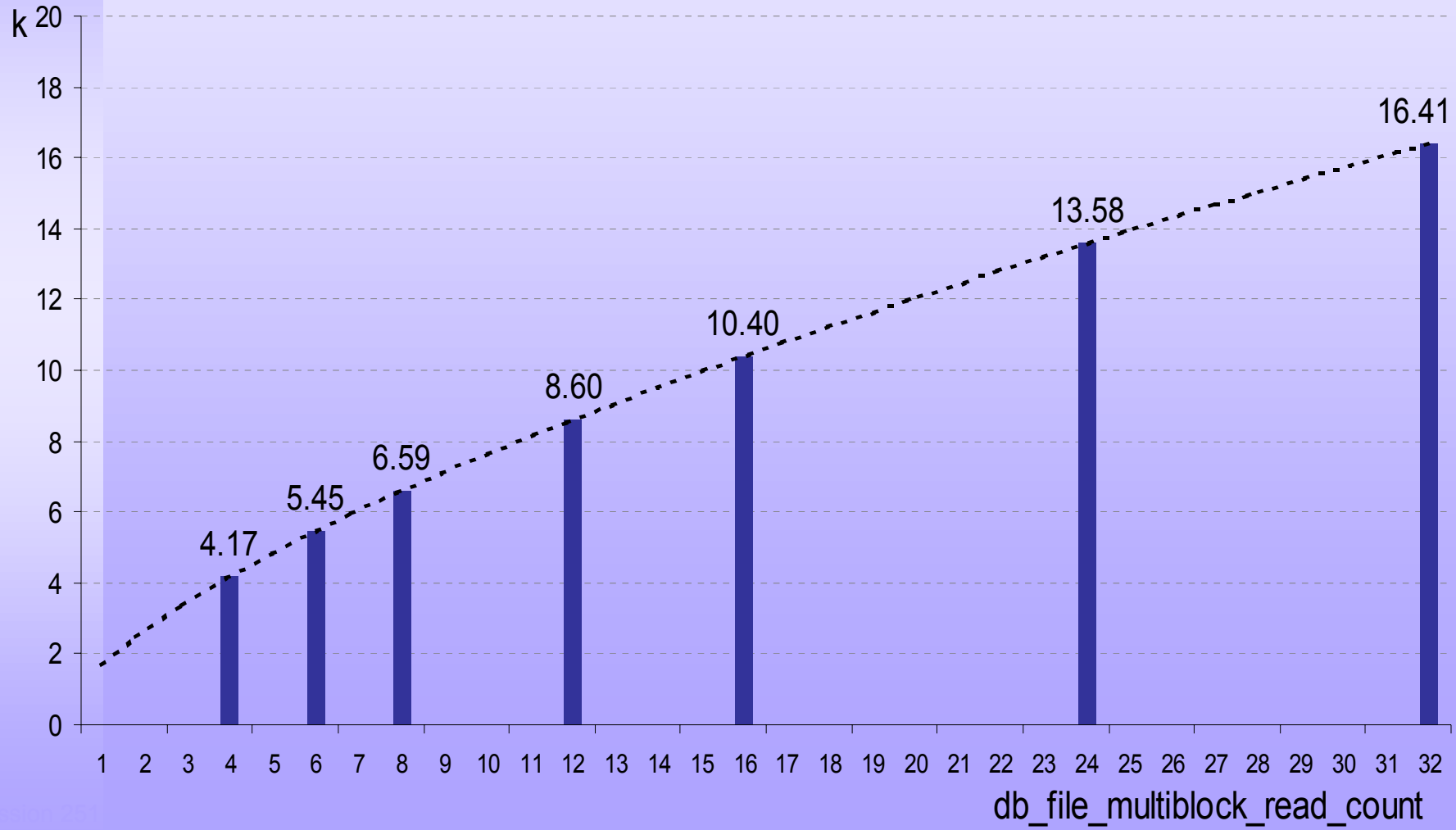
4339 / 265 = 16.373

Table stats  Table: [redacted] Alias: A
TOTAL :: CDN: 454503  NBLKS: 8975
SCAN_CST: 548

8975 / 548 = 16.377

**SCAN_CST = NBLKS / k**

# Table Scan Cost and multi_block_read_count



# Predicates and Filter Factors
## without Bind Variables

| Predicate | filter factor |
| --- | --- |
| c1 = value | c1.density |
| c1 like value | c1.density |
| c1 > value | (Hi - value) / (Hi - Lo) |
| c1 < value | (value - Lo) / (Hi - Lo) |
| c1 between | (val2 – val1) / (Hi - Lo)<br>+ 2 * c1.density |

# Predicates and Filter Factors
## with Bind Variables

| Predicate | filter factor |
| --- | --- |
| c1 = :b1 | c1.density |
| c1 like :b1 | { $5.0e^{-02}$ \| c1.density } |
| c1 { > \| >= \| < \| <= } :b1 | $5.0e^{-02}$ |
| c1 between :b1 and :b2 | $2.5e^{-03}$ ($5.0e^{-02} * 5.0e^{-02}$) |

# Predicates and Filter Factors
## Combining Predicates

| Predicate | filter factor |
| --- | --- |
| P1 AND P2 | FF1 * FF2 |
| P1 OR P2 | FF1 + FF2 - FF1 * FF2 |

# Column Statistics and Histograms

- Value Based Histogram

  # buckets = NDV

- Height Based Histogram

  # buckets < NDV

# Index Access Costs

| | |
|---|---|
| Unique scan | blevel + 1 |
| Fast full scan | leaf_blocks / k |
| Index-only | blevel + FF*leaf_blocks |
| Range scan | blevel + FF*leaf_blocks + FF*clustering_factor |

# Index Access Costs

| INDEX# | Col# | LVLS | #LB | #DK | CLUF |
|---|---|---|---|---|---|
| 8417 | 27, 1 | 1 | 13100 | 66500 | 1469200 |
| 8418 | 1, 12, 7 | 2 | 19000 | 74700 | 1176500 |
| 8419 | 3, 1, 4, 2 | 2 | 31000 | 49700 | 118000 |
| 15755 | 1, 12, 8 | 1 | 12600 | 18800 | 1890275 |

| | | |
|---|---|---|
| Col#: 1 | NDV: 10 | DENS: 1.0000e-001 |
| Col#: 12 | NDV: 8 | DENS: 1.2500e-001 |
| Col#: 8 | NDV: 33 | DENS: 3.0303e-001 |

$$\begin{array}{rr} & 2 \quad\quad 2 \\ + 19000 * 1.0000e^{-1} * 1.2500e^{-1} & 237.5 \\ + 1176500 * 1.0000e^{-1} * 1.2500e^{-1} & \underline{14706.25} \\ & 14945.75 \end{array}$$

Access path: index (scan) INDEX#: 8418 CST: 14947

# Index Access Costs

| INDEX# | Col# | LVLS | #LB | #DK | CLUF |
|---|---|---|---|---|---|
| 8417 | 27, 1 | 1 | 13100 | 66500 | 1469200 |
| 8418 | 1, 12, 7 | 2 | 19000 | 74700 | 1176500 |
| 8419 | 3, 1, 4, 2 | 2 | 31000 | 49700 | 118000 |
| 15755 | 1, 12, 8 | 1 | 12600 | 18800 | 1890275 |

| | | |
|---|---|---|
| Col#: 1 | NDV: 10 | DENS: 1.0000e-001 |
| Col#: 12 | NDV: 8 | DENS: 1.2500e-001 |
| Col#: 8 | NDV: 33 | DENS: 3.0303e-001 |

$$\begin{aligned} & & 1 & & 1 \\ & + 12600 * 1.0000e^{-1} * 1.2500e^{-1} * 3.0303e^{-1} & & & 47.73 \\ & + 1890275 * 1.0000e^{-1} * 1.2500e^{-1} * 3.0303e^{-1} & & & 7160.13 \\ & & & & 7208.86 \end{aligned}$$

Access path: index (equal) INDEX#: 15755 CST: 7209

# Default Index Statistics

INDEX#: 23574  COL#: 1
  TOTAL ::  LVLS: 1   #LB: 25  #DK: 100  LB/K: 1  DB/K: 1
  CLUF: 800

INDEX#: 23575  COL#: 2
  TOTAL ::  LVLS: 1   #LB: 25  #DK: 100  LB/K: 1  DB/K: 1
  CLUF: 800

INDEX#: 23576  COL#: 8
  TOTAL ::  LVLS: 1   #LB: 25  #DK: 100  LB/K: 1  DB/K: 1
  CLUF: 800

# Default Table Statistics

Table stats  Table: EMP  Alias: EMP

TOTAL :: (NOT ANALYZED) CDN: 2240 NBLKS: 55
SCAN_CST: 4 AVG_ROW_LEN: 100

Table stats  Table: EMP  Alias: EMP

TOTAL :: CDN: 4457 NBLKS: 55
SCAN_CST: 4 AVG_ROW_LEN: 36

CDN = NBLKS * (db_block_size – 24) / 100

# Default Column Statistics

Column: ENAME Col#: 2 Table: EMP Alias: E
NO STATISTICS (using defaults)
NDV: 70 NULLS: 0 DENS: 1.4286e-002

Column: HIREDATE Col#: 5 Table: EMP Alias: E
NO STATISTICS (using defaults)
NDV: 70 NULLS: 0 DENS: 1.4286e-002

DENS = NBLKS * m

# Join Costs

1. **NL Join**

   join cost = cost of accessing outer table
   + (cardinality of outer table * cost of accessing inner table )

2. **SM Join**

   join cost = (cost of accessing outer table + outer sort cost)
   + (cost of accessing inner table + inner sort cost)

3. **HA Join**

   join cost = (cost of accessing outer table)
   + (cost of building hash table)
   + (cost of accessing inner table )

# NL Join

join cost = cost of outer table access

+ (cardinality of outer table * cost of inner table access )

Outer table: cost: 1 cdn: 4 rcz: 11 resp: 1

Inner table: EMP

Access path: tsc Resc: 4

Join resc: 17 Resp: 17 *[ 17 = 1 + 4 * 4 ]*

# Join Cardinality

Join cardinality:  36 = outer (4) * inner (107) *
sel (8.3333e-002)  [flag=0]

join selectivity = min(t1.col1.density, t2.col2.density)
* (t1.cdn – t1.col1.#nulls)/t1.cdn
* (t2.cdn – t2.col2.#nulls)/t2.cdn

# SM Join

join cost = (cost of accessing outer table + outer sort cost)
+ (cost of accessing inner table + inner sort cost)

Outer table:

resc: 1 cdn: 4 rcz: 11 deg: 1 resp: 1

Inner table: EMP

resc: 4 cdn: 107 rcz: 13 deg: 1 resp: 4

# SM Join

SORT resource Sort statistics
Sort width: 3 Area size: 43008 Degree: 1
Blocks to Sort: 1 Row size: 23 Rows: 4
Initial runs: 1 Merge passes: 1 Cost / pass: 2
Total sort cost: 2

SORT resource Sort statistics
Sort width: 3 Area size: 43008 Degree: 1
Blocks to Sort: 1 Row size: 25 Rows: 107
Initial runs: 1 Merge passes: 1 Cost / pass: 2
Total sort cost: 2

Merge join Cost: 8 Resp: 8 *[(1 + 2) + (4 + 2)]*

# HA Join

join cost = (cost of outer table access)
+ (cost of building hash table) + (cost of inner table access)

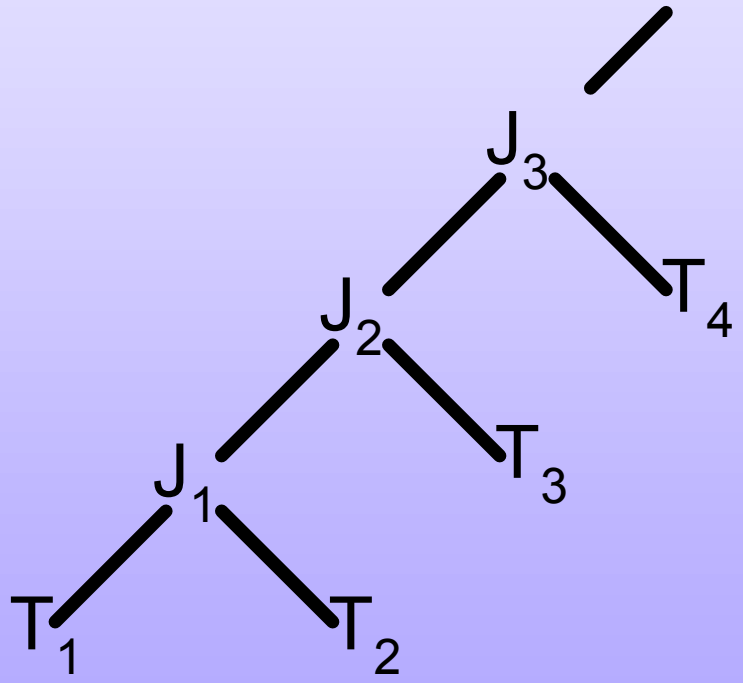
Outer table: resc: 1 cdn: 4 rcz: 11 deg: 1 resp: 1

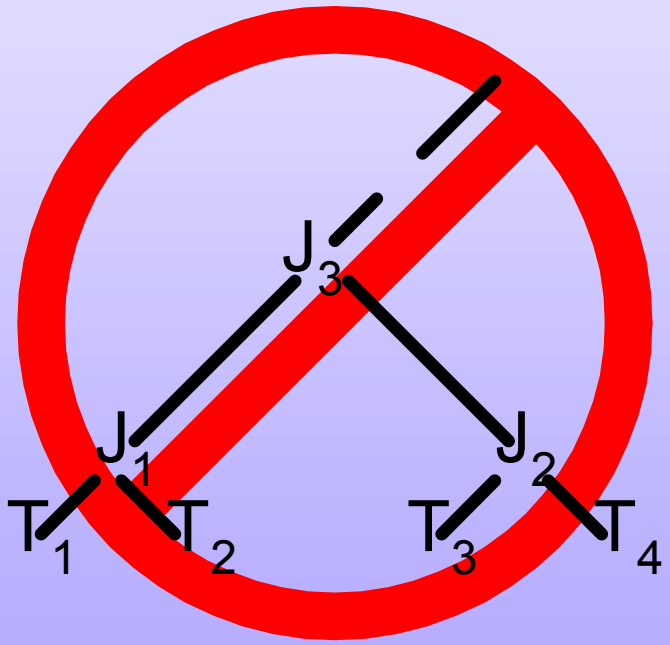
Inner table: EMP
resc: 4 cdn: 107 rcz: 13 deg: 1 resp: 4

Hash join one ptn: 1 Deg: 1
hash_area: 32 buildfrag: 33 probefrag: 1 ppasses: 2

Hash join Resc: 6 Resp: 6 *[1 + 4 + 1]*

# Multi-table Joins



# Multi-table Joins

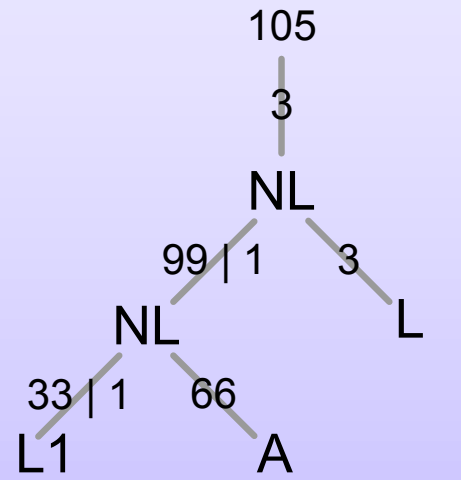
SINGLE TABLE ACCESS PATH

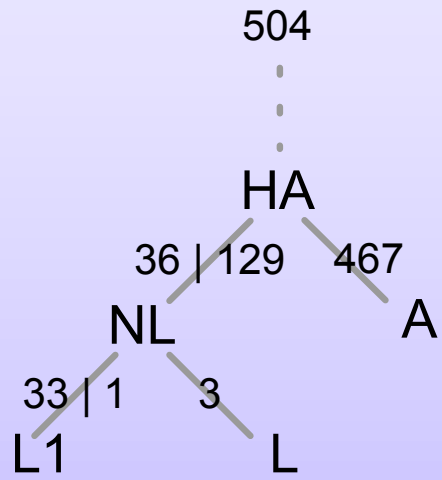
TABLE: [redacted] ORIG CDN: 683620 CMPTD CDN: 29
BEST_CST: 467.00 PATH: 4 Degree: 1

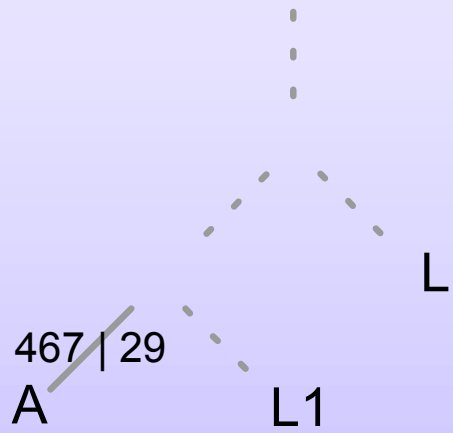
TABLE: [redacted] ORIG CDN: 125263 CMPTD CDN: 1
BEST_CST: 33.00 PATH: 2 Degree: 1

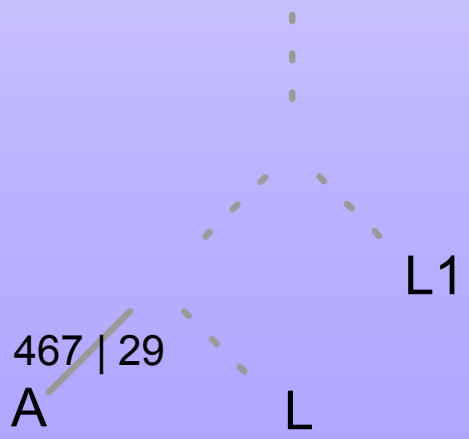
TABLE: [redacted] ORIG CDN: 238504 CMPTD CDN: 129
BEST_CST: 3.00 PATH: 4 Degree: 1

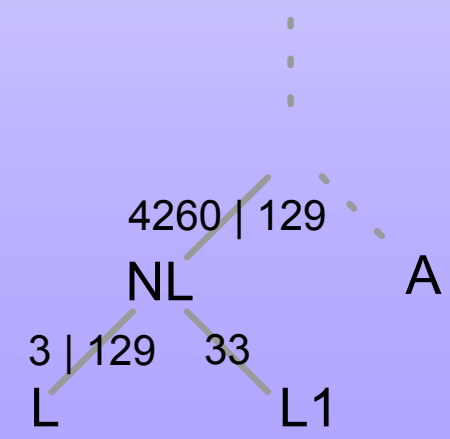
# Multi-table Joins

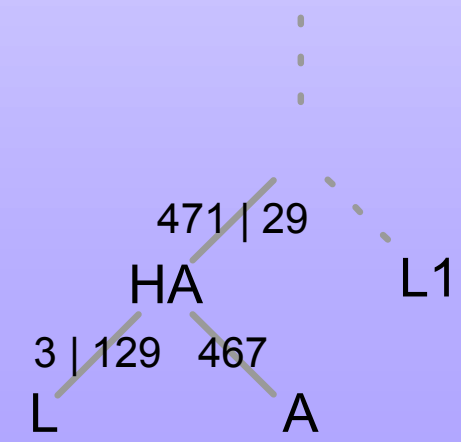


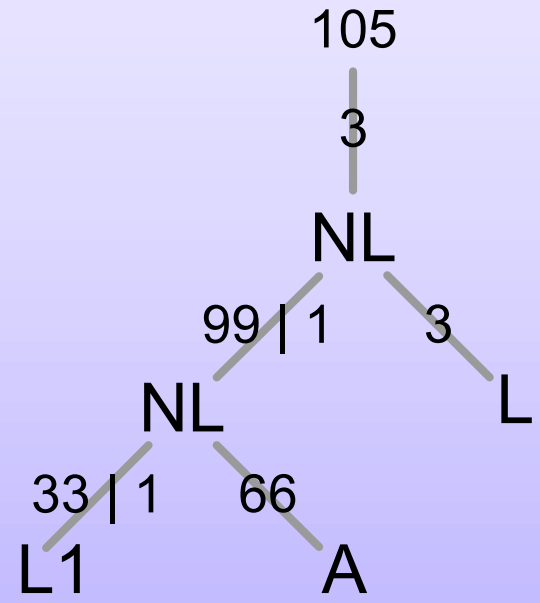



# Multi-table Joins

TABLE: A CMPTD CDN: 29
TABLE: L1 CMPTD CDN: 1
TABLE: L CMPTD CDN: 129




```
   cost      card operation
------- -------- --------------------
    105         1 SELECT STATEMENT
    105         1   SORT GROUP BY
    102         1     NESTED LOOPS
     99         1       NESTED LOOPS
     33         1         TABLE ACCESS FULL L1
     66        29         TABLE ACCESS BY LOCAL INDEX ROWID A:6-6
      2        29           INDEX RANGE SCAN A_ACC:6-6
      3       129       INDEX RANGE SCAN L
```

# Analysis of the Explain Plan

```
 cost      card operation
----- -------- ------------------------------------
  792         1 SELECT STATEMENT
  792         1   SORT ORDER BY
                    FILTER
  790         1     HASH JOIN
  760        83       HASH JOIN
  758        11         NESTED LOOPS
  749         1           HASH JOIN
    3         6             TABLE ACCESS FULL A
  731    28,762             TABLE ACCESS FULL B
    9   239,142           TABLE ACCESS BY INDEX ROWID C
    4   239,142             INDEX RANGE SCAN C_IX0
    1        15         TABLE ACCESS FULL D
   10    13,679       TABLE ACCESS FULL E
```

# Metalink Notes

| | |
|---|---|
| 40656.1 | Supposedly a note about event 10053. Not externally available (yet). |
| 75713.1 | Important Customer Information about numeric EVENTS |
| 35934.1 | Cost Based Optimizer - Common Misconceptions and Issues |
| 66030.1 | Relationship between optimizer_max_permutations and optimizer_search_limit |
| 32895.1 | SQL Parsing Flow Diagram |
| 68992.1 | Predicate Selectivity |
| 104817.1 | Discussion on Oracle Joins - Costs - Algorithms & Hints |
| 67522.1 | Why is my index not used? |

# More Metalink Notes

| | |
|---|---|
| 62364.1 | Hints and Subqueries |
| 46234.1 | Interpreting Explain plan |
| 33089.1 | Troubleshooting Guide: SQL Tuning |
| 1031826.6 | Histograms: An Overview |
| 72539.1 | Interpreting Histogram Information |
| 77228.1 | How to Tell if a Table has been analyzed |
| 70075.1 | Use of bind variables in queries |
| 31412.1 | Select to show Optimizer Statistics for CBO |
| 43214.1 | Autotrace Option in 7.3 |

# Resources

Oracle University - Course ID: 65340

Oracle8i: Everything You Always Wanted to Know about the Optimizer

http://www.evdbt.com/library.htm

look for ev10053.txt

| | |
|---|---|
| asktom.oracle.com | (Thomas Kyte) |
| www.ixora.com.au | (Steve Adams) |
| www.hotsos.com | (Cary Millsap) |
| www.orapub.com | (Craig Shallahamer) |
| www.jlcomp.demon.co.uk | (Jonathan Lewis) |

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